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SCALING UP OF SAHEL RICE VARIETIES IN SENEGAL

REVIEW OF SUCCESSFUL SCALING OF AGRICULTURAL TECHNOLOGIES

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E3 Analytics and Evaluation Project

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ACRONYMS

AECID	Spanish Agency for International Development Cooperation
AI	Aménagement Intermédiare (Intermediate Irrigation Scheme)
ANCAR	Agence Nationale de Conseil Agricole et Rural (National Agricultural and Rural Advisory Agency)
BFS	Bureau for Food Security (USAID)
BNDE	Banque National pour le Développement Economique
CBR	Chemin du Bon Riz (Pathway to Good Rice)
CBSP	Community-Based Service Providers
CEDAF	Union des Femmes Productrices de Ross Bethio
CFAF	CFA Franc
CGER	Centres de Gestion et d'Economie Rurale
CIRIZ	Comité Interprofessionnel du Riz (Interprofessional Committee on Rice)
CNAAS	Compagnie National Assurance de Senegal (National Insurance Company of Senegal)
CNCAS	Caisse Nationale de Crédit Agricole du Sénégal (National Bank for Agricultural Credit in Senegal)
CNCR	Conseil National de Concertation et de Coopération des Ruraux (National Council for Discussion and Cooperation with Farmers)
CNT	Coumba Nor Thiam (Rice Miller)
CQR	Controle Qualité Riz (Rice Quality Control)
CSA	Commissariat à la Sécurité Alimentaire (Commissariat for Food Security)
DAP	Diammonium Phosphate (fertilizer)
DAPS	Direction de l'Analyse, de la Prévision et des Statistiques (Department of Analysis, Prediction and Statistics)
DPSA	Department of Projections and Statistical Analysis
DR	Document Review
DRDR	Direction Régionale du Développment Rural (Regional Department of Rural Development)
E3	Bureau for Economic Growth, Education, and Environment (USAID)
FCFA	CFA Franc (used in quoted text)
FGD	Focus Group Discussion
FPA	Federation du Perimetres Autogerés du Senegal (Federation of Self-Managed Irrigation Areas of Senegal)
FTF	Feed the Future
GA	Grand Aménagement (Large-Scale Irrigation Scheme)
GAP	Good Agricultural Practice

GIE	Groupement d'Intérêt Économique (Farmers' Economic Interest Group)
GOANA	Grande Offensive pour la Nourriture et l'Abondance (Grand Offensive for Nutrition and Abundance)
GOS	Government of Senegal
Ha	Hectares
IDG	International Development Group
IMF	International Monetary Fund
ISRA	Institut Sénégalais de Recherche Agricole (Senegalese Institute for Agricultural Research)
JICA	Japan International Cooperation Agency
Kg	Kilograms
KII	Key Informant Interview
MOA	Ministry of Agriculture
MSI	Management Systems International
MT	Metric Tons
NGO	Non-Governmental Organization
OPV	Open Pollinated Varieties
PAMECAS	Partenariat pour la Mobilisation de l'Epargne et le Crédit Au Sénégal
PCE	Projet Croissance Economique (Economic Growth Project)
PIP	Périmètre Irriguée Privée
PIV	Périmètre Irrigué Villageois
PNAR	Programme National d'Autosuffisance en Riz
QDSS	Quantitative Data Collection from Secondary Sources
SAED	Société d'Aménagement et d'Exploitation des Terres du Delta du fleuve Sénégal et des Vallées du fleuve Sénégal et de la Falémé (National Company for Development and Exploitation of the Senegal River Delta)
SNDR	Stratégie Nationale de Développement de la Riziculture (National Rice Development Strategy)
SRV	Senegal River Valley (Vallée du Fleuve Senégal)
SUARL	Société Unipersonnelle à Responsabilité Limitée
UNACOIS	Union Nationale des Commerçants et Industriels du Sénégal
UNIS	Union Nationale Interprofessionnelle des Semences (National Interprofessional Union of Seeds)
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

A. Introduction and Purpose

This report examines the scaling up of a package of innovations in the irrigated rice seed sector in Senegal through commercial pathways from 2010 to 2015.[1] This package includes: capacity to certify quality rice seed; good agricultural practices (GAPs); the capacity of the value chain in key areas to supply inputs, services and downstream market linkages; and perhaps most importantly, financial innovations. This study focuses only on the irrigated rice value chain in the Senegal River Valley (SRV) region and does not examine the scaling up of Nerica rice varieties in rainfed areas of Senegal. It is one of five studies looking at successful scaling up of agricultural innovations in developing countries. The United States Agency for International Development's (USAID) Bureau for Food Security (USAID/BFS) has commissioned the E3 Analytics and Evaluation Project to conduct these studies as part of its efforts to scale up the impact of the Feed the Future (FTF) food security initiative. The goal of these studies is to produce lessons learned and ultimately guidance for USAID and its country Missions interested in integrating a commercial pathways approach to scaling up into their FTF project designs, procurements, and implementation. This overall research is designed to provide a better understanding of what types of innovations and country contexts are best suited to scaling up through commercial pathways, and what activities, strategies, and support are necessary to facilitate that successfully.

B. Background

The Senegal River Valley is by the far the largest area of irrigated rice production in Senegal, currently around 60,000 hectares (ha) with a potential of at least 120,000 ha. Irrigation was first put in place during the colonial period and expanded from independence through the early 1990s. With structural adjustment in the early 1990s, the Government of Senegal (GOS) disengaged from its primary role in providing inputs, purchasing output, setting prices, and delivering extension and other support services, though it continued to provide credit to farmers who qualified. Disengagement by the state led to the breakdown of the rice value chain, especially extension support, processing, and downstream linkages to formal markets. As a result, up until GOS emergency measures in light of the 2007-2008 food crisis, there was a steady decline in the surface area of irrigated rice that was cultivable and the percentage of potentially cultivable area that was actually planted. Perhaps more importantly, a number of factors prevented farmers from realizing the full yield potential of Sahel rice varieties introduced in the mid-1990s and widely adopted over the ensuing five years.

Nonetheless, even during this period when the SRV accounted for a fraction of total surface area cultivated in rice, it made up a disproportionately large share of total national rice production. Sahel rice was introduced in the mid-1990s and widely adopted in the SRV by 2000. However, yields were significantly below potential until scaling up of a package of innovations was significantly "completed" between 2010 and 2016. During this period the GOS, USAID, and other donors worked together to rehabilitate and strengthen the irrigated rice value chain. This study focuses on those efforts led by the USAID-financed Economic Growth Project (PCE), which was part of the FTF initiative to scale up a

[1] Sahel varieties were initially developed in the early 1990s by Africarice and other international research institutes. They were bred to be appropriate for the climatic conditions of the Sahel e.g. heat, low rainfall, salinity, while generating much higher yields than indigenous varieties. At the time of their initial introduction they had yield potentials of 10 metric tons per hectare, with average yields of 6-7 mt/ha, much higher than indigenous varieties. The three key varieties introduced at that time were Sahel 108, 201 and 202. Sahel 108 was targeted for the dry season when short duration is important for enabling farmers to double-crop. Sahel 201 and Sahel 202 are medium duration and therefore targeted for use in the wet season. Sahel 201 was introduced for high yield and moderate tolerance to salinity and Sahel 202 for high yield with good grain quality. More recent Sahel strains introduced since 2005 remain suitable for the region with yield potentials of 10-12 mt/ha.

package of innovations. This involved promoting and facilitating adoption of a mix of improved agricultural practices and rehabilitating and strengthening the rice value chain and relevant aspects of the rice market system. The package ultimately scaled was not introduced in its entirety in 2010, but identified iteratively as binding constraints became apparent in the course of efforts to support the sector as a whole.

Prior to the intervention of PCE and its donor partners, most farmers were growing one of three Sahel rice varieties. However as there was no system of seed certification in place, farmers used either saved seed of those varieties or seed produced by seed multipliers of often low quality. Most rice was grown only in one season, the rainy season (hivernale), even though yields were lower than in the dry, hot season (principally because of lower costs as less irrigation is needed). Machinery services for land preparation and harvesting were well established in that most farmers were aware of them, though for the majority of farmers actual use of mechanical services was minimal due to limited availability, high costs, and lack of credit. All farmers already preferred to use fertilizer, but whether they did so in practice, or used the full recommended amounts, was again dependent on access to banking credit.

Access to credit was and remains central to a relatively capital-intensive form of agriculture (about CFA 500-600,000 per ha or $1000/ha). Until recently, almost all credit was supplied by the state-owned agricultural bank, Caisse Nationale de Crédit Agricole du Sénégal (CNCAS). Yet in most years significantly less than half of farmers had access to credit, in large part because of their inability to repay previous credit. Even farmers who received credit were often not able to harvest and especially plant rice on a timely basis because of delays in approval or disbursement of bank credit. As a result, average yields ranged between 4.9 and 6 metric tons per hectare (mt/ha) between 2005 and 2010 for hivernale (rainy, winter season) rice, whereas potential yields were 10–12 mt/ha,[2] depending on the variety. Moreover, because of the near collapse of many of the larger rice mills, almost all processing (dehulling) was done by local mills that had neither the economic incentive nor the capacity to clean or sort rice by quality. Rice processed by local millers was below the quality to compete with imported rice in urban markets, so this surplus rice was sold at lower prices in local markets or to informal buyers to be sold in nearby regions.

C. Characteristics of Scaling

The story of scaling up of Sahel rice is atypical in several ways. First, maximum potential scale was and remains constrained by the extent of irrigation infrastructure. Second, from the beginning the SRV produced a marketable surplus of rice, and thus the producers who were the target of scaling up always had something of a commercial orientation, even if many consumed the majority of their own production. Third, Senegal has been and remains a huge rice importer, so there has always been a huge potential market for domestic rice, assuming it could compete with imported rice. Fourth, almost all of the institutions needed for a viable commercial rice value chain already existed in the SRV as of 2010, even if many were weak or barely functioning. The same was true for the relevant technology and knowledge of GAPs, with the important exceptions of key financial innovations and large, reliable seed certification process. Fifth, all rice grown in the SRV is irrigated, substantially mitigating the impact of

[2] In farmer interviews conducted for this report, some farmers reported getting 8,9,10 mt/ha in the dry season, consistent with yield potential found in agricultural research stations. For the latter, see, for example, the chapter, "Potential yield of irrigated rice in African arid environments" by M. Dingkuhn and A. Sow**,** in Applications of Systems Approaches at the Field Level. pp 79-99**,** Springer Volume 2: Proceedings of the Second International Symposium on Systems Approaches for Agricultural Development, held at IRRI, Los Baños, Philippines, 6–8 December 1995 and **"**Simulation of potential yields of new rice varieties in the Senegal River Valley" by Vries, M.E. de; Sow, A.; Bado, V.B.; Sakane, N.S. in: Improving soil Fertility Recommendations in Africa using the Decision Support System for Agrotechnology Transfer (DSSAT) edited by Kihara, J., Fatondji, D., Jones, J.W., Hoogenboom, G., Tabo, R., Bationo, A., Dordrecht : Springer Science+Business Media p. 141 - 155.

adverse weather events, which are the primary source of risk to farmers and buyers. Finally, while government subsidies have proved to be important in other cases of agricultural scaling up, they were particularly comprehensive in the PCE case.

The policy environment in Senegal played a key role in scaling up, both as a driver of scaling and creating a supportive context for scaling activities. Senegal experienced a huge increase in imported rice prices in 2007–2008 as well as difficulty getting the necessary import quantities because of export bans by major rice exporters like China, India, and Thailand. Senegal was and remains heavily reliance on imports of this staple food, with imports accounting for 75 percent or better of national consumption. In response, the GOS subsequently adopted a policy of rice self-sufficiency. This translated programmatically into substantial increases in the size and scope of subsidies to multiple aspects of the rice sector, direct purchases for strategic reserves and state agencies, and an active policy of soliciting donor support for irrigation rehabilitation and new investment. Particularly important were government policies that *de facto* guaranteed good returns to rice farmers by effectively setting paddy prices well above production costs. These prices also served as a key benchmark that could be used as the basis for financial innovations.

In this context, USAID and other donors chose to support the rice sector in the SRV. USAID's PCE took the lead. PCE adopted an adaptive management and virtuous circle approach to reviving the rice value chain. Through this approach, PCE identified the immediate obstacles to increased production, prices, and sales, and promoted and facilitated the adoption of innovations to meet each obstacle, e.g. producing during the *saison chaud* (hot dry season) when farmers could generate higher yields with lower risks of pest or rain damage, or even growing during both seasons. When these efforts faced new constraints and limitations as the scale of production expanded, it promoted and facilitated the adoption of innovations those in turn: the production of certified seed; mechanization services; crop insurance and other financial innovations; and quality process. Where those innovations were not already present at small scale, it brought them in from other countries, often combining them in creative ways and adapting them to the SRV context, or even innovated *de novo*. This was particularly the case with financial innovations. Taken as a whole, the two key elements to this approach to innovation and scaling were to: (1) address supply and demand issues simultaneously; and (2) increase both quality and quantity. In other words, PCE worked both on "push" factors to increase yields, area planted, production, and quality, and on "pull" factors to increase demand.

All of these efforts were complemented by substantial investments in road and irrigation infrastructure by the World Bank, the Millennium Challenge Corporation, the French Agency for Development, and the Korea International Cooperation Agency, among others. Finally, the GOS also put through three important policies that helped increase the supply of credit and market size. They provided debt forgiveness for farmers and processors in 2014 and made additional capital available to the agricultural bank, CNCAS, to increase the supply of commercialization and equipment credit. The GOS required rice importers to purchase domestic rice in proportion to their imports, effectively guaranteeing the competitiveness of domestic rice against cheap foreign imports.

These activities took a few years to put into place and have an effect. Thus while scaling efforts began in 2009–2010 by the GOS and then donors, there was almost no increase in area, yield, production, or quality until 2013–2014. At that point the cumulative effects of these multiple efforts reached critical mass in both scale and scope, along with the equally important debt forgiveness of 2014.

The three greatest sources of increase in yields and production that occurred after 2014 were: (1) the shift from hivernale to saison chaud planting or double cropping; (2) improved access to certified seed, and; (3) better adherence to a crop calendar (i.e., timeliness in land preparation, planting, and

harvesting). Adoption and scaling of all three was facilitated by financial innovations that improved access to credit.

More generally, in terms of scaling up strategy, the key aspects that underlay the success of PCE's scaling up were:

- Using a push-pull approach by helping producers to increase yields, production, and quality, while also increasing market demand by facilitating linkages to processors and distributors and strengthening those downstream institutions.
- Kick starting private upstream and downstream investment through subsidies, risk mitigation, and market facilitation. PCE's support for agricultural machinery leasing through Locafrique and innovating crop insurance with the GOS are examples.
- Translating this push/pull and kick starting into a virtuous spiral that by 2014–2015 had become increasingly self-generating.
- Aligning the incentives for farmers, banks, processors, machinery services, and wholesalers so that everyone makes money. In some cases in Senegal, this has been complicated by GOS-induced distortions of prices and margins at various stages of the value chain.
- Addressing and, where possible, lowering risk for key actors. This was particularly true for banks and the CNCAS. PCE addressed risk through the innovations of contractualization, crop insurance, and the use of a warehouse receipts system.

D. Lessons Learned

The Sahel rice value chain case has many important and positive lessons for scaling up of agricultural innovations through commercial pathways. The principal lesson from this case is that scaling up may not involve introducing one new technology like new rice seed varieties. Multiple innovations may be required to complement new seed varieties, animal breeds, etc. to fully realize the potential benefits for yield, production, and food security, let alone scale, sustainability, and poverty reduction. It needs to be accompanied by technical assistance to encourage the adoption of GAPs. The entire value chain needs to be in place.

The second lesson is that scaling is multi-dimensional, and time is an often overlooked dimension that can affect both intensive and extensive scaling. New technology and practices impact the ability of farmers to complete the various activities of the crop cycle at the optimal times. Scaling improves as farmers develop the ability to plant two crops per year, in some cases on the same land, and in a timely way. Scaling up over space, i.e., greater area, is not the only way to go, and in this case was less important, at least to date.

Context can play a key role in scaling up. Irrigation already existed, seriously mitigating risk to all parties, and almost all rice farmers had a commercial orientation and were accustomed to using improved seeds, fertilizer, and other inputs; employing machinery services; and selling on commercial markets. The majority of rice farmers were already organized into farmers' organizations, usually "hydraulic unions" or other groups around irrigation, which greatly facilitated provision of inputs, extension services, market linkages, and technical assistance. World and domestic prices for rice have been consistently high since the food crisis of 2008, making a strong business case for irrigated rice.

Even when scaling through commercial pathways, the public sector can and often does play a significant and necessary role. In the SRV, PCE emphasized wherever possible commercial pathways. Nonetheless, GOS support played a key role through subsidies on inputs, credit, insurance, and purchases of machinery. GOS policy improved profitability significantly for farmers and lowered risks changing the risk-return tradeoff through regulating prices, supporting demand for domestic rice, and the role of

parastatals in agricultural credit and insurance. Arguably, GOS intervention in agricultural credit and insurance, machinery services, etc. and an overall policy stance of encouraging rice self-sufficiency has helped crowd in the private sector through both a demonstration effect and an implicit 'guarantee" on investments in the sector. As of this writing, the private sector is now the dominant force in machinery services and has a growing share of agricultural credit. Without these policies and programs, scaling up of the package of innovations by PCE and others to increase irrigated rice production in the SRV would have been, much more difficult, expensive, time consuming, and arguably impossible. It is important to note that, at least in this case, GOS subsidies appear to be fiscally sustainable for the foreseeable future. At the same time, the GOS-facilitated price setting has distorted incentives, especially for wholesalers and processors. Exaggerated and inaccurate GOS production and yield statistics have adversely affected planning by rice farmers and processors.

I. INTRODUCTION

A. Background and Context of This Report

The United States Agency for International Development's Bureau for Food Security (USAID/BFS) and the Agency's country Missions have been implementing the Feed the Future (FTF) food security initiative since 2010. In many cases, innovations developed and introduced at a small scale have since gone to scale or are in the process of doing so. Yet at the same time it appears that some innovations that potentially could have gone to scale have not done so, have not reached their full scale potential, or are not fully sustainable at scale.

There are many reasons for this unfulfilled potential, such as a substantial focus on achieving the immediate outcomes and objectives defined in an activity solicitation and award/agreement with an implementing partner. However, there is substantial anecdotal evidence that one of the reasons is that how to scale up through commercial pathways is often not well understood or incompletely integrated into activity designs, procurements, and implementation plans. In other words, it appears that USAID/BFS and Missions could do more in both scaling and sustainability by using commercial pathways.

In this context, USAID/BFS has commissioned the E3 Analytics and Evaluation Project[3] to conduct and synthesize approximately five case studies to better understand how commercial pathways have been used successfully in the scaling up and sustainability of agricultural innovations in developing countries. The goal of this overall study is to produce lessons learned and ultimately guidance for USAID/BFS and Missions interested in integrating this scaling up approach into activity designs, procurements, and implementation. A particularly important goal is to develop a methodology that will allow USAID and its implementing partners: (a) to estimate the speed and level of adoption by farmers; (b) to identify the time and resources required to create the institutional foundations and enabling environment that would allow for a transition to commercially driven and/or spontaneous scaling up and diffusion; (c) to identify critical levels of initial adoption that would allow for such a transition; and (d) to provide for general benchmarks to monitor progress and success in creating the foundations for and a transition to commercially driven and/or spontaneous adoption and scaling.

This overall study is designed to address five research questions:

1. Are there models using commercial innovation and growth mechanisms for bringing new agricultural technologies to scale in FTF countries?
2. What are the essential characteristics of innovations, value chains, and other spaces for identifying where commercial innovation growth and diffusion models are appropriate for reaching potential scale?
3. What determines the shape of the S-curve [4](e.g., size of critical mass of adopters, speed and timing of technology adoption and diffusion, peak levels of scale reached), and how can these factors be estimated?

[3] The E3 Analytics and Evaluation Project is implemented by team lead Management Systems International, in partnership with Development and Training Services (dTS) and NORC at the University of Chicago.

[44] The S shaped curve is a curve commonly used to characterize the pathway over time of the number of adopters of new innovations, based on the path breaking work of Everett Rogers and others in the diffusion of innovation. These researchers found that empirically adoption can be thought of as a normal distribution, a few very early adopters, a large number of early and middle adopters, and then a decreasing number of later adopters. When this normal distribution is graphed against time, it takes the shape of an S.

4. What types of activities are appropriate to implementing or facilitating a commercial scaling pathway? Examples may include strengthening value chains and distribution mechanisms, using media and other communication forms, and leveraging and strengthening social networks and channels.
5. What are the implications of achieving scale and sustainability using commercial scaling pathways for USAID's project designs, procurement mechanisms, planning, budgeting, cost/benefit analysis, and monitoring and evaluation of FTF programs?

B. Purpose of This Report

This report examines the successful scaling up of a package of innovations to improve irrigated rice production in the Senegal River Valley (SRV) region. High-yielding Sahel rice varieties were first introduced in 1994 and widely adopted by farmers in the SRV over the next five years. This was accompanied by a withdrawal or disengagement of the public sector in supporting irrigated rice production as part of structural adjustment policies. As a result, the introduction of the Sahel varieties was not accompanied by adoption of good agricultural practices (GAPs), and many key parts of the irrigated rice value chain declined in quality, capacity, or both. As a result, the potential impact on yields and production of Sahel rice, not to mention national food security, was never fully realized. Efforts to realize this potential were initiated by the Government of Senegal (GOS) in the midst of the world food crisis of 2007-2008. The GOS commitment to move towards food self-sufficiency led to USAID creating and financing the Projet Croissance Economique (PCE) which, from 2010-2015, in collaboration with other donors, introduced various innovations to fill gaps in, strengthen and rehabilitate the irrigated rice value chain. This study focuses on the 2010–2015 period and PCE's efforts in particular.

C. Methodology Used

The approach developed by the review team for conducting these case studies is grounded in the spaces, drivers, and pathways analytical framework developed by Hartmann and Linn[5] and the scaling up framework authored by Cooley and Kohl of Management Systems International (MSI)[6]. These frameworks detail the roles in which spaces, drivers, and pathways contribute to successful scaling. The term space is multidimensional and encompasses the fiscal/financial, political, policy (legal and regulatory), organizational, socio-cultural, agro-ecological, partnership,[7] and learning components that could affect scaling. Drivers are those factors or actors that move an innovation from pilot towards scale, including the individuals or organizations that lead the scaling up effort, their motivation and incentives, and how these interact with the characteristics of the innovation itself and the spaces or context. Pathways are the sector used to take the innovation to scale: the private and public sectors, donors, and other third parties or some combination thereof. This study assesses the respective roles played by each sector, with a special emphasis on the role of the private sector, i.e., the commercial pathway, as that is the primary focus of this research.

Within this framework, the review team examined the following components in terms of their role in scaling up the innovation:

[5] "Scaling up: A framework and Lesons fro development Effectiveness form Literature and practice," Arntraud Hartmann and Johannes Linn. 2008. https://www.brookings.edu/wp-content/uploads/2016/06/10_scaling_up_aid_linn.pdf
[6] "Scaling Up – from vision to large scale change," Larry Cooley and Ricard Kohl, MSI. 2006. http://www.msiworldwide.com/files/scalingup-framework.pdf
[7] The partnership space looks at the potential organizations whose sponsorship and resources can be enlisted by the lead or driving organizations to support scaling up.

- **Characteristics of the innovation:** The package of components needed to be adopted; knowledge and physical input requirements for effective adoption and implementation; cost, complexity, and sophistication required; changes needed, if any, in farmers' existing agricultural practices; and the relationship to adoption of other innovations, whether complementary, substitutes, or pre-requisites.
- **Adoption drivers and results over time and space:** The reasons for adoption; variation in the degree of adoption and other patterns; socio-economic and demographic characteristics; and the role of different information sources in affecting adoption.
- **Business case for the innovation:** The costs, risks, and returns of adopting, producing, marketing, and distributing the innovation (or innovation package) relative to the motivations and incentives of potential adopters and other private actors in the value chain.
- **The external context or spaces:** In the case of irrigated rice in the Senegal River Valley, a review of the documents collected narrowed the relevant spaces to: the policy enabling environment; the input supply chain; the downstream market; access to credit and insurance;; and institutions and partnerships. The review team determined that the role of gender, was at best marginally relevant to scaling up in this case and therefore these issues are not discussed in this case. (The agro-ecological space is covered in the background section).
- **Scaling up strategy and activities:** In rice in Senegal, there were a number of complementary scaling strategies in place at the same time; those of the GOS for food security, those of donors to support the rice sector, and that of PCE in particular, the lead organization in this case. While the objectives of these actors remained fairly constant, their strategy and activities change over time based on experience and binding constraints as they appeared. Indeed, this is a notable conclusion of this study that strategy needs to be adaptive. In this context, this report focuses primarily on PCE's strategy and activities to: improve farmers productivity and scale; address gaps or otherwise strengthen the market system and external context; and facilitate other actors both private and public sector, to drive or support the scaling up process, including the state-owned agricultural bank and insurance agency, rice millers, and agricultural machine leasing companies.
- **Potential scale of adoption (the market space):** The number of farmers who do or can grow rice given agro-ecological conditions; the effect that the innovation may have on the potential number of farmers growing rice or the area of rice planted; the implications of full-scale adoption for the overall production of rice, its absorption by the market, its impact on rice prices, and the profitability of growing rice.

The methodology for this case study involved four data collection techniques: documents reviews (DR), key informant interviews (KIIs), focus group discussions (FGDs), and analysis of quantitative data from secondary sources (QDSS). These approaches were used to collect qualitative and quantitative data from a diverse and large number of stakeholders associated with the rice value chain and the large enabling environment of Senegal agriculture. The sources and key spaces and drivers for the data collected are summarized in Table 1. Each cell notes whether relevant data was provided for a particular topic, ranked on a scale of 1 (X) to 4 (XXXX) as to the importance and utility of the information gathered. Four (4) represents most important.

TABLE 1: DATA COLLECTION OVERVIEW

Data Source	Data Collection Method-ology	Data Collected					
		Innovation Character-istics	Adoption Drivers & Results	Potential Scale & Output Markets	Business Case	External Context	Scaling Strategy & Activities
Rice farmers and organizations (CEDAF)	KII, FGD	XXX	XXXX	X	XXX	XX	XX
Rice research institutions (ISRA, AfricaRice)	KII, DR	XXXX	X	XX	XX	XX	XX
GOS Ministry of Agriculture Central Office (DAPS)	KII, DR, QDSS	XX	XXX	XX	X	XXXX	X
GOS Central Statistical Office	KII, QDSS	X	XXX	XXXX	X		
NGOs working in agriculture	KII, FGD	XXXX	XXX	XXXX	XX	XXX	XX
GOS agencies and parastatals (SAED, ANCAR,)	KII, DR, QDSS	XXX	XXXX	XX	XX	XXXX	X
Financial institutions (CNCAS, CNAAS)	KII		XXX		XXX		
USAID and other donors (JICA)	KII, DR	XX	XXX	XX	X	XXXX	XXX
USAID implementing partners (PCE)	KII	XXXX	XXX	XXXX	XXX	XXX	XXXX
National and regional farmers' associations (CNCR, FPA)	KII, DR, QDSS	X	XX	XXX	XXXX	XXXX	XX
Rice mills and wholesale buyers (UNACOIS Teranga Enterpise CNT, SUARL)	KII	XX	XXX	XX	XX	XXXX	X

The data collection took place during a three-week period in January 2016 in Dakar and the major cities and towns along the SRV from Saint Louis to Matam. The majority of rice production in that region is located within 10 km of the river valley. The review team spent six working days conducting field research (KIIs and FGDs) along this route, stopping in all the major commercial towns along the way: Richard Toll, Ross Bethio, Podor, and Dagana. This allowed for a diversity of farmer experience across the region in terms of proximity to markets, different types of irrigation infrastructure and systems, and different quality of agro-ecological micro-zones for growing rice.

During the three-week period, the review team was able to interview a large number of stakeholders. This included seven FGDs with rice farmers from a variety of public, village, and private irrigation schemes, agricultural research organizations involved in rice breeding (e.g., AfricaRice, ISRA), and several large-scale rice processors. The team met multiple times with relevant GOS ministries, parastatals, and consultative bodies, including Programme National d'Autosuffisance en Riz (PNAR, which coordinates and implements the overall national rice self-sufficiency policy), Société d'Aménagement et d'Exploitation des Terres du Delta du Fleuve Sénégal et des Vallées du Fleuve (SAED, which is in charge of building and maintaining public irrigation infrastructure and providing extension support), Agence Natonal de Conseil

Agricole et Rural (ANCAR), Direction Régionale du Développment Rural (DRDR, Ministry of Agriculture central departments in charge of extension), and the central statistical office. In addition to meeting with USAID staff and its PCE/Ntaal Mbay team in both Dakar and the SRV, the review team also met with the Japan International Cooperation Agency (JICA) team which has been heavily involved in improving the quality of rice processing.

The review team was able to gather some quantitative data on rice production and cultivation from Ntaal Mbay (the successor project to PCE), SAED, the Ministry of Agriculture (MOA), and the PNAR. SAED and Ntaal Mbay provided data in several Excel spreadsheets, which the review team used to create a number of time series (e.g., on production, area planted, and yields) that form the basis for much of the statistical analysis presented below. The team complemented its quantitative analysis with an exhaustive document review, especially of a number of studies that PCE commissioned and PCE's annual reports.

D. Structure of the Report

Section II of this report provides background information on irrigated rice cultivation in the SRV. It covers the history of the introduction of new rice varieties beginning in the mid-1990s amidst the withdrawal of the GOS from an active role in the rice sector, the decline of the rice value chain between 1995 and 2008, and the shift in the policies of the GOS towards targeting rice self-sufficiency.

In the review team's other case studies, Section III specifies the technology being scaled. However, in this case Sahel rice varieties, narrowly defined, were already at scale,[8] and though PCE introduced some new varieties after 2010—Sahel and others—that was one of its least successful activities. Instead what was being "scaled" was a package of innovations. This package, which was developed over time in response to challenges as they arose and/or were identified, included both a number of GAPs and various innovations to strengthen, rehabilitate or otherwise fills gaps in the value chain. In this case, for the purposes of exposition only, the former are presented in Section II while those pertaining to the value chain are described in Section III. Section III also assesses the business case for Sahel rice production by farmers and other actors in the rice value chain. Given the extensive subsidies from the GOS for multiple aspects of rice production, it could be that scaling was an artificial construct of these subsidies and not really commercially sustainable.

Section IV looks at the scale that this package of innovations, as embodied in the potential for irrigated rice production in the SRV, has and could have reached as the value chain recovered, in terms of levels of adoption along with their impacts on yields and production levels. It looks at the issue of whether there were potentially any demand constraints on an increase in the production and supply of rice (e.g., adverse price effects as a result of increased production of irrigated rice).

Section V describes the status of the value chain at the beginning of scaling efforts post-2008. It identifies where there were gaps or weaknesses constraining scaling (i.e., whether there was adequate space for scaling up). It then goes on to discuss what PCE and others did to create sufficient space and relieve existing constraints, and the success of those efforts. Subsections here include:

- The production and certification of quality rice seed.
- The downstream pathways and institutions for farmers to store, process, and sell rice and market linkages.

[8] According to Africarice, "The proportion of the total area under the Sahel varieties in the region increased from 3% in 1995/96 to 72% in 2000/2001." See Africarice, "Irrigated Varieties. Improved Varieties for Irrigated Rice Farming in Africa" http://www.africarice.org/warda/irrigated.asp By 2000, Sahel 108 had reached 100% adoption.

- The complementary inputs space, including credit, insurance, and mechanization.
- The policy and political space (i.e., the policies, laws, and regulations that affect, support, and constrain irrigated rice production in the SRV).

Section VI quantifies scaling up over time and space in terms of the impact of the value chain activities on the area, yields, and productivity of Sahel rice in the SRV.

The "Conclusions" and "Lessons Learned" sections focus on addressing the overall research questions: the characteristics of the innovation, context, and strategy that facilitated or hindered scaling up and sustainability. Particular emphasis is given to the role of commercial actors versus the omnipresent public sector, and the generalizability of the Senegalese Sahel rice case to other countries, value chains, and innovations.

E. Team Composition

This review was conducted by Dr. Richard Kohl of MSI. Dr. Kohl is an economist and internationally recognized expert on scaling up, and has been working with USAID/BFS and Missions in improving scaling up strategies for FTF programs and innovations for the past two years. Additional research and logistical support was provided by Professor Katim Toure, a Senegalese national and university professor with expertise in agriculture and the irrigated rice value chain in particular. Extensive home office support was also received from Gwynne Zodrow, a technical manager and monitoring and evaluation expert with MSI.

II. BACKGROUND ON RICE IN SENEGAL

Senegal is a small country in Francophone West Africa, bordering on both the Atlantic Ocean and the Sahel. Like many developing countries, agriculture accounts for a large share of employment and a small share of GDP. Between 2003 and 2007, prior to the start of scaling, the share of agriculture in GDP fluctuated between 6.7 and 8.3 percent.[9] Rice is the staple cereal and is eaten at least twice daily by most Senegalese households; however, because of the country's historical poverty, the Senegalese historically purchased cheaper rice (e.g., broken rice). While some urban, higher-income households have developed a taste (and the means) for unbroken rice, aromatic varieties, and other higher-priced quality and varieties, broken rice remains the preference of most Senegalese, especially in rural areas.

> *Senegal is the second largest rice importer in Africa, ahead of Côte d'Ivoire and behind Nigeria. Senegal's imports reached 1,113,000 MT in 2005, with net imports estimated at 854,000 MT [before declining during the food crisis]. Consumers' preference is for 100 percent broken rice originating from Asia, mainly Thailand and India…. Per capita rice consumption continues to grow and is estimated at 70 to 75 kilograms and total annual consumption is estimated at 700,000 MT. Local rice production meets about 20 percent of the country's needs and 30 percent of this production is used for subsistence. In 2005/06, local production of rice paddy was estimated at 265,000 MT.*[10]

[9] Source: Ministere De L'agriculture, Government of Senegal, PROGRAMME AGRICOLE 2008-2009 : La Grande Offensive Agricole pour la Nourriture et l'Abondance. VERSION DU CIM DU 9 MAI 2008, p.13 http://inter-reseaux.org/IMG/pdf_Textegoana-mai08.pdf

[10] Agriculture in Senegal. https://en.wikipedia.org/wiki/Agriculture_in_Senegal

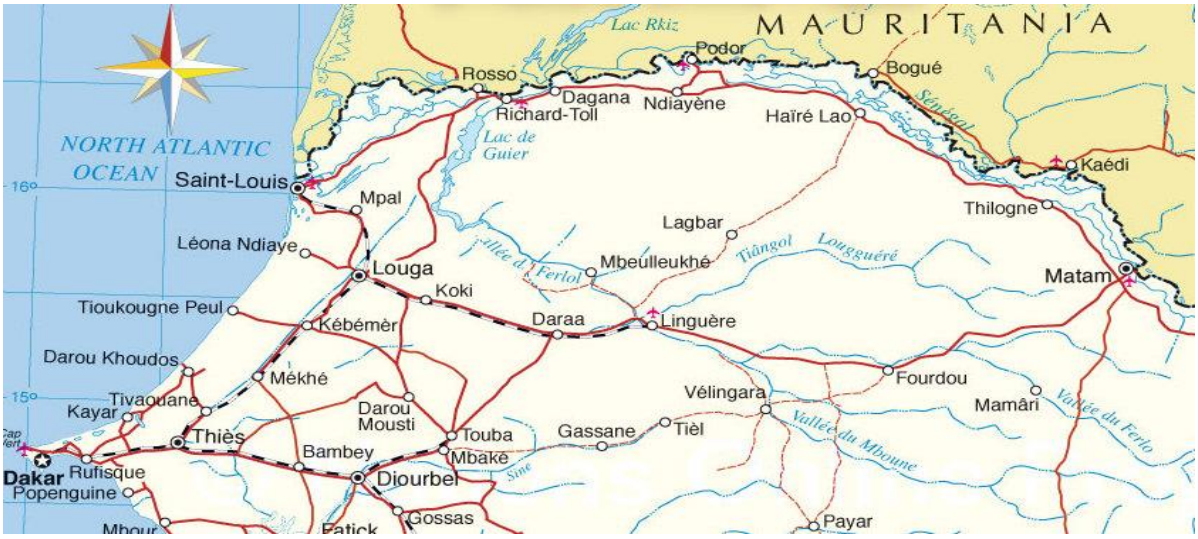
A. Geography and Seasonality

Rice is grown almost exclusively by smallholders and emerging farmers; there is no large-scale commercial production of rice. Most rice is grown either in the Casamance—the part of Senegal south of the Gambia—in areas around Velingara, Goudomp, Kolda, and Bounkiling. Rice in the Casamance is mostly rainfed. Irrigated rice is found almost exclusively in the SRV. While as of 2010 the SRV accounted for only about one-third of total cultivated surface area (around 35,000 ha out of 108,000 nationally), it accounted for almost two-thirds of national rice production (214,000 metric tons (mt) out of 339,000 mt) because of much higher productivity. According to the PNAR, average yield in the SRV was 6.1 mt/ha in 2010, compared with 1.7 mt/ha in rainfed areas.[11]

This yield advantage is reinforced by the fact that there are two seasons in the SRV, the *saison hivernale* (wet, cooler, rainy winter season) and the *saison chaud* (hot, dry, summer season). In the saison chaud, as there is no rainfall, crops require irrigation throughout the season, which goes from planting from mid-February and mid-March to harvesting in June-July. Planting in the saison hivernale is in June/July and harvesting from October through December. The hivernale was historically the season when most rice is grown in the SRV, despite the fact that yields have been, and remain, higher in the saison chaud, primarily because it was cheaper as less irrigation and associated pumping expenses were required.[12]

Average yields in the SRV for the 2003–2010 period were 5.5 mt/ha in the saison hivernale versus 6.4 mt/ha in the saison chaud. Up until the food crisis of 2007-2008, hivernale rice accounted for about 85 percent of both production and surface area planted in the SRV. Even after farmers expanded production in the saison chaud following the food crisis, production in that season remained around 60 percent as of 2010. Some farmers grew rice in both seasons, and usually not on the same land because they could not harvest and sell their crop, repay their loans, get approved for a new loan, and engage in land preparation in sufficient time. This was due to a combination of factors—delays in credit approval, bottlenecks in payments and processing due to cash flow constraints on processors, and shortages of machinery services for harvesting and land preparation.

FIGURE 1: SENEGAL RIVER VALLEY AND DAKAR



[11] Rice statistics were drawn from a variety of sources and combined to create consistent time series. These sources include Ntaal Mbay, the GOS Department of Projections and Statistical Analysis (DPSA), PNAR, and SAED.
[12] This is why the saison chaud is also called the contre-saison (loosely translated as the off-season) in the SRV.

The SRV begins in the delta region with the regional capital, Saint Louis, and has four sub-regions: Dagana, Podor, Matam, and Bakel. From Dagana to Matam is 216 miles or 260 miles by road. Dagana is in the delta and is the most heavily irrigated, fertile, and appropriate sub-region for growing rice. As one moves upstream from Dagana to Podor to Matam, the intensity of irrigation decreases, as does the density of value chain institutions such as large rice processing mills, machinery service providers, and access to urban markets. As shown in Table 2 below, Dagana accounts for two-thirds of area cultivated and production, with another 21 to 22 percent in Podor. Matam and especially Bakel historically contributed little to SRV rice production, mostly because of the lack of irrigation and value chain infrastructure, and the soil is less suitable for rice, and more suitable for onions, tomatoes, and other horticulture crops which are also more profitable. In sum, most rice is grown in the very small region between Rosso and Podor.

TABLE 2: SRV RICE PRODUCTION, CULTIVATION AND YIELDS PRIOR TO PCE AND OTHER INTERVENTIONS

	Surface Area Cultivated (ha)				*Production (mt)*				*Yield (mt/ha)*			
	Dagana	**Podor**	**Matam**	**Bakel**	**Dagana**	**Podor**	**Matam**	**Bakel**	**Dagana**	**Podor**	**Matam**	**Bakel**
2000/01	16,738	5,678	3,311	225	67,287	22,826	13,310	905	4.02	4.02	4.02	4.02
2001/02	16,214	5,315	3,215	226	91,771	30,083	18,197	1,279	5.66	5.66	5.66	5.66
2002/03	14,244	5,828	2,869	256	82,045	33,569	16,525	1,475	5.76	5.76	5.76	5.76
2003/04	16,954	5,779	3,421	143	99,341	33,946	20,198	845	5.86	5.87	5.91	5.92
2004/05	23,255	6,696	3,501	95	135,909	39,365	20,551	331	5.84	5.88	5.87	3.50
2005/06	22,023	6,463	3,617	63	125,065	37,542	21,050	250	5.68	5.81	5.82	4.00
2006/07	18,983	5,475	3,253	80	96,929	30,890	16,462	320	5.11	5.64	5.06	4.00
Average	18,345	5,890	3,312	155	99,764	32,603	18,042	772	5.42	5.52	5.44	4.69
Share of SRV	66%	21%	12%	0.6%	66%	22%	12%	0.5%				

Source: Ntaal Mbay

BOX 1: TYPES OF IRRIGATION IN THE SRV

Not only is the SRV differentiated as one moves downstream, but there are also important differences in types of irrigation infrastructure. There are basically four categories of irrigation:

1. Grand aménagement (GA): Large, publicly constructed primary and secondary irrigation canals constructed, maintained, and managed by SAED, that irrigate prime land in large areas. Farmers who cultivate land in a GA are members of hydraulic unions set up by the GOS.
2. Aménagement intermédiaire (AI): Similar to GA but smaller in size and surface area.
3. Périmètre irrigué villageois (PIV): Small-scale, village-operated and maintained irrigation schemes that were also constructed by SAED but at a scale that allowed for traditional village cultivation practices.
4. Périmètre irriguée privée (PIP): Constructed and maintained by private individuals or private farmers' associations, these vary widely in terms of size and quality depending on the means of the owners. However, the vast majority are more poorly constructed and maintained than the public sector schemes.

There are some important differences between the four schemes in addition to size. The PIVs and PIPs are usually of lower quality, lack tertiary canals and access roads, and often lack drainage. For these and other reasons, particularly the lack of drainage, they have a tendency to build up mineral salts from repeated irrigation, and the land becomes unusable.

During the post-structural adjustment period, lack of maintenance from SAED and private actors led significant areas that have irrigation infrastructure to become unusable. Of the remaining usable land, an additional portion was not cultivated, often for lack of financial resources to access inputs. Thus at the

beginning of scaling efforts, there were somewhere between 80,000 and120,000 ha aménagée (with infrastructure), out of which 50,000 to 60,000 ha were cultivatable. Between 2000 and 2007, irrigated rice actually planted fluctuated between 23,000 to 33,500 ha.

B. Post Structural Adjustment and the Decline of the Irrigated Rice Value Chain

The reasons for the stagnation in yields and decline in area cultivated are three-fold: (1) the steady regression of irrigation infrastructure; (2) the elimination of several state-sponsored support institutions; and (3) the failure of private value chain actors to adequately fill the gap left as the state retreated. The disengagement of the state was a consequence of structural adjustment agreements between the GOS and the IMF and World Bank in the first half of the 1990s. Prior to this policy change, the state provided for marketing, distribution, processing, and financial support. In addition,

> *… [t]he state's price stabilization fund operated an import monopoly; it organized the marketing and fixed the prices of both imported and local rice. The price of broken rice was fixed at around 50 percent of the price of whole rice. Within this system, a substantial levy was imposed on imported rice; in 1994/95, the year before the system was abolished, the difference between the cif world market price and the wholesale price in Senegal amounted to 28-31 FCFA/kg (compared with 8-19 FCFA/kg under the liberalized conditions introduced after 1996). Some of the revenue from the import monopoly was used to promote local production; however, a substantial proportion went towards funding the general state budget and the Senegalese Progressive Union party [emphasis added].*
>
> *The currency was devalued by 100 percent, imports were liberalized and privatized, and the role of the rural development associations was reduced to a handful of core tasks such as the granting of loans, agricultural extension and providing support to private producers and processing companies. The transfer of responsibility for rice imports from the state to the private sector proceeded smoothly, despite fears to the contrary, although over time a significant concentration process has occurred. With the liberalization of imports, the state's levies and quota system were abolished and the basic tariff now stood at around 15 percent. Rice imports increased dramatically as a result. [Emphasis added].*[13]

In the SRV, this meant the privatization of the large rice mills and of agricultural machinery services that had been owned and operated by SAED. Similarly, SAED's ability to provide infrastructure maintenance, technical assistance, and agricultural extension services was dramatically curtailed both as a matter of policy and because of reductions in their financial and operational capacity (e.g., fewer human resources and agricultural machines). Access to mechanical services became increasingly confined to those farmers working land on GAs and AIs, with limited access by PIPs and almost none by PIVs.

While the transfer of rice importing to the private sector went smoothly, this was not the case for other parts of the rice market system. By and large this support and these services were not replaced by the private sector as it too declined. Large rice mills declined in number, operating capacity, and the quality of the rice they produced as their cleaning and sorting capabilities decreased. The privatized rice mills suffered from severe cash flow constraints, for investment and especially for operating funds to buy rice, process it, and sell it. Many shut down or limped between 1995 and 2010. As a result, downstream linkages to urban markets were disrupted. Farmers increasingly turned to small, local millers called décortiqueses (literally dehullers) to process their rice for their own consumption and local sales.

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[13] Michael Brüntrup, Thao Nguyen and Christian Kaps, "The rice market in Senegal" **Agriculture & Rural Development** 1/2006 , pp. 23-24. http://www.rural21.com/fileadmin/_migrated/content_uploads/ELR_The_rice_market_in_Senegal_0106.pdf

According to studies done by and interviews with PCE and JICA, the décortiqueses produced much lower quality rice even compared to the degraded large rice mills, as they did not have the facilities to clean, sort, or polish rice. At the time of the food crisis in 2007–2009, there were only 15 large processors active in Dagana compared with 112 décortiqueses; no large processors were active in Podor, Matam, or Bakel. All processing was done in those areas by 143 décortiqueses.

Rice in the SRV became known for having uneven quality and color and a significant presence of stones and other impurities. Farmers reverted to selling their extra rice on local markets or to local intermediaries (banabana) who transported rice to neighboring areas of Senegal as well as across the Mali and Mauritania borders. While farmers continued to sell surplus rice and did not revert to being subsistence or safety-first farmers, there was effectively a degree of decommercialization of the SRV rice sector.

The effects of the decline of millers and market access created a vicious circle in terms of credit and production. The state-owned agricultural bank, Caisse Nationale de Crédit Agricole du Sénégal (CNCAS), was also partly privatized as part of structural adjustment. Even though the state and civil society stakeholders retain a majority ownership, CNCAS was put on a more commercial footing. As a result of this tighter policy, farmers and millers who were in arrears or default were unable to access credit, limiting their ability to buy inputs for the next rice season or operate their mills. In years of poor production, millers and farmers were unable to repay their CNCAS loans, so that in the following seasons, CNCAS lending to farmers was largely confined to farmers' organizations associated with GAs, but not PIVs or PIPs. While the GOS periodically provided resources to CNCAS to forgive bad debt (usually after presidential elections), the resumption of credit lasted only until the next poor harvest. As a result, a very small proportion of rice farmers had access to credit during this period, around one-third of the total.[14] CNCAS did not during this period offer either commercialization or equipment credit, further constraining the ability of the private sector to offer these services. Without access to credit, indebted farmers and millers were not able to earn enough to repay bank loans, falling further behind.

The problems with processing, access to credit, and downstream market linkages were compounded by governance issues. The governance structures and resources of the hydraulic unions in the GAs and AIs were (and remain) much stronger than those of PIVs and PIPs. GAs and AIs received significant technical support from SAED and other government agencies; a state-sponsored consulting firm even provided assistance with financial accounting and management, crop calendars, and planning. Nonetheless, a noteworthy characteristic of the SRV—which was to facilitate scaling up and may not be present in other contexts—is that farmer organizations are omnipresent. Almost all rice farmers are highly organized and members of some form of farmers' association or economic interest group (GIE – groupement d'intérêt économique).

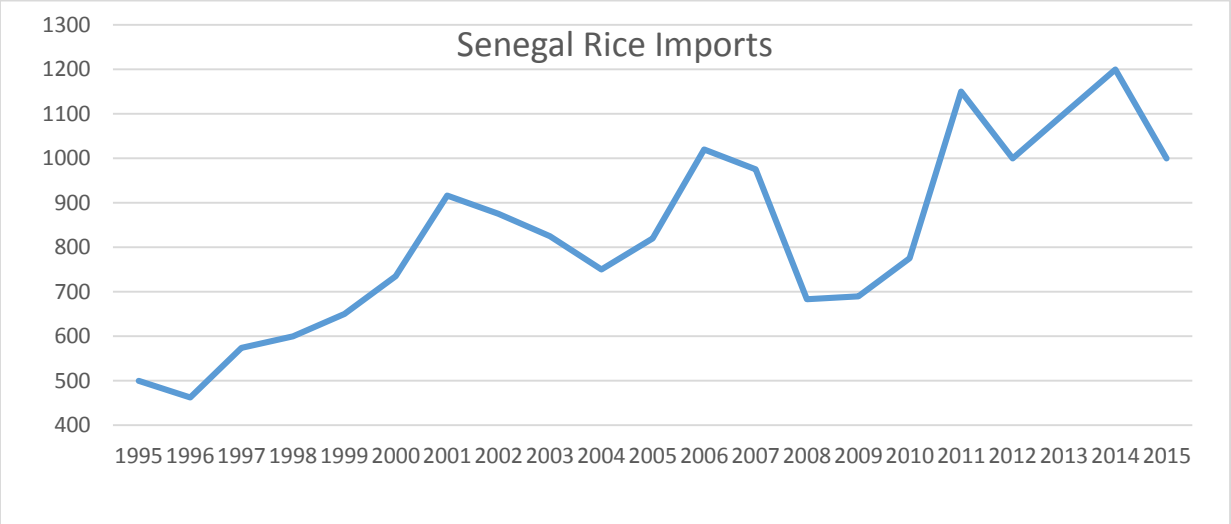
C. The World Food Crisis of 2007–2009 and the Government of Senegal's Policy Response

Despite domestic production, Senegal has consistently been one of the largest rice importers in the world[15]. In Africa, it is second only to Nigeria, and it varies in international rankings between seventh and ninth, depending on the year. In recent years, Senegal has had to import over one million metric

[14] Source: SAED Statistical Yearbook.
[15] See, for example the World Atlas website, http://www.worldatlas.com/articles/the-largest-rice-importers-in-the-world.html According to their data, as of 2015 Senegal was ranked 9th in the world, after China, Nigeria, the Philippines, Iran, Indonesia, Saudia Arabia, the EU and Iraq. It is noteworthy that the EU imported 1,500 tons of rice vs. Senegal's 1,100, despite the differences in population.

tons to meet domestic demand, and Senegal's imports have increased steadily over the last decade despite the efforts of the GOS to stimulate increased production since 2006.

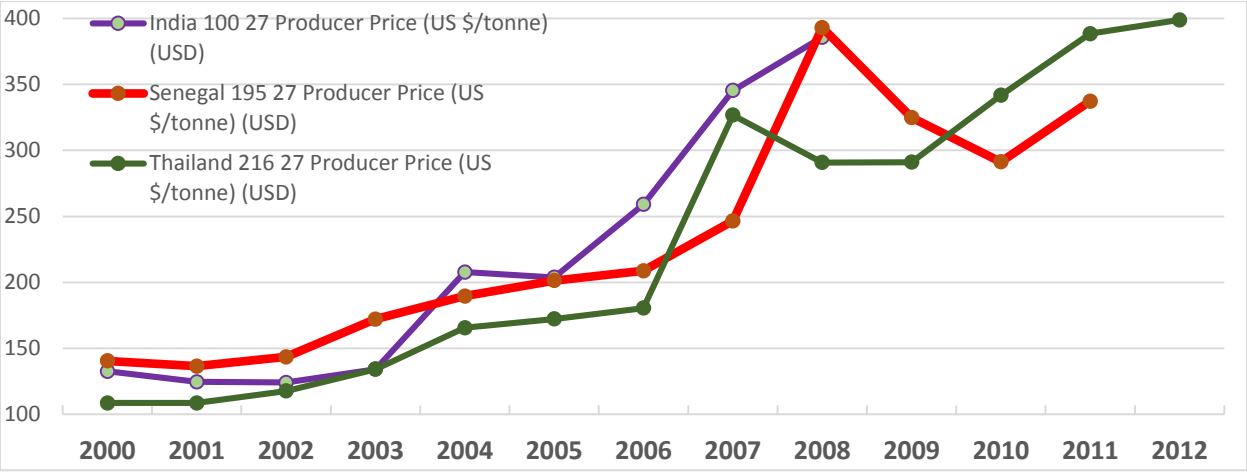
FIGURE 2: SENEGAL RICE IMPORTS IN METRIC TONS, 1995–2015



Source: FAOSTAT, Rice – total (Rice Milled), annual averages

As can be seen in Figures 2 and 3, the spike in world rice prices between 2006 and 2009 had a substantial impact on Senegal. Moving closely with world prices despite some government intervention, domestic rice prices doubled at their peak in 2008. This caused rice imports to plummet by around 30 percent before resuming their steady climb in 2010. Interestingly enough, Senegal rice prices tended to track Thai prices until Thailand prohibited exports during the crisis. Senegalese importers shifted towards Indian rice, especially as India had large supplies of broken rice that both suited Senegalese tastes and was significantly cheaper. Senegalese importers were also under pressure from the GOS to keep rice prices down, and so substituted the cheaper Indian rice.

FIGURE 3: PADDY RICE PRICES, SELECTED COUNTRIES



Source: FAOstat

The price spike spurred the GOS to action. This was because of both concerns about the domestic political backlash of higher prices and a lack of food security among politically all-important urban consumers.

The rice crisis led to an increase in the prevalence of food insecurity in urban areas. City dwellers in countries with high rice consumption levels spend 20 to 25% of their income on rice. In such contexts, the spike in rice prices had serious implications for household food security[16].

The change in GOS policy also was driven by the impact on Senegal's balance of trade. Despite the decline in import volumes, Senegal's rice import bill jumped from CFAF 130 billion in 2005 to nearly 180 billion in 2009 (from $220 million to $308 million at 2016 exchange rates). The GOS embraced a policy of pursuing self-sufficiency in rice, setting a target for domestic production of one million metric tons (mt) of milled rice by 2012 (later reset to 2017 when this quickly showed itself to be unachievable). The GOS expected 800,000 mt to come from irrigated rice (mostly the SRV) and the rest to be rainfed. As milled rice is about two-thirds the weight of paddy rice, this translated into production of around 1.5 million mt of paddy rice nationally and 1.25 million mt of irrigated rice. Almost all of the irrigated rice would have to come from the SRV.

TABLE 3: RICE PRODUCTION BY SEASON, TOTAL IN THE ENTIRE SENEGAL RIVER VALLEY, 2006/7 TO 2011/12

	Riz d'hivernage			Riz de saison chaude			Total		
	Area (ha)	*Prodt° (MT)*	*Yield (MT/ha)*	*Area (ha)*	*Prodt° (MT)*	*Yield (MT/ha)*	*Area (ha)*	*Prodt° (MT)*	*Yield (MT/ha)*
2006/07	24,052	122,770	**5.1**	3,740	21,832	**5.8**	27,792	144,601	**5.2**
2007/08	25,863	144,211	**5.6**	13,219	100,141	**7.6**	39,082	244,352	**6.3**
2008/09	37,419	223,094	**6.0**	22,764	148,076	**6.5**	60,183	371,170	**6.2**
2009/10	35,435	174,163	**4.9**	17,415	107,570	**6.2**	52,850	281,733	**5.3**
2010/11	34,657	191,069	**5.5**	21,419	145,248	**6.8**	56,075	336,316	**6.0**
2011/12	32,623	168,360	**5.2**	29,237	200,109	**6.8**	61,859	368,469	**6.0**
Average	31,675	170,611	**5.4**	17,966	120,496	**6.6**	49,640	291,107	**5.8**

Source: Ntaal Mbay, SAED and PNAR

To achieve these targets, the GOS initiated the Stratégie Nationale de Développement de la Riziculture (SNDR – National Rice Development Strategy) in 2008. It created the Programme National d'Autosufficanse en Riz (PNAR or National Program for Rice Self-Sufficiency) to translate this strategy into action. This was complemented by emergency campaigns to deal with the crisis, specifically the Grande Offensive pour la Nourriture et l'Abondance (GOANA – Grand Offensive for Nutrition and Abundance) which expected to dramatically accelerate cereal production immediately. The budget for this big push was set at CFAF 355 billion or $600 million, though at the time of the announcement the GOS had funding of only CFAF 32.2 billion.[17] For rice, this included CFAF 13 billion for tractors and 2.4 billion for combines.

[16] Rice crisis, market trends, and food security in West Africa. http://www.oecd.org/swac/publications/47853480.pdf It is produced by consortium of organizations, including CILSS, CIRAD, FAO, FEWSNET, and the WFP (World Food Program). It is funded by the French Ministry of Foreign Affairs.

[17] GOANA was widely criticized at the time, including by the Conseil National de Concertation et de Coopération des Ruraux (CNCR – the National Council for Rural Cooperation and Consultation), the national quasi-official farmers' organization. The various criticisms included fact that the goals were way too ambitious, the cost per ton was way too high, there was no way the GOS would be able to obtain and distribute sufficient agricultural inputs in a timely way, and that this was simply opening the door to vast corruption by organizations without distribution networks. It was also seen as a ploy to give land to the politically favored. The word "gabegie" was widely used, meaning defective and dishonest financial management, or waste.

TABLE 4: GOANA* PROGRAM GOALS IN METRIC TONS

Crop	Goals 2008-2009	Actual 2007-2008	Percent Change
Rice	500,000	195,000	256%
Corn	2,000,000	160,000	12,500%
Millet	1,000,000	320,000	312%
Sorghum	500,000	100,000	500%

*Grande offensive pour la nourriture et l'abondance

Source: GOS

The PNAR had, in principle, authority and resources both to implement its own activities and to guide and coordinate the activities of other public actors working in the sector. Its broad areas of operations included:[18]

1. Development of the rice seed sector.
2. Rehabilitation of irrigation schemes in disuse, building of new schemes, and achieving an average cropping intensity of at least 1.5 rice crops per year in these schemes (i.e., increasing double cultivation). It targeted putting into production around 115,000 ha of irrigated rice.
3. Providing farmers with access to agricultural equipment for irrigation, harvest, and post-harvest activities (specifically irrigation pumps, tractors, and combines) and rice processing plants.
4. Increased diffusion of integrated crop management options to reduce yield gaps in both irrigated and rainfed systems.
5. Better organization of marketing, and the creation of private professional agencies in charge of buying, processing, and selling milled rice.
6. Development of a coherent input subsidy policy.
7. Improved access to agricultural credit.

The specific activities of GOANA and PNAR included massive support for the cereals sector. The GOS targeted rehabilitating 35,000 ha in the SRV alone. It spurred CNCAS to increase credit, which went from CFAF 2.1 to 3.2 billion. Forty percent of this credit went to saison chaud in 2008–2009 compared to zero in 2007–2008. The GOS also increased subsidies on inputs, credit, and other costs to the farmers, and instituted two government buying programs. Subsidies covering the costs of fertilizer and plant treatments alone were valued at CFAF 4.8 billion, and irrigation rehabilitation and investment at CFAF 18.1 billion.[19] Part of this was the strategic rice reserve, the so-called Commissariat for Food Security (CSA – Commissariat à la Sécurité Alimentaire). This was complemented by the requirement that government agencies, especially the military, purchase domestic rice.

D. SRV Rice Production Prior to Scaling of Rice Innovation Package

The result of these policies, at least according to Senegal's official statistics, was a dramatic surge in cereals production nationally in 2008–2009. As can be seen in Table 3 above, paddy rice production in the SRV increased by 257 percent over two years, from 144,601 mt in 2006–2007 to 244,352 mt in 2007–2008 to 371,170 mt in 2008–2009. Among independent experts in research institutions, SAED staff, rice farmers and processors, and implementers of donor-funded projects, not one person interviewed believed that SRV (and national) rice production had increased anywhere to this extent. There was a general judgment that senior policymakers in the GOS pressured the relevant statistical agencies to inflate the numbers to look like the policy targets were being reached. In this view, the fact

[18] Source: http://ricepedia.org/senegal
[19] Source: http://inter-reseaux.org/IMG/pdf_Textegoana-mai08.pdf

that production declined in 2009–2010 to 281,000 tons is a more realistic appraisal of the facts on the ground.

BOX 2: SCALING, NOT SELF-SUFFICIENCY

It is important to note that this report is about the scaling up and sustainability of a package of innovations in the irrigated rice sector. While designed to increase yields, area planted and production, it was only expected to contribute to national self-sufficiency in rice, not achieve it. Scaling occurred in the context of a GOS strategy and programs to achieve self-sufficiency, and benefited from those programs and policy context. However, national rice self-sufficiency is impossible to achieve in Senegal, and in the rice consuming countries of West Africa writ large. Thus the success of scaling needs to be measured on its own terms. National self-sufficiency was and remains impossible because the required growth rate to catch up to demand is impossibly high given the large initial gap and the continued rapid growth of demand. Rice consumption in Senegal and West Africa has been growing at 5 to 6 percent annually, up 700 percent since 1961. Population growth alone has averaged nearly 3 percent annually for decades and has been augmented by increased incomes and urbanization. While potentially the area cultivated in the SRV could double from levels planted in 2006, yields could increase by 50 percent, and yields in rainfed rice could double, this would not be sufficient. Thus, despite the supposed surge in production between 2006 and 2010, rice imports rebounded to over one million metric tons in 2010 and fluctuated between 1.0 and 1.2 million mt for the ensuing years, or 1.5 to 1.8 million mt in paddy equivalent. Domestic paddy production of 250,000 to 429,000 mt remained around 25 to 30 percent of total consumption from 2010 to 2012, far from self-sufficiency. As noted by a joint publication of CIRAD, FAO, WFP and others:

> "Following the measures taken in 2008, the annual rate of increase of West Africa's rice production has risen from 3.8% to 5.4%. However, the increase in consumption remains at 5 to 6% per year, a rate that is too high for local production to make a lasting impact on self-sufficiency in the region. Thanks to support measures and to an increase in local production, imports slowed in 2008 and 2009. In 2010, imports began to increase again as international rice prices fell [and incentives to local rice farmers to produce declined]. The increase in production has not, as of yet, led to a lasting reduction in the region's dependence on international imports."

The good news for scaling up was that, assuming that domestic rice was competitive on price and quality, there was ample market demand for the increased production resulting from scaling up given the huge potential for import substitution. Because of this, there was no concern about flooding the market or lowering the prices.

Source: http://inter-reseaux.org/IMG/pdf_Textegoana-mai08.pdf

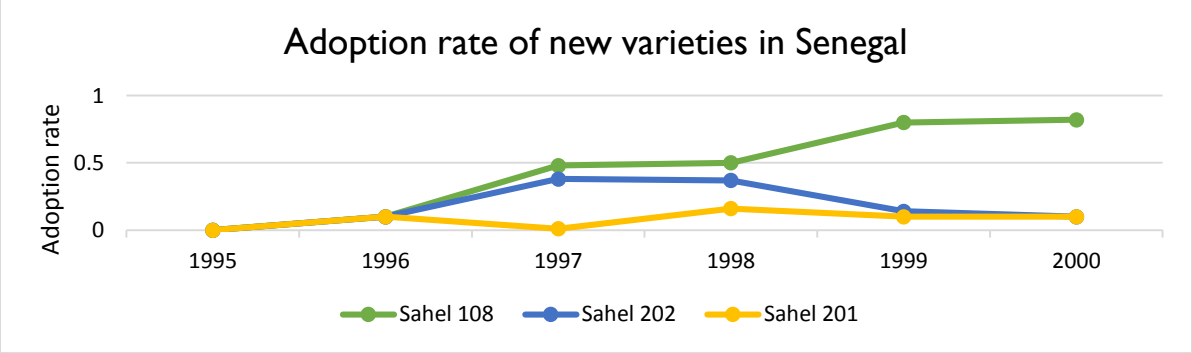
One of the other key takeaways from the effort to increase production was that many SRV rice farmers faced binding constraints on the land they could cultivate during the hivernale season and so increased the area cultivated during the saison chaud as an alternative. This led the total cultivated area, as reported in the official statistics, to increase from 27,792 ha in 2006–2007 to between 50,000 and 60,000 ha in 2008–2010. Of the increase of approximately 30,000 ha over that period, around two-thirds were in saison chaud. The increase in area cultivated during the saison chaud allowed farmers and institutions like SAED to recognize more broadly what had long been true, namely that yields in the saison chaud were much greater than in hivernale, 1.25 to 1.65 mt/ha higher on average. Despite the higher costs of production, especially energy to run irrigation pumps, rice production in saison chaud turned out to be more productive and profitable. By 2009–2010 the share of saison chaud in total production had risen from 15 percent to between 35 and 45 percent, depending on the year. This was the state of play at the beginning of the scaling efforts led by PCE that started in 2010.

III. CHARACTERISTICS OF THE INNOVATION

A critical component to studying scaling up is having a clear understanding of the innovation (or technology) under consideration. This includes examining how the technology is embodied in a product or service, as well as whether it is bundled with complementary products and services that are either necessary for successful implementation or have positive synergies with the innovation. This section discusses the rice innovation package that was scaled up in the Senegal River Valley.

For this particular case study, the identification of the technology package was challenging because what was scaled up was a package of innovations, from Sahel rice varieties to GAPs to value chain innovations. Improved Sahel rice varieties were introduced in the 1990s and were widely adopted quickly in the SRV (Figure 4).

FIGURE 4: ADOPTION RATE OF SAHEL VARIETIES POST 1995



Source: AfricaRice, Improved Varieties for Irrigated Rice Farming in Africa, http://www.africarice.org/warda/irrigated.asp

In other words, extensive scaling of Sahel rice varieties was already achieved well before 2010 on existing areas of rice cultivation. While PCE did introduce, with its partners such as AfricaRice, a number of new varieties, uptake has been at best uneven and the majority of farmers continue to grow the same three to four Sahel varieties introduced in the 1990s. However, the introduction of Sahel rice varieties did not translate into anywhere near the potential increase in yields that these varieties can produce (intensive scaling), nor in an expansion of land under rice cultivation in the SRV. The innovations that were introduced by PCE and its partners to support scaling and to achieve these results were:

1. GAPs, what came to be known as Le Chemin du Bon Riz (CBR – Pathway to Good Rice), with a special focus on the importance of adhering to the crop calendar (i.e. timeliness) and using certified seed.
2. Double cropping during both saison chaud and hivernale.
3. Financial products:
    - Crop insurance to cover the value of bank loans taken for inputs.
    - Commercialization/contractualization, a mix of a warehouse receipts system, negotiated prices, which facilitated cashless exchanges and economized on cash flow.
    - Machinery leasing.
    - Credit to millers and processors to provide cash flow in between purchases of paddy and sales of processed rice.
4. Strengthening of the rice value chain:
    - Quality seed production.

- Quality seed processing and certification facilities.
- Supply, quality and increased use of mechanical services for land preparation and harvesting.
- Rice processing capacity and quality.
- Downstream linkages to formal wholesalers and urban markets.

What is important to note about this list is that it was part of a scaling strategy with two key elements: (1) identifying immediate barriers to or constraints on scaling up, such as lack of 'space' for scaling in the Hartman and Linn framework sense, and (2) simultaneously supporting increased production (supply) and demand for rice. This section discusses the promotion of GAP and double cropping. The other innovations will be discussed in Section VI under scaling strategies.

A. Good Agricultural Practices

As part of its efforts to improve the quality and quantity of irrigated rice produced in the SRV, PCE introduced two sets of GAPs. The first was the Chemin du Bon Riz (CBR – Pathway to Good Rice) and the second was the Controle Qualité Riz (CQR – Rice Quality Control). PCE helped support rice quality control by teaching farmers how to monitor the quality of the rice as it developed. It trained farmers when to harvest for maximum quality and yield, both by visual inspection and by providing farmer organizations with mini-hullers that could be used to achieve maximum yield (minimum of 63 percent polished rice from paddy, 71.7 percent for quality). The CBR contained 12 steps, listed in Table 5 below.

TABLE 5: GOOD AGRICULTURAL PRACTICES INTRODUCED BY PCE

Chemin du Bon Riz	Pathway for Good Rice
Itinéraire technique	Crop calendar
Critères qualité paddy • **Variété** • **Maturité** • **Propreté** • **Humidité**	Paddy quality criteria • Variety • Maturity • Cleanliness • Percent Humidity
Préparation du sol	Soil preparation
Bonne préparation des semences	Good seed preparation
Prépare bien tes semences	Prepare seeds well
Bonne fertilization minerale	Good chemical fertilizer
Bien gérer l'eau	Manage water well
Lutter contre les adventices	Fight against weeds
Récoltez á temps	Harvest at the right time
Coupe et séchage	Cut and dry
Mise en meule et battage	Stack and thresh
Vannage et ensachage	Winnow (remove chaff) and put in sacks

Source: Projet Croissance Economique (PCE)

Based on interviews with PCE staff and farmers, the most important innovations in terms of their impact on productivity were using certified Sahel rice seed and respecting the crop calendar. Planting on time had a significant impact on yields, and the same was true for harvesting at the optimal time for quality

and quantity. As many farmers had effectively been using grain as seed for years, use of certified seed made a significant difference in yield potential. However, as discussed below, at the start of PCE there existed significant constraints to actual implementation of these practices. Planting on time was often affected by delays in approval of farmers' bank credit or the lack of bank credit. Planting and harvesting were both constrained by timely access to machinery services.

Other changes in behavior as CBR was scaled up are illustrated by the testimony of the head of a farmers' association working 300 ha on a PIV:

> *After the PCE training, they started levelling the land, turning over the soil, lowered the amount of seeds from 160 to 80-120 kg/ha, did drainage of the land at the right time, and now harvest at the target maturity.*

An interview with a group of GIEs yielded the following insights:

- They were able to change from a PIV to a GA thanks to SAED's obtaining donor financing and constructing better, state-managed irrigation infrastructure in 2000.
- Up until they became a GA, only a fraction of their members were able to access bank credit. After 2000 they all had access to CNCAS credit.
- They produced only in hivernale until 2012. After that they started producing in saison chaud because the SAED pushed them to adopt double cropping.
- They have difficulties in respecting the crop calendar that they learned from PCE: they get their input coupons late; they often start late because they have rain in the hot season, which interferes with the harvest from the previous season; there have been delays in getting combines onto their land.
- They started the CBR training with PCE in 2013–2014.
- They used the seed varieties 108, 201, and 202 until 2011. After 2011 they began to try other seed varieties, such as 134, 177, 328, 329, and AfricaRice varieties. These were excellent varieties, but they were too tall, and they were easily affected by wind.

Several characteristics of the components facilitated scaling up of the CBR. First, most farmers were familiar with these GAPs, even if the extent to which they actually implemented them varied. The SAED provided most agricultural extension services in the SRV. The GAPs that PCE was promoting were drawn from a manual that SAED and AfricaRice had jointly developed[20] and that SAED had supported and used since the 1990s. (The exception to this was the use of mini-hullers to test rice maturity, which was new.) An additional characteristic which facilitated adoption was that farmers could try the GAPs in small amounts (i.e., on only part of their land).

The major challenges to adoption of the CBR by farmers were complexity, cost, and access to credit. According to group interviews with farmers and PCE staff, it often would take two to three seasons for a farmer to master all of the CBR. PCE, its implementing partners, and partner farm organizations devoted substantial time and human resources to providing extension services and technical assistance.

Perhaps the other major innovation in rice production was the promotion of double cropping. According to various interviews, farmers favored growing only during the rainy (hivernale) season up until the food crisis. This was because it was cheaper, as less irrigation was necessary, and also it was encouraged by SAED. According to CNCAS, another reason was the deterioration of the formal rice processing sector. As the millers started to go out of business, the farmers had to do milling and selling

[20] Manuel Pratique de Riziculture Irrigué dans la Vallée du Fleuve Sénégal

for themselves. This was quite time consuming and prevented farmers from having either the time or the cash flow to grow a second crop.

B. The Business Case

The various interventions detailed above had both costs and benefits to paddy producers. On the cost side, the shift to saison chaud production increased irrigation costs significantly, as more water is pumped than in the hivernage. Similarly, many farmers increased fertilizer and pesticide usage to the recommended levels as bank financing became more widely available. Higher production also implied higher harvesting, sacking, and transport costs; for example, mechanical harvesters charge 20 percent of the crop. On the benefits side, quality improvements resulted in higher prices negotiated with millers; prices have steadily increased from around CFAF 100 per kg to 120, 125, and now 130 since 2010.

There are multiple sources for crop budgets for irrigated rice in the SRV. The ones examined in this report are from SAED, Centres de Gestion et d'Economie Rurale (CGER), and a recent study for USAID by the International Development Group (IDG). A comparison between the three sources showed that their results were within 10 percent of each other, with the exception of the IDG analysis which did not take into account the cost of bank charges, interest, and insurance. This report uses the IDG figures, presented in Table 6A below, as the basis for the business case analysis.

TABLE 6A: CROP BUDGET FOR IRRIGATED RICE IN THE SRV – IDG CFAF PER HECTARE

Costs	IDG report	IDG plus bank and insurance charges
Cost of Inputs		
Certified seeds	CFAF 36,000	CFAF 36,000
Herbicide	CFAF 30,000	CFAF 30,000
Fertilizer	CFAF 66,280	CFAF 66,280
Fuel	CFAF 94,860	CFAF 94,860
Sacks	CFAF 21,000	CFAF 21,000
Rental cost of land	CFAF 10,000	CFAF 10,000
Total	**CFAF 258,140**	**CFAF 258,140**
Cost of Labor		
Land prep and offset	CFAF 25,000	CFAF 25,000
Family labor	CFAF 15,000	CFAF 15,000
Harvesting 20%	CFAF 153,600	CFAF 153,600
Total	**CFAF 193,600**	**CFAF 193,600**
Other Costs		
Total	**CFAF 115,700**	**CFAF 143,547**
Grand Totals	**CFAF 567,440**	**CFAF 595,287**
in US$	**$ 961.76**	**$ 1,008.96**

Source: International Development Group, "Cost Benefit Analysis of USAID/Senegal's Rice Value Chains: Draft Report" December 11, 2015

TABLE 6B: CROP BUDGET FOR IRRIGATED RICE IN THE SRV – PAPRIZ (RESULTS OF CROP BUDGET ANALYSIS FOR DRY SEASON RICE FOR 25 FARMERS FROM 5 GIEs IN THE PILOT AREAS OF PODOR)

Costs and Benefits	2009	2013
Grain yield (kg/ha)	4,740	5,820
Farm gate price of grain (CFAF/kg)	125	125
Gross benefit	*593,000*	*727,000*
Total production cost (CFAF/ha)	**433,000**	**441,000**
○ **Land preparation**	23,000	25,000
○ **Farm input (seed, fertilizer, agro-chemicals)**	116,000	87,000
○ **Irrigation**	130,000	159,000
○ **Labor (transplant and harvest)**	52,000	57,000
○ **Threshing (both manual and machine)**	59,000	66,000
○ **Other costs (materials and transport)**	54,000	48,000
Net benefit	**160,000**	**286,000**
Unit production cost (CFAF/kg)	93	76
Unit net benefit (CFAF/kg)	32	49

Source: PAPRIZ (Baseline survey in July 2010; interview survey in October – December, 2013)

TABLE 6C: CROP BUDGET FOR IRRIGATED RICE IN THE SRV – PCE PARTNER AVERAGE (20 GROUPS)

Category	Average	St Dev	Min	Max
Land preparation	26,000	1,225	25,000	27,500
Seeds	39,225	3,919	36,000	48,000
DAP fertilizer	18,975	6,161	8,600	40,000
Urea fertilizer (top dressing)	51,745	7,172	33,210	68,950
Herbicde 1	7,550	2,819	0	15,000
Herbicide 2	25,315	5,384	8,000	32,000
Irrigation fuel costs	78,658	15,230	42,800	103,500
Harvest	60,000		60,000	60,000
Threshing	82,258	13,408	48,840	104,250
Bagging	32,119	5,987	17,806	41,700
Post-harvest transportation	25,138	3,618	15,263	31,275
Labor	34,750	1,090	30,000	35,000
TOTAL PRODUCTION COSTS per ha	481,733	25,004	430,509	534,950
Surface Area	617	610	25	2,172
Number of producers	612	702	14	2,638
Average Hectares Per Producer	31		0.24	66
Average yield (mt/ha)	6.66	1.03	4	8
Average paddy price received	123		120	125
Gross margin per hectare (US$)	$ 682	$ 229	$ 116	$ 1,088
Gross Margin per Hectare (CFAF)	CFAF 340,845.51	CFAF 114,482.15	57,891	544,075
Production Cost per KG	CFAF 73.81	CFAF 10.44	60	106
Paddy Quantity used to repay Bank Credit	1,390	1,532	42	5,610
Share of Production Sold	55%	21%	15%	85%

Source: PCE

Total costs per hectare are around CFAF 550,000 to 600,000 (approximately $1000); however, this depends on yields, since some costs are variable, such as sacking, land rental (which is a cost for many farmers), and family labor. This is consistent with the anecdotal information provided in farmer group interviews where participants cited between CFAF 525,000 and 550,000.[21] For example, the farmers in one union hydraulique stated that:

> *… they borrow around CFAF 270,000 per farmer, that doesn't include harvest, transport, reaping or irrigation. These cost at least CFAF 125,000 additional plus irrigation costs. They harvest around 125-130 sacks per hectare. They pay 20% of their harvest to the combine owner and have to reimburse 25-30 sacks to the bank, that leaves around 50-55 sacks for you. If they have surplus rice, they sell mostly to the* banabana *[local trader].*[22]

Paddy prices historically were around CFAF 100 but over the last several years have ranged from CFAF 120 to 130 per kilogram[23] with improvements in quality.[24] Average production levels went from 5.4 mt/ha in 2000–2006 to 5.75 in 2007–2010 to over 6 mt/ha since PCE started working. At paddy prices of CFAF 100/kg, breakeven production levels using modern technology would be between 5.05 and 5.33 mt/ha depending on whether or not land rental and family labor costs are included, and around 2.7 mt/ha if less capital-intensive technology was used. Using the lower figure of 5.05 and assuming the production yields of individual farmers are normally distributed, at a mean of 5.4 mt/ha, about two-thirds of farmers in any given year were making money. This means that one-third of farmers would be unable to repay their bank loans if they borrowed from the bank, and explains why there were persistent problems of bank arrears for rice farmers through the 2000s.

As average yields rose to 5.75 mt/ha, not only did farming become more profitable, but the probability of negative returns fell to 25 percent and at 6.0 mt/ha to only 13 percent. At current prices, breakeven production levels fall to between 4.4 and 4.75 mt/ha, and profitability for farmers now exceeds 20–30 percent on yields above 6 mt/ha. At the same time, risks have decreased. At an average yield of 6 mt/ha, less than 6 percent of farmers are likely to be unprofitable. However it is important to note that this 6 mt/ha average combines very high yields of 6–8 mt/ha during the saison chaude with continuing low yields in the hivernage of around 5–5.5 mt/ha, depending on adverse weather, disease, and pests. At these lower yields, 15–20 percent or more of farmers may be unable to repay their loans, levels which are consistent with farmer interviews, where many farmers complained of being unable to repay because of recent adverse events in the hivernage season. As a result, many farmers are increasingly not planting during the hivernage.

[21] The likely difference is that many farmers do not take into account, or defer, the costs of family labor, the rental costs of equipment and sprayers, and irrigation maintenance. Taken together these four items account for about CFAF 62,700.
[22] Group interview with members of a union hydraulique, Rossbechol, January 2016
[23] As discussed below, paddy prices are set through negotiations between the relevant social partners: farmers, processors, and other interested parties, with the Ministry of Agriculture.
[24] According to the IDG report, the increase from CFAF 100/kg was due to an increase in milled rice yields from 57 percent to 63 percent of paddy.

TABLE 7: BREAKEVEN YIELDS, PROFITS, RATES OF RETURN

Breakeven Yields/Paddy Prices		CFAF 100	CFAF 120	CFAF 125	CFAF 130
IDC report		5.67	4.73	4.54	4.36
IDC report plus bank charges		5.95	4.96	4.76	4.58
IDC report less rental/family		5.05	4.21	4.04	3.88
IDC report plus bank less rental/family labor		5.33	4.44	4.26	4.10
Profits at Varying Yields and Prices (US$) (on production cost of $1,009)		**CFAF 100/kg**	**CFAF 120/kg**	**CFAF 125/kg**	**CFAF 130/kg**
5 mt/ha		$ (161.50)	$7.99	$50.36	$92.73
5.5 mt/ha		$ (76.76)	$ 109.68	$156.29	$ 202.90
6 mt/ha		$7.99	$ 211.38	$262.23	$ 313.07
6.5 mt/ha		$92.73	$ 313.07	$368.16	$ 423.24
7 mt/ha		$ 177.48	$ 414.77	$474.09	$ 533.41
7.5 mt/ha		$ 262.23	$ 516.46	$580.02	$ 643.58
8.0 mt/ha		$ 346.97	$ 618.16	$685.95	$ 753.75
Rate of Return at Varying Yields and Prices (US$) (production cost of $1,009)		**CFAF 100/kg**	**CFAF 120/kg**	**CFAF 125/kg**	**CFAF 130/kg**
5 mt/ha		-16%	1%	5%	9%
5.5 mt/ha		-8%	11%	15%	20%
6 mt/ha		1%	21%	26%	31%
6.5 mt/ha		9%	31%	36%	42%
7 mt/ha		18%	41%	47%	53%
7.5 mt/ha		26%	51%	57%	64%
8.0 mt/ha		34%	61%	68%	75%
	Paddy Rice Prices	**CFAF 100**	**CFAF 120**	**CFAF 125**	**CFAF 130**
Share of farmers losing money given average yields	***Breakeven production levels***	***5.33***	***4.44***	***4.26***	***4.10***
	Average yield 5.00	63%	29%	23%	19%
	Average yield 5.50	43%	15%	11%	9%
	Average yield 6.00	25%	6%	4%	3%
	Average yield 6.50	12%	2%	1%	>1%

Source: Author's calculations, SAED crop data, and IDG crop budgets

The business case is equally important for the rest of the value chain, certified seed producers, millers, and financial intermediaries. The two relevant financial intermediaries, CNCAS and CNAAS, are both majority state-owned and their agricultural loans and insurance are subsidized by the GOS. Interviews with management from both organizations indicates that they evaluate potential loans/customers and set prices to be profitable. However, the large number of non-performing loans, need for regular debt forgiveness and capital infusions suggests that de facto at least CNCAS is loss making. Yet GOS interviewees said that these capital infusions, and subsidies for that matter, are fiscally sustainable (though there are no plans in the future for additional debt forgiveness).

Certified seed production is profitable and was profitable prior to scaling up. The IDG report found that producers of certified seed were already profitable prior to the PCE intervention, and thanks to improved yields, this increase further:

> *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 532.8 thousand CFA/ha (US$ 926.6/ha) to 718.5 thousand CFA/ha (US$1,249.6/ha).[25]

The one area where profitability is uncertain is in rice milling. As noted above, millers suffered severely after privatization, with their capacity, quality, and profitability all declining. PCE, JICA, and the Spanish Agency for International Development Cooperation (AECID) all provided assistance to millers. This included: equipment and training to improve quality (cleaning, sorting); warehouse construction to lower transactions costs; and cash flow financing for the period between collection from farmers and sales to wholesalers (contractualization, which allowed for a cashless system with farmers roughly based on warehouse receipts). The eight largest mills have a total capacity of 40.5 metric tons per hour. If the mills operated 24 hours, 365 days per year, their capacity would be 355,000 mt per year, compared with the total SRV paddy production in 2015 of around 440,000 mt. Assuming a more realistic capacity utilization of 66 percent, this implies that mills can currently handle about 50 percent of current production. However, the majority of farmers/production—around 77 percent—still goes through the local processors, the décortiqueses, so that the large mills appear to be operating at around 50 percent of capacity. Because of this, many millers complain about shortages of supply and low capacity utilization rates, though others state that they are well-supplied. According to a study done by CGER and commissioned by PCE, capacity and quality of large and medium-sized rice millers will have increased to the point where there will be sufficient capacity to handle all the rice being produced in the SRV by 2017.

TABLE 8: LARGE RICE MILL CAPACITY IN THE SENEGAL RIVER VALLEY

Mills	Production Capacity (in MT/Hour)	Total Capacity at 66% Capacity Utilization
Vital Agro-Industries	10	57,816
Coumba Nor Thiam Suarl	6	34,690
GIE Naxadi Deret	5	28,908
Mbodji et Frères	5	28,908
Teranga Sarl	5	28,908
GIE Malal Yoro Guèye	5	28,908
Groupe Thiaytou	3	17,345
Pellital	1.5	13,140
Total	**40.5**	**238,622**

Source: Project Croissance Economique, author's calculations

Because of the wide variance in capacity and utilization rates, and the fact that income statements are proprietary, it was not possible to provide a quantitative analysis of miller profitability. In the five interviews with millers, three complained of supply shortages and also constraints on their margins. Specifically, they mentioned that during negotiations around paddy prices they face pressure from the Ministry of Agriculture to pay higher prices to farmers, while at the same time they are squeezed on the other side by wholesalers, who in turn face price pressures from the Ministry of Commerce to keep retail prices low. At the same time, because of recent requirements that importers must make domestic purchases in proportion to their imports, many millers complain that they cannot get enough paddy rice to meet demand.

[25] IDG report, op. cit., p. 18

Photo: Richard Kohl

Unfortnatly, financial information for machinery service providers was not accessible. In one interview, a service provider who had purchased both a tractor and combine with credit from Locafrique in 2014 explained that he was able to repay 50 percent of the loan within six months. Because of the high profitability, he purchased another three tractors and three combines with Locafrique credit in June/July 2015. He has net annual earnings for a tractor of CFAF 28 million ($56,000) versus a purchase price of CFAF 37.5 million, not including interest expenses ($75,000). The comparable figures from this provider were gross sales for a harvester of CFAF 28 million ($56,000) and net profits of CFAF 19.75 million ($39,500), versus a purchase price of CFAF 18 million ($136,000). Given that both combines and tractors nearly pay for themselves in a year, they appear to be highly profitable. This service provider noted that tractors are not only used for rice but also for land preparation for higher value added crops such as onions and tomatoes.

IV. ADOPTION DRIVERS AND RESULTS OVER TIME AND SPACE

A. Market Potential

In many cases of scaling up, the potential for demand to absorb increased supply without adverse price effects is a major challenge. This is not the case in Senegal. As noted in Section II, Senegal has been a major rice importer for decades, and despite government efforts at self-sufficiency since the 2007–2009 food crisis, rice imports have continued to increase (see Figure 2). As rice imports have exceeded one million tons since 2012, more than double the current production levels in the SRV, from a purely quantitative perspective, there is no shortage of demand.

BOX 3: RICE IMPORTS AND PRICING IN SENEGAL

Before liberalization under structural adjustment, rice imports were a monopoly under the Caisse de Péréquation et du Stabilization des Prix (the Office or Fund for Price Equalization and Stabilization), which set prices for both local and imported rice. While the import monopoly was eliminated in 1995, it was replaced with price controls which persisted until 2006. A short period of liberalization was followed by a return to price controls on imported ordinary broken rice in 2008, which were then extended to aromatic rice in 2011 and finally the reintroduction of officially fixed prices in 2013. Prices for non-aromatic broken imported rice were set at CFAF 240/kg for importers, CFAF 245/kg for wholesalers, and CFAF 260/kg for retailers. This price freeze led to annual budget allocations of CFAF 25 billion for rice price supports, or roughly $50 million. It also incentivized importers to search out lower and lower price (quality) rice in an attempt to sustain and increase margins, following on the switch from aromatic to ordinary rice.

Over this same period, post food crisis, prices for paddy were set through price negotiations between millers and producers, with other social partners also participating. Under the guidance of the Comité Interprofessionnel du Riz (CIRIZ – Interprofessional Committee on Rice), prices were set at 125 CFAF/kg in 2013–2014 and 120 CFAF/kg in 2014–2015 in line with declining import prices. The GOS must respond to conflicting pressures to keep prices down for consumers and to increase prices for producers.

A 2015 study by Dr. Ibrahima Hathie and Oumar Samba Ndiaye, on behalf of the European Commission, found that, despite price controls, there is significant but imperfect transmission of international into domestic prices. Transmission occurs because imports set the price at the margin. At the same time, domestic rice markets are relatively segmented between urban and rural, household and commercial, and even the prices for rice used at different meals. This is illustrated by the very different downstream market paths of rice that is milled by décortiqueses versus industrial mills. Surplus rice processed by décortiqueses is largely sold through informal channels by small traders, as opposed to formal market channels for industrially processed rice.

This raises the question of whether SRV irrigated rice is competitive at world prices. This question is reinforced by significant government interventions at all stages of the rice value chain and imports. Currently the domestic rice sector benefits from a large number of significant government subsidies, including on inputs, bank credit, crop insurance, and purchases of agricultural machinery, as well as requirements on importers that they buy domestic rice. Studies of competitiveness are complicated by the questions of quality and what is the comparable international product.[26] Choosing the comparable import is also complicated by the setting of imported and domestic prices (see Box 3).

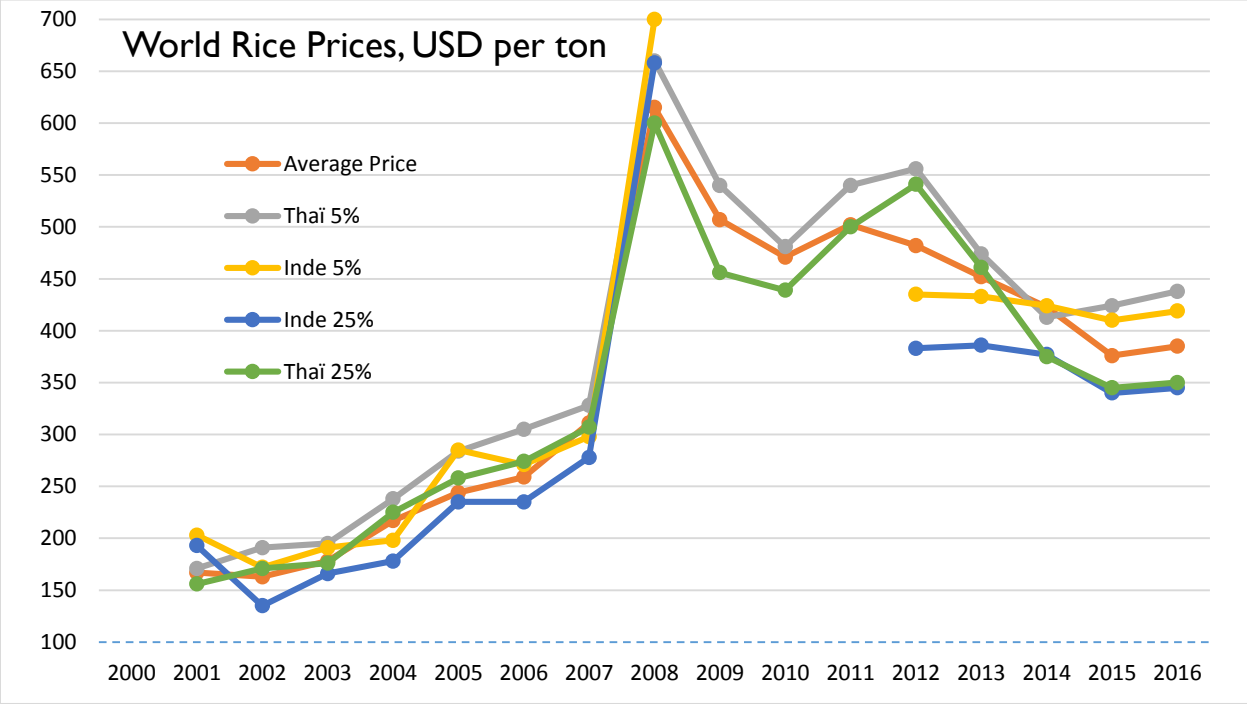
Despite the challenges of quality, there have been a number of studies over the last several years with general conclusions that SRV rice has been competitive since world prices rose during the food crisis and then remained at historically high levels. Interviews with CNCAS, the national agricultural bank, state that domestic rice was not competitive during the period between the mid-1990s and 2007. In one study, GIG Consultants (a Paris-based firm),[27] concluded that efforts to improve domestic quality were proving successful and that domestic rice would progressively conquer the national market ("conquérir

[26] Prior to the food crisis, most imported rice was aromatic, but with the price jump, consumers—and therefore importers—switched to ordinary rice. Senegalese consumers have preferred broken rice, initially because it was cheaper, but now the mouthfeel and texture have become preferences for rural consumers. In the last few years there has been a growing demand by higher-income urban consumers for whole rice and aromatic rice, and many urban consumers prefer whole rice. In general, domestic rice has to compete with imported broken rice. However, internationally marketed broken rice is of a certain quality in terms of uniformity of color, shape, size of the grain, and especially the presence of foreign materials such as dirt, stones, and rice straw. PCE and other donors have therefore undertaken efforts to improve quality as part of scaling up. According to Hathie and Ndaiye, 95 percent of imported rice is broken rice. See Dr. Ibrahima Hathie and Oumar Samba Ndiaye, "Etat des lieux des impacts des importations de riz sur la commercialization du riz local", RAPPORT FINAL, Iniative Prospective Agricole et Rurale (IPAR), Janvier 2015. p. 14.

[27] Pierre Baris et Niclas Gergely, "Actualisation de l'etude sur al competitivité du riz de la vallée du fleuve Senegal (VSF) sure les marches regional et national", GIG Consultants, November 2012

progressivement le marché national"). The GIG study found that production costs were around CFAF 100/mt with gross margins between 26 and 32 percent. They found that rice remained profitable even without input subsidies, but gross margins fell to 15 percent (as inputs account for only 18 percent of costs, slightly less than the share of either labor or irrigation costs). They concluded that domestic rice has been profitable because international rice prices remained at historically high levels, even after they came down from their 2008–2009 peak, as shown in Figure 5.[28] However, they argued that there was a narrow band of rice prices that made it sufficiently profitable to incentivize sustained and increased production, and to ensure this, there needed to be continued government subsidies, in the form of either tariffs or input subsidies.

FIGURE 5: WORLD RICE PRICES, US$ PER METRIC TON



Source: OSIRIZ, http://www.infoarroz.org/portal/uploadfiles/20160804093456_14_world_prices.htm. Gaps in prices reflect that some countries banned exports in the immediate aftermath of the world food crisis, i.e., from 2008 to 2011.

These general conclusions were confirmed by other studies. A 2015 study by Dr. Ibrahima Hathie and and Oumar Samba Ndiaye, on behalf of the European Commission,[29] also found that production was quite profitable, but very price sensitive, and the same was true for other members of the value chain.

> *La marge des producteurs est intéressante mais elle est très sensible au prix pratiqué. Se le prix paddy pratiqué s'écarte beaucoup du prix official, la rentabilité du producteur s'en resent fortement. Cette situation est rendue plus fragile par les volumes relativement faibles sur lesquels opèrent la majorité de ces producteurs ….*

[28] The French agency, Observatoire de Statistiques Internationales sur le Riz (OSIRIZ) publishes an index of rice prices. The rice price index was around 100 in 2003, and then jumped from 144 in 2007 to 294 in 2008. Since 2009 the OSIRIZ index has hovered in a range between 210 and 255.

[29] Dr. Ibrahima Hathie and Oumar Samba Ndiaye, "Etat des lieux des impacts des importations de riz sur la commercialization du riz local", RAPPORT FINAL, Iniative Prospective Agricole et Rurale (IPAR), Janvier 2015.

La marges des autres acteurs ne sont pas non plus assez elevées. Ce qui explique sans doute les fortes pressions que ces acteurs de l'aval exercent sur les producteurs afin de revoir à la baisse le prix official du paddy. (Hathie and Ndiaye, p. 7)

Translation: Producer margins are attractive but very sensitive to actual paddy prices. If the actual paddy price deviates much from the official prices, the profitability for producers would be seriously affected. This situation is even more the case for the majority of producers, i.e., those who cultivate relatively small parcels.

The margins for other value chain actors are also not much higher. This explains the strong pressures that downstream actors have put on producers to lower official prices.

Later, in discussing the relationship between imported and domestic prices, Hathie and Ndiaye reinforce the negative impact on rice value chain actors of the price squeeze. They note that the massive importation of low-quality Indian broken ordinary rice has strongly affected the margins for millers and distributors, menacing their profitability.[30] The finding that downstream actors face serious pressures on margins was confirmed in the review team's interviews and by other sources as well.[31]

V. THE EXTERNAL CONTEXT OR SPACES

Context is usually very important to the success and strategy in scaling up. That was equally true in the Sahel rice case. This section looks at spaces of the rice value chain, including credit and insurance, mechanization, politics and policy, and institutions and partnerships.

A. Rice Value Chain

Most of the necessary institutions for a viable commercial rice value chain in the SRV already existed before 2010, but many were weak or barely functioning. There was an inadequate supply of certified rice seed, quality rice milling capacity was very limited, and downstream linkages to formal markets were almost nonexistent. Each of these issues is discussed in more detail below.

Certified Rice Seed Production

As noted above, as of 2010 most rice farmers in the SRV were already using improved seeds that had been introduced in the 1990s. A few varieties accounted for nearly all rice planted: Sahel 108 (a short maturity variety of 105–115 days) and Sahel 201 and 202 (medium maturity varieties of around 120–140 days) with potential yields of 10 and 11 mt/ha. By 2000 these three varieties accounted for over 70 percent of rice planted in the SRV.[32]

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[30] Hathie and Ndiaye, op. cit., "Les importations massive"

[31] See, for example, CGERV (Management Center of Rural Economy of the Valley) in its publication Bulletin Economic Analysis for the Rice Sector. The June 2015 issue, ***Rice Self-Sufficiency in Senegal***, stated "However, in the absence of some opportunities for white rice paddy or milled, distributors, processors and commercants are struggling to make their activities profitable." P.14

[32] In 2005, the GOS approved and officially released five additional varieties for use by rice farmers in the Senegal River Valley. These were: Sahel 134, Sahel 159, Sahel 208, Sahel 209, and Sahel 210, with the 100 series being short maturity and the 200 series medium/long maturity. These new varieties were supposedly superior, e.g., the new 200 series varieties had 12 mt/ha potential yields, but uptake was limited, and the majority of seed planted remained 108, 201, and 202. According to interviews with most farmers, they stuck with the old varieties for several reasons: they were not getting anywhere close to potential yield on the old varieties; those varieties did well under local conditions, especially in the longer rainy season (hivernale); they

The structure of certified seed production dates back to the late 1980s. The Institut Sénégalais de Recherches Agricoles (ISRA – Senegalese Institute for Agricultural Research) controls rice foundation seed and production of breeder seed. Multiplication is done by an association of seed farmers, the Union Nationale Interprofessionnelle des Semences (UNIS – National Interprofessional Union of Seeds). However, as adoption of new rice seed varieties scaled up over the second half of the 1990s, production of certified rice seed did not keep pace. Most rice planted in the SRV is broadcast after soaking. Recommended seed usage is 130 kg/ha, so surface areas of roughly 25,000 ha during the 2000–2007 period would have required approximately 3,500 mt of seed per year. By contrast, only 400 mt of certified rice seed was produced as recently as 2011.Thus by the time PCE started in 2010, the majority of farmers were not only planting saved seeds, but seeds that had become essentially grain.

The seed sector suffered from numerous challenges detailed in a study conducted by PCE at the beginning of its activities.[33] These challenges included:

- Disorganization of upstream production of foundation seed.
- Difficulties in planning for demand with little effective collaboration or communication between ISRA, the foundation seed producer, and UNIS-Nord, the union of seed multipliers.
- Difficulties in controlling the costs of collection, processing, and transaction, making the seeds' sale price unaffordable for many producers.
- No effectively functioning seed testing and certification laboratories in the SRV.
- Inadequate and poorly functioning seed conditioning centers.

As part of its scaling efforts, PCE began by creating "space" for certified rice seed by both increasing supply and increasing demand for certified seed. PCE supported:

- Upgrading of two ISRA research stations (e.g., cold storage, electricity, facilities, and cost accounting system).
- Construction/rehabilitation and modernization of the equipment at a regional seed lab in the city of Richard Toll, boosting seed processing capacity to 6,000 mt.
- Financial coaching and governance support to UNIS.
- Better linkages between ISRA and UNIS-NORD (i.e., three-year procurement plans and placement of foundation seed orders with ISRA).
- Capacity building of UNIS-NORD.
- Establishment of a network of seed inspectors to supplement existing government inspectors.
- Public-private partnership between Coopérative Semencière du Nord (COOSEN), a seed cooperative organized by PCE, and the MOA to manage a seed conditioning center at Richard Toll.
- Introduction of additional new varieties combined with demonstration and marketing efforts.
- Requirement for use of certified seed for farmers involved with contractualization.

The results of these efforts have been a steady increase in the supply, availability, and adoption of certified rice seed and a better ability to match the three-year multiplication cycle with demand. Roughly 2.2 mt of rice seed were produced by UNIS in the 2014 rainy (hivernale) season. As of 2010, and through the period under study, the majority of certified seed used continued to be the three dominant

themselves and consumers like the taste and mouthfeel; and they already owned them as these are all OPVs. See AfricaRice's note on Irrigated Rice Varieties: http://www.africarice.org/warda/irrigated.asp.

[33] Economic Growth Project, STRATEGIC OPTIONS FOR THE SEEDS VALUE CHAIN IN SENEGAL, Sept. 2011

varieties first introduced in 1995 -- Sahel 108, 201 and 202.[34] It is estimated that certified seed now accounts for about 30 percent of total production in the SRV; this was achieved despite the more than100 percent increase in the surface area planted since 2006. Seed certification and processing capacity has now increased so that it can meet nearly 70 percent of potential demand, though production is nowhere close to that yet. There are some estimates that using certified Sahel seed may increase rice yields by as much as 25–30 percent, which may have contributed significantly to intensive scaling efforts and results.

TABLE 9: VOLUME OF CERTIFIED RICE PROCESSED AT RICHARD TOLL SEED CENTER

Variety	Period of Initial Introduction	Level of Multiplication	Weight (mt)	Share of Certified R1/R2 seed
Sahel 108	1995-2000	R1	1,890	75.1%
Sahel 108	1995-2000	R2	139	5.5%
Sahel 134	2005-2015	R1	290	11.5%
Sahel 201	1995-2000	R1	131	5.2%
Sahel 202	1995-2000	R1	17	0.7%
Sahel 208	2005-2015	R1	2	0.1%
Sahel 209	2005-2015	R1	34	1.4%
Sahel 210	2005-2015	R2	13	0.5%
TOTAL			2,516	100.0%
Demand (@130kg/ha		60,000	8,340	
Percent coverage			30.2%	

Source: Richard Toll Seed center

Other Input Distribution

In terms of the space for other inputs, the supply chain has been less problematic than the supply of certified seeds. There is a fairly dense network of agricultural input suppliers in SRV, though this becomes progressively thinner as one moves upstream from Dagana to Podor and Matam. Farmers with access to bank credit receive something resembling a voucher for the agreed upon inputs from the CNCAS and are able to retrieve the needed inputs from designated depots. The major issue with access to inputs has been the timeliness of availability. As much of the supply of fertilizer in particular is controlled by state entities, as it is subsidized, that supply is not always available in time for optimal planting or secondary top dressings. This also can be caused by delays in approval of bank credit, as farmers are required to submit their applications twice per year if they farm both seasons, but historically the bank has waited until the previous season's loan has been repaid.

Processing

Rice milling was one of the major constraints on scaling up as of 2010. The steady deterioration of the ability of large mills to process sufficient quantities and quality of paddy rice after 1995 meant that SRV rice could not compete in quality with imported rice in urban markets. Thus, despite the huge potential for import substitution and selling in formal urban markets, de facto the market for surplus rice was

[34] Sometimes there is a mismatch between the varieties produced and farmers' preferences as the Senegalese authorities have encouraged the production of seed for the new varieties introduced since 2005 to facilitate their adoption, yet the majority of farmers still prefer the old Sahel varieties.

limited to either local village markets, or to those traders who would buy locally and sell in nearby regions.

In response to these issues, PCE, JICA, and AECID worked together to rehabilitate the processing sector. JICA provided new milling equipment and training that expanded the quantity and quality of rice produced, allowing the large mills to do better cleaning and sorting. PCE subsidized loans to buy new machinery or expand capacity, covering 35 percent of the capital cost, and partnered with CNCAS to provide working capital to millers.

As a result of these efforts, large milling capacity increased to 155,000 mt at the end of the 2013–2014 season as compared with production of around 332,731 mt. Thus large mills could cover around half of the processing, although in reality they are covering somewhere between one-eighth and one-quarter as farmers continue to prefer working with the small décortiqueses. Faced with excess capacity, most larger mills both started to grow their own rice and also directly contracted with farmers, in some cases supplying inputs in advance. For example, one mill in Caoumba produces 1,000 ha of its own rice and finances a network of 13,000 farmers producing on 7,000 ha. Nonetheless, it appears that many farmers still find it more profitable or preferable to use local décortiqueses, possibly because transport and storage costs are lower or because they can process rice in small batches as they need income over the course of the year.

Marketing and Downstream Linkages

Marketing SRV rice to domestic markets in Senegal was and remains complicated by the fact that the market is highly segmented. Tastes and preferences differ between urban and rural consumers and even by meal. Historically, urban consumers, especially those with higher incomes, have favored whole, aromatic rice that has been well cleaned and sorted. Rural consumers are more price-sensitive, so that the choice of cheaper broken rice evolved into a taste preference over time. Similarly, rural consumers tend to be less sensitive to uniformity of color, shape, or the presence of foreign materials, and are willing to sort and clean rice themselves.

The disintegration of the rice value chain since the 1990s meant that rice processors in the SRV had little contact with formal market outlets in urban areas. Urban consumers were completely unaware that domestically produced rice was available, let alone the quality improvements which had taken place after 2010 in processing as well as the introduction of aromatic rice. As of 2010, the vast majority of surplus SRV rice was sold by small traders to surrounding areas, mostly rural consumers. However, there were limits as to how much rice these channels could absorb, as well as the price that they were willing to pay.

Once the quality of SRV rice had been improved to meet urban market standards, PCE helped with the downstream market linkages from millers to wholesalers. PCE helped millet producers improve their branding and packaging, organized several meetings between millers and wholesalers, and brought SRV rice to several agriculture fairs (e.g., the annual International Fair of Agriculture and Animal Resources). PCE sponsors the participation of both millers and producers in this fair. PCE created a promotional caravan of Senegal origin rice that took place in three major cities, including Dakar. Finally, PCE helped SRV mills in successfully bidding on World Food Program tenders for rice; the Coumba Nor Thiam mill won a tender for 3,000 mt of white rice.

Demand for domestic rice has also been supported by a number of government policies. The GOS began purchasing domestic rice for a strategic reserve and required that government agencies (e.g., the military and schools) purchase domestic rice. Perhaps most importantly, as importers began shifting to cheaper imported Indian rice, the GOS required that importers purchase domestic rice in proportion to

the level of their imports. This latter move has greatly increased the demand for SRV rice, so that many of the large mills and importers cannot get sufficient rice to meet demand.

B. Credit and Insurance

Intensive production of irrigated rice requires substantial financial resources to purchase the necessary inputs; for land preparation, harvesting, and threshing services; and to finance supplementary labor. As discussed in Section III-B, farmers spend CFAF 550,000+ per hectare to grow rice.

Despite the disengagement of the state from providing direct services, up until recently the state remained the sole source of bank lending through the CNCAS. While not a state agency, the CNCAS is majority-owned by the GOS, and many of the remaining shares have been distributed to social partners such as farmers' associations. Since the 1990s, CNCAS has been providing credit to less than half of rice farmers in the SRV. In large part this is because many small and medium producers regularly become (re)indebted when there is a bad harvest. This has meant that CNCAS regularly carried a large amount of non-performing agricultural loans, or loans in arrears. As CNCAS is not permitted to extend further credit to farmers in arrears, these farmers have had no access to credit and accordingly used lower quantities of seed and other inputs, and less mechanization. In most cases they obtained lower yields.

Repeated rounds of debt forgiveness between 1995 and 2010 only proved to be temporary solutions to this problem, as the problem reemerged with the next poor harvest, and there was no crop insurance available during this period. Similarly, the fact that agricultural interest rates are subsidized by the GOS has not solved the availability and creditworthiness problems. Moreover, even for farmers able to access bank loans, the lending amount was limited to the value of tangible inputs and some key services, somewhere between CFAF 250,000 and 350,000. In cases where an adverse weather or pest event

required farmers to reapply seeds, fertilizer, or herbicides, this additional cost was not covered by bank loans. This meant that farmers had to find the remaining funds themselves.

Similar problems plagued processers (e.g., rice mills) and entrepreneurs interested in purchasing agricultural machinery (usually farmers themselves or their associations). Processors suffered from acute shortages of working capital to purchase and store paddy rice until it could be processed and sold to wholesalers, and payment from wholesalers was received. Bank financing for this was not available, nor was financing available for capital investment in equipment and expanding facilities. Mills had difficulty in paying farmers for their production in a timely way, so farmers faced delays in paying off their bank loans, delaying receipt of a loan for the next season, delaying land preparation and timely planting. This delay was particularly problematic for farmers interested in adopting double cropping (i.e., planting in both the saison chaud and the hivernale). Financing for purchases of agricultural machinery was very limited as it required collateral apart from the machine itself, due to the lack of a secondary market.

Addressing this constraint, the lack of financial "space," has probably been the most important of all the contributions PCE made to revive the irrigated rice sector. PCE, working with several partners, introduced several financial innovations that increased the availability of financing not only to farmers, but to mills and machinery service providers. PCE did this through a variety of instruments, providing cost sharing or co-financing of investment, to cover the costs. Several common themes emerged in terms of what worked, including: reducing risk to economic actors on both ends of financial transactions; making iterative progress, as solutions required repeated tweaking; and not covering the losses from partners' poor business decisions (while PCE was willing to absorb some of the risk, they maintained a firm position on this).

The most important financial innovation introduced by PCE was known by the French term 'contractualization', a mix of contract farming and a warehouse receipts system. This was introduced beginning with the 2011–2012 season.

> *In 2011, a pilot was launched in collaboration with Vital agro-industries [the largest rice processor and foreign investor in the SRV rice sector], CNCAS and water user associations to integrate financial models that would improve CNCAS reimbursement rates while laying the foundation for a formal and solvent rice market. Consolidated in 2012 through a series of meetings and workshops with key stakeholders, these models have enabled the sale of nearly 20,000 T and mobilized more than US $11 million.*[35]

Contractualization eventually emerged in two forms: (1) between banks and producers, and (2) in a three-way relationship between the bank, producer, and processor. In the first form, farmers were required to find their own purchaser, which often led to delays in sales and in farmers' receiving payment. In the second form, banks provided credit to farmers who sold the contract on a forward sale to a processor, all of which was done at a price agreed in advance. Once transfer to the processor actually took place, the proceeds were used to repay the loan, with the loan now being between the bank and the processor. In this process, no cash was actually used; repayment was effectively in the form of paddy rice deposited in a warehouse. Bank credit was issued to farmers that allowed them to buy inputs through vouchers; farmers deposited their production in processors' warehouses and received a warehouse receipt that was considered as payment once it was transferred to the bank. This economized on cash.

For contractualization to work, PCE had to put in place, with its partners, several foundational pieces. These included:

[35] PCE, FY14 Annual Report Final, p. 49

- Establishing a fixed forward price. This price could be and ultimately was used by banks, producers, and processors as a reference price. Eventually, the price produced by the CIRIZ multi-stakeholder consultative process emerged as the reference price and has been used for the last several years.
- Improvements in yields and quality from both farmers and processors. Higher average yields increased the likelihood of repayment, and quality improvements made the rice more marketable and allowed SRV rice to be competitive with imported rice. CNCAS bank loans have now for several years required the use of certified seed.
- Providing storage facilities for paddy and processed rice. Construction of a large number of warehouses was financed by the AECID. Unfortunately, construction is slow and expensive, and the existing volume of storage remains much less than need. As of this writing, storage is a major constraint on further scaling.
- The innovation of crop insurance. It may appear surprising that crop insurance is needed in the case of irrigated rice, but while drought was rarely a factor, there were several other important risks. These included excess rain or flooding in the hivernale season, and attacks by pests, either birds or insects. (See Box 4).

BOX 4: CROP INSURANCE IN THE SRV

In its initial version, the crop insurance that was developed with CNAAS was designed to protect the lending bank against losses rather than the farmer, as the insurance covered only the amount of the bank loan. It was also limited in its coverage to very specific types of water and pest damage. In the 2015 hivernale season, many farmers experienced severe damage from bird attacks, but they were the wrong kinds of birds, ordinary birds as opposed to the grain-eating birds (i.e., grainivores) that are specified in the insurance contract. These two characteristics of the crop insurance caused substantial controversy in the winter of 2016 when claims were not being honored. However, changes are currently under consideration, including expanding coverage to the value of the crop rather than the financed inputs.

In Figure 6, the subtitle in French says: "I insure my harvest, I secure my revenues." However, the insurance sold did not insure the harvest, but only the value of the bank loan, which is half of the cost of production, or roughly one-third the value of the harvest. Given this promotional billboard, it is not surprising that farmers were upset by the limited coverage when they filed claims. As with bank interest rates, crop insurance premium are supposedly set at actuarially fair rates and the subsidized by the GOS; the actual premium is CFAF 10,000, while the unsubsidized rate would be 20,000. Crop insurance benefitted 5,000 farmers by the end of 2013–2014.

FIGURE 6: PROMOTIONAL BILLBOARD FOR CROP INSURANCE IN THE SRV[36] ("I Insure My Harvest, I Secure My Income")

The result of these efforts was a substantial increase in bank lending by CNCAS and by other banks such as Banque National pour le Développement Economique (BNDE) and Partenariat pour la Mobilisation de l'Epargne et le Crédit Au Sénégal (PAMECAS) (see Table 10 below). According to PCE, total lending for irrigated rice using contractualization was $14.3 million in 2014, or around CFAF 7 billion.

GOS policy and intervention played a major role in increasing access to credit. In particular, in 2014 the GOS injected CFAF 8 billion to wipe out the debts of farmers and millers. In 2014, the GOS also created a commercialization fund of CFAF 5 billion that was available to finance working capital for rice mills for the 2015 season. The combination of debt forgiveness and additional access to capital no doubt played an important role in the jump in lending in 2014–2015. However, as the head of one large farmers' association testified in an interview, the concerns about debt repayment remained: "Right now in 2016 there are seven GIEs [in our association] who are again in debt and can't fully repay their current loans; there were two to three who benefitted from the debt forgiveness in 2014." This indebtedness has impeded not only farmers' access to semi-annual financing for the rice seasons, but also their ability to buy additional agricultural equipment when needed (i.e., tractors).[37]

[36] Ibid., p. 52
[37] Group interview with members of a Union Hydraulique, January 2016, Rossbechol, Senegal.

TABLE 10: VALUE OF CNCAS AGRICULTURAL LOANS IN THE SRV

Season	Total Flow of CNCAS Loans	
2010/11	3.9 billion CFAF	650 million in saison chaud
2011/12	4.9 billion CFAF	
2012/13	4.1 billion CFAF	
2013/14	5,3 billion CFAF	
2014/15	10 billion CFAF	5.6 billion in saison chaud

Source: Interview with Director of CNCAS office, Saint Louis

PCE supported increased purchases of agricultural machinery through a partnership with Locafrique, a leasing company. Lease financing by Locafrique was available for combines, tractors, graders, and factory equipment. This was a major innovation as Locafrique was willing to make loans with the machinery itself as collateral. In interviews, Locafrique management said that they found that because of substantial excess demand for machinery services, most loans were relatively risk-free; they were successfully able to make such loans based on business plans and the character of the borrower. Locafrique has steadily expanded the size of its business. According to PCE, by 2014 it was supporting CFAF 1.6 billion (or around $3.4 million) in leasing credit, with additional applications currently in process of CFAF 3 billion ($6 million). According to Locafrique, they have been so successful in their activities that they have started to withdraw from lending in the Dagana area, as they believe the agricultural machinery leasing market there is saturated.

C. Mechanization

Machinery services for irrigated rice has been available in the SRV for many years, including the use of combine harvesters, tractors, and graders for land preparation. Prior to the disengagement of the state, SAED provided most of these services. Since the mid-1990s, the private sector has provided them, but not necessarily on a timely or affordable basis due to shortages of machinery, financing to purchase machinery, and access to credit so that farmers could pay for machinery services. While there are no statistical data available on the share of farmers using machinery services, by 2010 the share of farmers appears to have been relatively low. For those farmers who could had sufficient funds or access to credit, delays in timing adversely affected productivity. Many farmers planted late while waiting for land preparation, and similarly harvesting was not done at the optimal time. In an interview, a tractor service provider noted that he went into the business to supply his own needs because of the long delays: "The biggest problem for years has been getting services on time, they often have to wait just until they were pushed to the limit of when you can plant. The same thing happens in the harvest."[38]

[38] Interview with Tractor Service operator.

Photo: Richard Kohl

The GOS has been active since the food crisis in increasing the supply of agricultural machinery in the SRV. The GOS has provided subsidized loans for machinery (subsidies of 60–70 percent of market price). However, according to interviews with farmers and machinery service operators, this program has been at best a mixed success. The quality of the machines provided was low, and many farmers reported mechanical problems after the first year, complicated by the fact that most GOS-subsidized machines came with no service guarantee. In general, repair and servicing have been very limited in the SRV, especially east of Dagana.

The GOS program, combined with the efforts of Locafrique, led to an enormous expansion of the availability of machinery services in the SRV and has largely eliminated delays and shortages. According to a group interview with farmers from a union hydraulique:

> *There are now [January 2016] more than enough tractors in the region for getting the services that they need. It is only since 2014 that there have been enough tractors, many of which came from the state-subsidy program. [They own three themselves, and rent the services of nine more].*
>
> *Until this season there haven't been enough combines to do the double culture because of the delays in harvesting that causes. They are hoping to do both in this season. They themselves only have one combine.*

D. Politics and Policy

As noted above, the Senegal's public policy and programming have been tremendously supportive of scaling up of irrigated rice production in the SRV given the government's commitment to achieving rice self-sufficiency (Figure 7). This alignment at the highest levels of government policy facilitated several critical partnerships for PCE and other donor efforts, such as with SAED, CNCAS, and CNAAS.

FIGURE 7: GOVERNMENT OF SENEGAL POSTER "LOCAL RICE FOR FOOD SELF-SUFFICIENCY"

In addition to this general support and cooperation, the GOS has provided substantial programmatic support to improving productivity and increasing scale of irrigated rice production in the SRV. First and foremost were subsidies from one end to the other of irrigated rice production. These subsidies included:

- Subsidized loans: conservative estimate of 12 percent of the loan value, 7.5 percent interest from CNCAS.
- Subsidized insurance: 50 percent of CFAF 20,000.
- Subsidized equipment: 60 to 70 percent of the cost.
- Subsidized fertilizers: 50 percent on urea and DAP.
- Value-added tax (VAT) exemption on local rice.
- Income tax exemption for millers.

In addition to these direct subsidies, the GOS also provided various guarantee funds and indemnification for losses to CNCAS and others. It is important to note that, according to interviews with the head of PNAR and other GOS officials involved in the rice sector, the size of these subsidies is small enough relative to the overall GOS budget to be sustainable at least until self-sufficiency is reached, which is likely to be a long time.

The second major area of support for irrigated rice has been through various efforts to influence and support prices received by producers. The CIRIZ mechanism of consultation by the relevant social partners is facilitated by the Ministry of Agriculture and Rural Equipment, and in general has tended to support higher prices for producers. This has been reinforced by, at various times, export bans, fixed prices for paddy and imported rice, GOS purchases for a strategic rice reserve and by GOS agencies for their own consumption, and, most recently, the requirement that rice importers purchase a certain amount of local rice.

Finally, GOS support allowed donors, such as JICA and AECID, to come into the sector and support it. In addition to the specific efforts by PCE, JICA, and others, many donors have also been persuaded to invest millions of dollars in rehabilitating or expanding irrigation infrastructure.

E. Institutions and Partnerships

PCE formed strategic partnerships and undertook capacity building with a number of institutions to strengthen the value chain and policy environment. Particularly important were its partnerships with financial institutions, Africarice and ISRA, and with SAED. Africarice and ISRA are and remain the suppliers of breeder and foundation seed that allowed for the increased supply of certified Sahel seed. SAED played a critical role in supporting technical assistance and extension services to farmer organizations, although SAED's own human resources are inadequate to sustain this past the USAID project life cycle. PCE's partnership with SAED was crucial given SAED's role as the lead government agency in supporting irrigated rice cultivation in the SRV. SAED helped with implementation of PCE activities. To create a sustainable basis for providing ongoing extension support to SRV rice farmers, PCE did extensive capacity building with both SAED and CGER. This included transferring the:

> *…various technology packages such as "Le Chemin du Bon Riz", the quality monitoring framework and the cloud based farmer data management system. In the SRV the project also partnered with Centres de Gestion et d'Economie Rurale (CGER), a team of financial analysts managed by SAED, to improve its databases and include farmer monitoring and profiling capacities that go beyond the monitoring of seasonal loans.*[39]

PCE had partnerships with CNCAS on contractualization, CNAAS on crop insurance, and Locafrique on cost sharing for agricultural machinery leasing. To increase competition and therefore availability and affordability of bank lending, PCE entered into partnerships with other banks, most notably BNDE, to expand their agricultural loan portfolios.

Equally important to scaling up were PCE's partnerships with various farmer organizations in the SRV. Scaling up was facilitated by the fact that farmers receiving irrigated water were organized into either GIEs or water user associations around the infrastructure (unions hydraulique). PCE used these organizations to deliver its various trainings and support in the Chemin du Bon Riz, rice quality training, and distribution of rice quality measurement tools, as well as creating linkages for farmers with financial intermediaries and processors.

Finally, as part of scaling to Matam and beyond, PCE partnered closely with the USAID Yaajeende project, which had been working closely with farmers in those areas. Both irrigation and input distribution networks are much weaker in those areas than in the SRV, and Yaajeende has been instrumental in innovating and expanding networks of community-based service providers (CBSPs) to fill gaps in input provision. This allowed for creating the foundations for further scaling of PCE's various activities in the eastern SRV and in the Casamance, which are now taking place under the successor project to PCE, Ntaal Mbay.

VI. SCALING STRATEGY AND ACTIVITES

A. Drivers of Introduction and Dissemination of GAPs, Quality

There were two major drivers of scaling up of Sahel rice production in the SRV. These were the GOS's commitment to rice self-sufficiency and the decision by multiple donors, especially USAID and JICA, to support increased domestic rice production with their own programming. In that context, the two organizations that took the lead in operationalizing that effort were PNAR on the GOS side and the USAID-supported PCE program. While donor support came from Japan, Korea, France, and Spain, as

[39] PCE, Annual Report, FY2014, p. 83

well as the World Bank and the Millennium Challenge Corporation, USAID was widely acknowledged for playing the lead role. Interestingly enough, these agencies worked successfully together without a formal consultation or coordination mechanisms. Perhaps equally important were PCE's partners on the farmers' association side, whether union hydrauliques in grand and intermediate amenegements, or GIEs based in other irrigation groups.

There were several drivers of adoption of CBR and better quality among producers. First, high prices were a major driver, because of both higher international prices and GOS efforts to incentivize farmers through price, import, and export controls. Second, subsidies on everything from inputs to machinery boosted profits for most farmers, at least those with the means or access to finance to afford those inputs and services. Third, successful experience with contre saison yields led to a steady switch to that season and some double cropping, and reinforced the possibility of increased yields and higher quality. Finally, many farmers interviewed expressed that they saw increasing yield and production as their patriotic duty, and are making efforts to support the GOS self-sufficiency policy. The favorable policy environment has reassured both farmers and private investors in the rice value chain that there is a "guaranteed" market for domestic rice (i.e., that there will be ongoing political and financial support). This has substantially reduced the risk perceived by investors, and, for that matter, donors, as well as lengthening the time horizon for investment.

B. Adoption Rates, Variability, and Continuity

Adoption of the GAPs contained in the Chemin Du Bon Riz and PCE's efforts at improving quality control on the production side are difficult to measure. The surface area and number of producers with whom PCE worked directly or through its partners were fairly stable between 2010 and 2015 at 14,000–16,000 ha and 14,000–16,000 farmers (clearly implying that average area per farmer was around 1 ha). See Table 11. This probably accounts for about 20–25 percent of the farmers in the SRV, and closer to 30–35 percent in the Dagana area. Adoption rates within the population appear to be somewhat variable. While data on adoption of the CBR was not available and would be hard to measure, proxies exist. In Section III, Table 6C, which presents data on PCE partners, shows that the amounts spent per hectare on seeds, fertilizer, herbicide, and threshing were quite variable across farmer organizations. This suggests that adoption of the CBR might be equally variable. On the other hand, there are likely to have been spillover effects (i.e., adoption by non-participants), so the impact is likely on balance to be much greater.

TABLE 11: PCE ACTIVITIES IN IRRIGATED RICE SUMMARY 2011-2015

Measure	FY 2011	FY 2012	FY 2013	FY 2014	Hivernale 2014/15
Area (Ha)	14,350	16,286	10,141	15,447	12,088
Production (T)	73,474	88,953	59,374	97,220	61,476
Yield (T/ha)	5.12	5.46	5.85	6.29	5.09
Number of Producers	14,000	15,340	14,102	15,447	16,463

Source: PCE

Scale-up in the areas of value chain strengthening shows particularly strong results. As noted above, certified seed production has expanded steadily, though would need to expand further to cover all farmers in the delta part of the SRV. According to PCE's own data, in FY 2014, 26,530 hectares were being farmed under contractualization across all crops, with probably around half in irrigated rice. Further spread of contractualization is limited by CNCAS's own capital limits—as of early 2016 it was

looking for further capital increases—as well as the limitations of the existing versions of crop insurance. Farmers will also need to be fully insured from adverse events, especially in the hivernale season with the increased frequency of floods, damaging rain, and bird and pest attacks. Until that happens, it is likely that more farmers will fall back into arrears, becoming ineligible for credit, and many others will be less eager to produce in the hivernale season. The same is true of the timeliness of bank credit approval; as of this coming crop year (2016–2017), CNCAS was willing to experiment with approving credit for the entire year, versus the current practice of season by season.

Quality processing capacity (i.e., big mills) has scaled significantly, and now appears to have excess capacity. Some of the excess capacity is clearly due to poor business decisions by Vital Agro-Industries, the largest miller as measured by capacity. Vital expected to have significant rice production of its own to process, but the land allocated to it proved to be not suitable for rice. On the upside, this development stimulated Vital to be the industry leader in early adoption of contractualization, both directly with its own producers and through CNCAS. It is unclear why many farmers still prefer to sell to the small décortiqueses. One explanation is that it saves on transportation costs; another may be that décortiqueses can pay more since they have lower processing costs, while there remains a significant rural market that is willing to pay less for lower quality. It may be the case that until retail prices are decontrolled and can rise, even with excess demand from processors and importers, farmers will continue to prefer the smaller processors.

Mechanization now appears to be at full scale in Dagana and Podor, and is clearly one of the success stories of PCE and GOS efforts. However, according to LocAfrique, the Dagana market is now saturated. This has had an important impact on improving yields by allowing farmers to plant and harvest on time, increasing the length of the growing season and allowing for harvesting at the optimal time.

Taken together, all of these interventions created a virtuous spiral and snowball effect that, after four years of investments (2010–2013) reached critical mass in 2014. Whereas both yields and hectares under rice cultivation were relatively flat between 2010 and 2013, both yields and hectares under cultivation increased in 2014 and 2015, though this was somewhat offset by adverse weather and pest attacks in the hivernale season leading to declining planting in that season. While it is highly likely that the cumulative and combined efforts of the GOS, PCE, and other donors contributed heavily to these results, it is impossible to distinguish how much of the surge in production in the last two years was from the GOS's injection of funds into CNCAS to finance debt forgiveness or its additional lending for commercialization and equipment. It is difficult to know exactly what production levels were in those two years, as there are widespread reports that SAED and other data collection agencies were under significant political pressure to show results for the increased expenditures associated with subsidies and support for CNCAS. The reported figures show over 63,000 hectares under cultivation in 2015 and yields of around 7 mt/ha, up from 6.4 mt/ha in 2013. The net result was a recorded increase in rice production of 100,000 mt of paddy, but this figure, and the underlying determinants in yields and area, may be exaggerated by as much as 50 percent.

C. Sustainability, Scaling, and Handoff to Commercial or Other Actors

The ability to take over sustaining and continuing scaling in the SRV and beyond is currently being put in place. Because seed multiplication is being done by farmer cooperatives and other inputs are provided principally by the GOS, ISRA, or AfricaRice, there is no upstream actor in place to drive or sustain scaling. In the Dagana and Podor regions, where scaling has largely occurred, downstream actors are now driving scaling. These are principally the large, commercial millers, supported by SAED and the CNCAS, with private credit playing a growing role. These actors are more than capable of both sustaining the scale already achieved and filling in scale to the other 50 percent of farmers. However, this will depend on resolving the remaining challenges in access to credit and insurance, storage facilities,

and persuading farmers to sell to millers versus décortiqueses. CNCAS in particular is limited by the size of its capital in the amount of loans it can extend, especially now that it has expanded into capital investment in mechanization and processing.

There are neither commercial nor other actors with the capacity or interest to scale up rice production in the rest of the SRV (e.g. Matam and further east) or in rainfed areas in other parts of Senegal, principally the Casamance. USAID has recognized and accordingly has funded the Ntaal Mbay project, a successor to PCE, to driving scale up in both areas. Scaling up in the upper parts of the SRV will be more challenging as the existing irrigation infrastructure and value chains are much less dense. The land is less suitable for rice versus much more profitable horticulture crops like tomatoes and onions. Perhaps more importantly, crop insurance has not yet been shown to work and still needs to be tweaked, a major challenge throughout the SRV.

Scaling up in the Casamance will prove much more challenging because of the greater risks involved with rainfed rice, lack of any existing milling capacity, and the fact that relatively few farmers currently produce a commercial surplus. In addition, rice also has to compete with maize and groundnuts. As a result, there are neither downstream processing nor milling capacity nor marketing linkages to Dakar or other urban areas. It is likely that the package of innovations scaled in the SRV will have to be modified or adapted, and potentially new ones innovated. PCE's approach of working simultaneously on supply and demand (i.e., push and pull) and addressing binding constraints iteratively, is clearly the right overall approach and is being applied by Ntaal Mbay. Whether rain index insurance, even subsidized by the GOS, can be made to work remains to be seen. Quality mechanized processing will have to be introduced along with downstream linkages though the demand is clearly there.

D. Potential Scale of Adoption

Given the challenges present with rainfed rice, this study was confined to the scaling up potential in the SRV. Demand for rice is clearly not an issue, given that there is huge potential for import substitution in the rice market in Senegal and the GOS is committed to controlling imports and prices, as necessary, to ensure the profitability of domestic production. Therefore the question is what is the potential on the supply side?

Supply is largely constrained by how much irrigated land there is (i.e., irrigation infrastructure). Currently around 60,000 ha have access to irrigation for growing rice. It is difficult to get a precise estimate of how much additional land already has irrigation infrastructure in place that needs to be rehabilitated, and how much new land could be utilized. According to interviews, SAED personnel believe that up to an additional 60,000 ha could be rehabilitated. According to an interview with the head of the PNAR and other sources,[40] the total potential in the SRV is 240,000 ha.

The GOS has committed to a long-term policy of encouraging donors to fund new investment in and rehabilitation of irrigation infrastructure in the SRV. This already met with great success between 2008 and 2015, with the World Bank, French Agency for Development, and Gulf Cooperation Council all providing funds to SAED for significant new investment and rehabilitation. Whether additional donor funds will be available remains to be seen, and the GOS itself does not have funding for this kind of expense. Until funds materialize, the goal of 120,000, let alone 240,000 hectares, is a long way off.

[40] "[T]hanks to the project [the construction of two dams the Diama and Manantali dams in 1988]), Senegal increased its potential for irrigated agriculture in the s-srv from about 10,000 to 240,000 ha." [emphasis added] – Stanley Malinowski and Alexandre Strapasson, "Sustainability Assessment of Large Irrigation Dams in Senegal: A Cost-Benefit Analysis for The Senegal River Valley." *Frontiers of Environmental Science*, 17 March 2016, Vol. 4, Article 18, p.2. http://dx.doi.org/10.3389/Fenvs.2016.00018

Intensive scaling is more likely to be possible and viable in the short to medium run (i.e., the next three to five years). The Sahel varieties in use have yield potential of 10–12 mt/ha depending on the variety. While some farmers are getting 8–10 mt/ha, the majority are in the 6–8 mt/ha range (in saison chaud), and some are getting still less. If credit availability continues to increase, so that more farmers are able to afford the inputs and services necessary, and other constraints are addressed, moving average yields up to 7–8 mt/ha is certainly possible. However, the impact of this on total annual production may be limited, as unless the increasing problems with pests and adverse weather in the hivernale can be addressed, double cropping may be limited or even decrease.

In addition to pests, adverse weather, and access to credit, constraints that need to be addressed in order to increase yields include: increased access to storage; willingness of farmers to sell to large processors; extending what is covered by crop insurance; and improving servicing and maintenance of machinery. Further scaling will also depend on domestic and world prices continuing to remain near or above current levels.

CONCLUSIONS

Before turning to conclusions it is important to note that the story of scaling up of Sahel rice is atypical in several ways. First, maximum potential scale was and remains constrained by the extent of irrigation infrastructure. In this case, current scale is probably limited to 120,000 hectares and some multiple of that in terms of numbers of farmer households affected (i.e., a few hundred thousand farmers at best). Though current efforts are being made to extend what was done in the SRV to other rice growing areas of Senegal, the applicability of what was done with irrigated rice to rainfed areas remains to be seen. Second, scaling up has taken place in two distinct and temporally disparate phases. Sahel rice seed was first introduced in the SRV in 1994 and was widely adopted by most farmers by 2000. As a result of the decline of the irrigated rice value chain, the yield potential of Sahel rice was not realized at that time. Instead, after a decade-long hiatus, this potential has been largely realized by the scaling up of a package of innovations between 2010 and 2015 (and is ongoing) that included both GAPs and strengthening the value chain. This latter effort was driven by the efforts of the USAID-supported PCE, in partnership with other donors and the GOS. This study focuses on those post-2010 efforts led by PCE, which involved a mix of improving agricultural practices and rehabilitating and strengthening the rice value chain and relevant aspects of the rice market system.

PCE identified the immediate obstacles to increased production, prices, and sales and how to address these. The key elements were to address constraints on supply and demand and increase quality in both production and processing. In other words, PCE worked both on "push" factors to increase yields, area planted, production, and quality, and on "pull" factors to increase demand. Doing these simultaneously proved to be important, as increased supply without demand made no sense, and vice-versa. When the impact of those activities met new obstacles to further scale, PCE and its partners addressed those in turn. Thus what was 'scaled' was inter alia the production and certification of quality seed, the use of certified seed, GAPs, increasing the availability and affordability of machinery services, large-scale quality commercial rice milling, and a whole set of financial innovations. Perhaps most important was this overall 'virtuous spiral' approach to scaling.

These activities took a few years to implement and have a perceivable effect. Efforts to increase rice production by the GOS, PCE and others began in 2009–2010, but there was almost no increase in area, yield, production, or quality until 2013–2014. At that point the multi-pronged strategy reached critical mass in both scale and scope (e.g., there was adequate supply of both certified rice seed and processing capacity to allow for a significant increase in production). This was complemented, importantly, by a

program of debt forgiveness and an injection of additional capital by the GOS to increase the availability of credit throughout the value chain.

The greatest sources of increase in yields were the shift from hivernale to saison chaud planting, use of certified seed, and farmers' preparing their land, planting, and harvesting at optimal times. Respecting the crop calendar was made possible through increased access to and more timely availability of credit and greater availability of machinery services. In turn, greater availability of credit was significantly driven by financial innovations introduced by PCE and its partners, principally crop insurance and contractualization. As is perhaps obvious, this required a layered approach, as one innovation built upon another.

A. Characteristics of the Innovation

It is difficult to draw any lessons from the irrigated rice case about the characteristics of innovations that facilitate scaling up because it was large and diverse package of innovations. For Sahel rice alone, it is clear that getting the benefits of Sahel rice required significant changes in agricultural practices by farmers, especially the timeliness of the various activities during the season. Helping farmers to acquire these GAPs required a significant investment of time; in most cases it appears to take a farmer several seasons to master the new approaches. As no existing actor, public or private, had the resources or capacity to provide the necessary technical assistance and extension services, this had to be provided by donor-funded projects. While PCE did significant capacity building with SAED and other relevant actors, it remains unclear whether any of them can either take over this role or provide such support on an ongoing basis.

B. Incentives and the Business Case

The success in helping farmers adopt GAPs and in getting other value chain actors to adopt new innovations is clearly linked to the fact that adopting these innovations has been profitable for several key actors. This includes seed multipliers, rice farmers, and (to a lesser extent) rice processors. Both seed multipliers and rice farmers have very solid returns on investment, especially given current international and domestic rice prices and subsidies on inputs. While some rice processors are clearly doing well and making money, the inability of others to find adequate supplies of rice suggests that many farmers still find it more profitable or preferable to use local décortiqueses.

Risk has also clearly played a role in farmers' decisions and those of other actors. One of the major appeals of several of the GAPs adopted—certified seed, respecting the crop calendar, changing to the saison chaud—is that they have decreased the risk of a poor harvest. While crop insurance was intended to decrease risk for both CNCAS and farmers, in its current form it has largely worked only for CNCAS.

C. Context

The context in Senegal played an essential role in scaling up. Extensive irrigation infrastructure already existed and the use of irrigation seriously mitigated risk to all actors in the value chain. Even prior to 2010, many rice farmers were producing at least a small surplus and were commercially orientated. Those who could afford it were accustomed to using improved seed varieties, fertilizer, and other capital-intensive inputs; employing machinery services; and selling in commercial markets. Even those who could not afford all of these used some of these inputs and aspired to use more. The majority of rice farmers were already organized into farmers' organizations based on "hydraulic unions" which greatly facilitated provision of inputs, extension services, market linkages, and technical assistance;

others were members of GIEs or other farmers' organizations. Without these farmer organizations, scaling up in the SRV would have been much more difficult, expensive, and time consuming; yet there are many contexts where such organizations are nonexistent or neither as strong or widespread as they were in the SRV.

World and domestic prices for rice have been consistently high since the food crisis of 2008, making a strong business case for irrigated rice. Close physical proximity to key urban markets like Dakar was helpful, as well as excess demand for rice and the opportunity for import substitution. While the rice value chain had notable weaknesses at the start of scaling, especially seed supply, certification and processing, many of the institutions necessary were in place to some degree (e.g., mechanized services providers, processing, input distribution, access to credit). This stands in marked contrast to, just for example, the situation with rain-fed rice in the Casamance region of Senegal.

Even though PCE emphasized wherever possible commercial pathways, the huge role of the GOS in the irrigated rice value chain meant that the public sector played a key role. Overall strong GOS policy support for rice self-sufficiency has provided private investors with a high comfort level for investment in the sector. Government subsidies on inputs, credit, insurance, and purchases of machinery improved returns and lowered risks for many actors, even though rice production was already profitable for farmers. At the same time, the GOS affected price setting, which has distorted incentives, especially for wholesalers and processors, and exaggerated and inaccurate statistics have adversely affected planning by rice farmers and processors.

D. Drivers of Adoption and Scaling Strategy

The major drivers of scaling up at the macro level were GOS policy and programs around rice self-sufficiency, USAID's PCE program, and the complementary activities of other donors. At the micro level, the fact that irrigated rice has been profitable and competitive with imports since the world food crisis has been key. This was supported by the large potential market based on import substitution.

In terms of scaling up strategy, the key aspects that underlay the success of PCE's scaling up were:

- Using a push-pull approach by helping producers to increase yields, production, and quality; increasing market demand through facilitating linkages to processors and distributors; and strengthening those downstream institutions.
- Kick starting private upstream and downstream investment through subsidies, risk mitigation, and market facilitation. PCE's support for agricultural machinery leasing through Locafrique and innovating crop insurance with the GOS are examples.
- Translating this push/pull and kick starting into a virtuous spiral that by 2014–2015 has become increasingly self-generating.
- Aligning the incentives for farmers, banks, processors, machinery services, and wholesalers so that everyone makes money. In some cases in Senegal, this has been complicated by GOS-induced distortions of prices and margins at various stages of the value chain. The fact that profitability for processors still remains a mixed situation may affect scaling in the future.
- Addressing risk for key actors. This was particularly true for banks (e.g., CNCAS) and processors and was addressed through the innovations of contractualization, crop insurance, and the use of a warehouse receipts system. As noted above, reducing risks for farmers is still a work in progress.

LESSONS LEARNED

A. General Lessons

Despite the relatively small potential scale and the many favorable aspects of the SRV context, the Sahel rice case has many important and positive lessons for scaling up of agricultural innovations through commercial pathways.

The principal lesson from this case is that introducing a new technology like improved seed varieties is only a small part of what needs to be done if its potential benefits for yield, production, and food security are to be realized, let alone at scale and sustainably. The entire value chain needs to be in place.

Second, a virtuous spiral/snowball approach can be highly effective in addressing constraints on scaling sequentially. However, to implement this effectively requires flexibility in annual work planning with a strong formal and informal monitoring system that can both identify new constraints as they become binding and assess progress in addressing existing constraints.

Third, there is often a need for complementary or supporting innovations in addition to new seeds (or other inputs) and GAPs. In this case, financial innovation (e.g., contractualization) was probably the most important complementary innovation, even if other innovations, such as crop insurance, remain works in progress.

Fourth, context matters, a lot. A context where there is already a market orientation, most value chain institutions are in place (even if quite weak), and risks are lower because of irrigation is quite different from scaling in a situation where those factors are not present. Similarly, a context where there is a huge existing demand and a potential market (in this case because of the possibility of import substitution) is very different from where demand is small, has to be created, and where there is a risk of increased supply putting downward pressure on prices.

Fifth, a supportive policy environment makes a huge difference. This was the case not only in terms of specific programs and subsidies, but in creating an overall favorable atmosphere. While subsidies can (and in this case have) created distortions, their role in reducing the risks of adoption and crowding in the private sector, if done well, is undeniable.

Sixth, scaling is multi-dimensional. In this case, increases in yield were largely driven by the time dimension of scaling up. New technology and practices impact the ability of farmers to complete the various activities of the crop cycle at the optimal times (i.e., timeliness) and has been shown in many research studies to be a major influence on yields. Yields improve as farmers are able to plant two crops per year, in some cases on the same land. Scaling up over space (i.e., greater area), while usually how one thinks about scaling, in this case was more limited, by access to both irrigation and credit.

Seventh, it is key for commercial scaling not only to make sure that production is profitable for farmers and downstream and upstream actors, but it is perhaps even more important to reduce risk. Crop insurance can help, but the Senegal case shows there are many challenges in making this viable and sustainable, even with government support. In this case, GOS support, programs, and subsidies played a key role. While it is natural to treat subsidies as unsustainable, in this case there is both the political will and fiscal space to sustain these in the medium term, though this could change if world fertilizer or rice prices change.

Finally, innovations whose adoption takes substantial technical assistance and extension support may be hard to make sustainable. In the case of Senegal, PCE has worked hard to embed the needed capacity in

SAED, hydraulic unions, and other farmer organizations. However, whether these organizations have sufficient human resources and institutional capacity to sustain this at the scale needed remains to be seen.

B. Lessons for USAID and Other Donors

From the perspective of USAID, there are a number of larger lessons, some of which duplicate those listed above. These are:

1. The innovation, or package of innovations, cannot easily be identified in advance but are more likely to reveal themselves as constraints and obstacles to scaling a basic innovation. Flexibility in both what and how scaling is conducted is preferable.

2. Actual potential scale can be significantly below potential scale based on agro-ecological considerations alone. Access to irrigation, inputs, markets, credit, labor, and other resources all can significantly constrain actual potential scale.

3. Scaling is multi-dimensional, and strategies need to consider the relative importance of each dimension, even though this can evolve in unpredictable ways based on the responses of various private sector actors. The intensive impact of scaling (e.g., increasing yields) can be as important as extensive scaling (e.g., spreading to more farmers, more surface area cultivated). Time and timeliness can be a key dimension of both types of scaling, and should be an explicit focus.

4. A scaling up strategy that combines three metaphors—virtuous spiral, snowball, and push-pull—can be highly effective in reaching critical mass for scaling and allowing scaling to become significantly self-generating. At the same time, it appears that there may be stages or thresholds of scaling in some cases, at which point new constraints appear that impede further self-generating scaling. Addressing these often involves public goods or externalities that private actors may not have the resources or incentives to address themselves.

5. Commercial ownership and sustainability can be achieved by combining kick starting private sector involvement with an explicit view to creating sustainable institutions that can function at scale. This requires an ongoing process of identifying bottlenecks and incentives, providing some initial incentives and risk mitigation, and iterative monitoring and problem solving.

6. Focusing on risk for all actors is equally important as profitability. Key risks that can and should be addressed include: timely, affordable, and accessible inputs and mechanization; affordable, timely access to credit, liquidity, and insurance throughout the value chain; and ensuring that there is demand for increased supply and supply for increased processing capacity and demand. Public or donor subsidies for inputs, credit, and services can be critical for kick starting increased production and private investment in key parts of the value chain, but as time goes on can create distortions that inhibit private sector efforts from snowballing and becoming self-generating. This was the case with GOS subsidies on agricultural machinery purchases, which undercut private efforts.

7. Aligning with public sector strategies and programs, as PCE did, is both essential and problematic. It often brings as many challenges as it does benefits. The GOS has regularly exaggerated rice performance for political reasons even though this has significantly complicated planning for farmers, processors, seed producers, donors, and others. Nonetheless, PCE could not have achieved its successes if it had not worked effectively with the government, and this often required substantial and ongoing advocacy and consultation. Further, governments are not monolithic and can have different interests varying across ministries, agencies, and parastatals. In

this case, the Ministry of Agriculture wanted to ensure high prices for farmers to encourage production, whereas the Ministry of Commerce wanted low consumer prices. The result has been a squeeze on margins for processors, wholesalers, and importers.

8. Even in a highly favorable environment like the SRV (e.g., an existing value chain, GOS support, access to irrigation), it can take four to five years to achieve results and for self-generating scaling to begin. Based on this case, donors should target (and be able to reach) 20–35 percent scale (i.e., critical mass). However, even this may be sufficient only to reach the next plateau, in this case around 50 percent of potential scale.

9. Scaling up, especially when it requires strengthening multiple aspects of the value chain and market system, is expensive and, even at this limited scale, beyond the resources of one donor. USAID was in the lead and was able to scale a number of innovations. Nonetheless PCE's efforts would have had little impact without the substantial complementary assistance from French, Spanish (warehouses), Japanese (crop and milling quality equipment), and World Bank (irrigation infrastructure) sources. Interestingly enough, this functioned extremely well without formal coordination mechanisms, as each donor took a niche and pursued it without duplication.

10. Despite these clear successes, a number of challenges remain to further scaling. PCE's follow-up project, Ntaal Mbay, is addressing these, including the need for increased warehouse storage, problems with the design of crop insurance, the continued predominance of local processors, and lack of servicing and maintenance for the much larger supply of agricultural machinery. At least some of these issues are due to distortions introduced by the sector-wide support policies of the GOS (e.g., machinery subsidies).

ANNEX A: STAKEHOLDERS TARGETED FOR INTERVIEWS/FOCUS GROUPS

TABLE 12: STAKEHOLDERS TARGETED

Stakeholder	Innovation Characteristics	Market System and Enabling Environment	Scaling Up and Market System Strengthening-Strategies	Drivers and Pathways of Diffusion
Farmers: broad demographic representation	3	3	2	3
Local farmers' associations	2	2	2	2
Other grassroots organizations (co-ops)	2	2	2	2
Retail distributors	1	2	2	2
Wholesale distributors	2	2	2	2
Field sales agents	2	0	2	3
Government extension agents	2	0	1	2
Local level agricultural research stations	2	0	0	0
Donor project field staff	2	2	2	2
Donor project field managers	2	2	2	1
Rural development relevant local NGOs	2	0	2	2
Local VIPs	0	0	0	0
Local government officials	0	0	1	0
Local Ministry of Agriculture officials	2	0	1	0
Local media	0	0	0	0
Producing company local agents	2	1	3	2
Downstream buyers and processors	1	2	2	1
Local agricultural financial institutions	0	1	1	0
National or regional farmers' associations	0	2	2	1
National level producing company management and sales staff	3	2	3	2
National Ministry of Agriculture officials	1	2	2	1
*Other relevant National Ministry officials	0	0	0	0
National or regional agricultural research stations	3	0	1	0
National or regional media	0	0	1	1
National level donor project management	1	1	1	2
Other donors working in agri/relevant projects	0	1	0	0
National distributors' associations	0	1	1	2
National agriculture relevant NGOs	0	1	0	1
National agricultural financial institution management	0	1	0	0

TABLE 13: STAKEHOLDERS MET IN SENEGAL

Organization Name	Date	Location	Personnel	Description
USAID Mission	11-Jan-16	Dakar	Anne Williams, Ronit Gerard	
Ntaal MBay	11-Jan-16	Dakar	Jean-Michel Voisard, Matar	Follow-up to USAID PCE project
JICA	12-Jan-16	Dakar	Mr. Koji SUNAZAKI, Takashi KIMIJIMA, Marina BAMBARA	
CNAAS – Compagnie National Assurance de Senegal	12-Jan-16	Dakar	Mouhamadou Moustapha Fall, DG Ajdoint	National insurance company
PNAR – Programme National d'Autosuffisance en Riz, Coordinator	12-Jan-16	Dakar	Dr. Waly DIOUF	GOS overarching program for rice self-sufficiency
CNCAS – Caisse Nationale de Credit Agricole du Senegal	13-Jan-16	Dakar	Gilbert Ndong, Directeur de Credit et du Réseau Marième DIOP, Directerur Adjoint de la MicroFinace	State-owned agricultural bank
ANSD – Agence National de Statistique	13-Jan-16	Dakar	Moises Gning	National Statistical Agency
DPSA	13-Jan-15	Dakar	Fatou	
UNACOIS Buyers association	13-Jan-15	Dakar	Ousmane NDIAYE	Rice buyers' trade association
ANCAR – Agence National de Conseil Agricole et Rural	14-Jan-15	Dakar	Mariama Drame	GOS farm support agency
Ntaal Mbay– Saint Louis office	18-Jan-15	Saint Louis	Amadou SOUARE, Assane DIEYE	Current USAID project supporting cereal production in Senegal
AfricaRice	18-Jan-15	Saint Louis	Mandiaye Diagne, Mamadou NDIAYE	Senegal branch of international rice research organization for Africa
CGER	18-Jan-15	Saint Louis		Parastatal accounting to support irrigated rice producer organizations
CNCAS	19-Jan-16	Saint Louis	Cheikh Ndiaye	Government agricultural bank, local branch
ISRA	19-Jan-16	Saint Louis	Madiama Cisse	Research institution on rice and other crops
SAED	19-Jan-16	Saint Louis		Government agency in charge of irrigation support in SRV
Teranga Enterpise	19-Jan-16	Saint Louis	Caty Lo, Directrice	Rice milling business
GIE	20-Jan-16	Ross Bethio		Private paddy buying and selling, rice milling business, also machinery services
CEDAF Union des Femmes Productrices de Ross Bethio	20-Jan-16	Ross Bethio	Ndeye Gaye, President	Women's irrigation union composed of 7 GIEs
	20-Jan-16	Ross Bethio	Ndiawar Diop, President	Federation of irrigation unions and GIEs in rice production in SRV

Organization Name	Date	Location	Personnel	Description
CIRIZ-FPA – Federation du Perimetres Autogerés du Senegal			Ousmane Ka, Economist	
CNT – SUARL	21- Jan -16	Richard Toll	Oumar Diop, Ibrahima Sall	Rice miller
Mboudj et Freres	21- Jan -16	Richard Toll	Alioune Mbodj	Rice miller
Vital	22-Jan-16	Richard Toll	Birame Ndiaye	Rice miller
Pelitel	23-Jan-16	Podor		
SP1 Fanaye	23-Jan-16	Podor	Amadou Tall	
Podor Fegina	23-Jan-16	Podor		
Ousmane Ndiaye UNACOIS	25-Jan	Dakar		