Private-Sector Agricultural Research and Innovation in Senegal

Recent Policy, Investment, and Capacity Trends

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Acronyms

ACP	African, Caribbean, and Pacific
ATRIP	African Trade Investment Program Policy
AU	African Union
CGIAR	Consultative Group on International Agricultural Research
CILSS	*Comité permanent inter-états de lutte contre la sécheresse* [Committee on Drought Control in the Sahel]
CIRAD	*Centre international de recherche agricole pour le développement* [International Center for Agricultural Research and Development]
CNFA	a nonprofit organization promoting public–private partnerships
CORAF/WECARD	*Conseil ouest et centre africain pour la recherche et le développement* agricoles [West and Central African Council for Agricultural Research and Development]
CSS	*Compagnie sucrière sénégalaise* [Senegalese Sugar Company]
DISEM	*Division des semences* [Seed Division]
DPV	*Direction de la protection des végétaux* [Directorate of Plant Protection]
ECOWAS	Economic Community of West African States
ENSA	*École nationale supérieure d'agriculture* [Advanced National School of Agriculture]
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FNRAA	*Fonds national de recherche agricole et agro-alimentaire* [National Agricultural and Agro-Alimentary Research Fund]
FTE(s)	full-time equivalent(s)
GOANA	*Grande Offensive Agricole pour la Nourriture et l'Abondance* [Great Push Forward for Agriculture, Food, and Abundance]
IFDC	International Fertilizer Development Center
ISRA	*Institut sénégalais de recherche agricole* [Senegalese Agricultural Research Institute]
ITA	*Institut de technologie alimentaire* [Food Technology Institute]
LOASP	*Loi d'orientation agro-sylvo-pastorale* [Agriculture, Forestry, and Livestock Act]
MFN	Most Favored Nation
MIR Plus	Marketing Inputs Regionally Plus (project)
NEPAD	New Partnership for Africa's Development
NMA	*Nouvelle minoterie africaine* [New African Flour Mill]
PIP	Pesticide Initiatives Programme
PNDE	*Plan national de développement de l'élevage* [National Livestock Development Plan]
PPP	purchasing power parity
PSAOP	*Programme des services agricoles et organisations des producteurs* [Agricultural Services and Producer Organizations Program]
R&D	research and development
REVA	*Retour vers l'agriculture* [Return to Agriculture]
SENCHIM	*Société de commercialisation des productions des industries chimiques* [Chemical Commercialization Company]
SOCAS	*Société de conserves alimentaires du Sénégal* [Canned Food Company of Senegal]
SODEFITEX	*Société de Développement des Fibres Textiles* [Textile Fiber Development Company]
SPIA	*Société de produits industrielles et agricoles* [Industrial and Agricultural Products Company]

SSA	Sub-Saharan Africa
UCAD	*Université Cheikh Anta Diop* [Cheikh Anta Diop University]
UEMOA	*Union économique et monétaire ouest africaine* [Economic and Monetary Union of West Africa]
USAID	United States Agency for International Development

ABSTRACT

Agricultural research and development (R&D) in Senegal has historically been spearheaded by the public sector. In 2008, the private sector accounted for just 14 percent of the country's total (public and private) agricultural R&D investments. While the public sector dominates R&D related to food crops, private-sector companies play a key role when it comes to export commodities, including cotton, groundnuts, and fisheries and horticultural products. Although data on public R&D capacity and investments are widely available, comprehensive information on R&D conducted by the private sector is not regularly documented. This paper attempts to fill this knowledge gap with new data and analysis on private R&D investment in Senegalese agriculture. In doing so, the paper also provides insights into policy and institutional issues constraining private investment, and options for addressing these constraints.

BACKGROUND

Introduction

Technological innovation is vital to enhancing agricultural productivity and reducing poverty in many developing countries. Effectively disseminated new technologies and varieties resulting from research and development (R&D) investments have enhanced the quantity and quality of agricultural produce, while at the same time increasing sustainability, reducing consumer food prices, providing rural producers with access to markets, and improving gender-based allocations and accumulations of physical and human capital within households. Given important challenges, such as rapid population growth, adaptation to climate change, increasing weather variability, water scarcity, and the volatility of prices in global markets, policymakers are increasingly recognizing the value of greater investment in agricultural R&D as an essential element in increasing agricultural productivity in Sub-Saharan Africa (SSA) (Beintema and Stads 2011).

Public investment in R&D has historically driven technological change in agriculture in developing countries worldwide; however, research conducted by private firms is becoming a growing source of agricultural innovation in many countries. Additionally, private firms are increasingly funding research carried out by public organizations. Efforts to promote private agricultural R&D through appropriate policies, donor support, and the strengthening of partnerships with the public sector have been held back by lack of reliable data on the involvement of the private sector in agricultural R&D and innovation. Senegal is no exception. The purpose of the current study is to fill the gap in information about private investment in agricultural R&D in Senegal, first, by describing the sector's role in generating or introducing new and improved agricultural technologies of relevance to Senegal's farmers and processors and, second, by considering options for facilitating private technology generation through policies and programs.

Agriculture in Senegal

Most of Senegal, except for the far south, lies within the drought-prone Sahel, a region characterized by irregular rainfall and relatively poor soil. With just 5 percent of its land under irrigation, Senegalese agriculture is mainly rainfed and seasonal, as is evidenced by sharply fluctuating production levels in the past decade. In 2008, the agricultural sector employed roughly three-quarters of the country's workforce. The vast majority of farmers are smallholders, combining cash crops (groundnuts and cotton) and subsistence crops (millet, sorghum, maize, and rice), while possessing some livestock. In recent years, large-scale horticulture has become more prominent in the Niayes (the coastal zone between Dakar and Saint Louis) and the irrigated lands along the Senegal River, where rice cultivation is also highly developed (Ndiaye 2007).

After Mauritania, Senegal is West Africa's most food import–dependent country. Senegal imports 70 percent of its cereal, as well as most of its dairy, vegetable oil, and processed foods. Vulnerable at the beginning of the 2008 global food crisis, the country undertook dramatic measures to protect consumers and farmers by subsidizing food consumption and agricultural production.

Senegal's agricultural sector performed poorly in recent decades. With the exception of maize and rice, production, yields, and acreage of most cereal crops have either stagnated or declined since the late-1960s. This can be explained by an unfavorable international context (declining prices for groundnuts and cotton), poor control of water resources, and degradation of land and agricultural inputs (seeds, fertilizers). Further, the withdrawal of state seed and fertilizer subsidies in the late-1980s severely affected production levels.

Despite recent domestic production increases, Senegal remains Africa's second-largest net importer of rice (after Nigeria), mostly from Asia. In 2008, Senegal imported 600,000 tons of rice, or three-quarters of local consumption, making its people vulnerable to high global rice prices. Production of millet, sorghum, and rice, Senegal's staple crops, rarely meets the country's demand. Only in years of favorable rainfall does the country approach self-sufficiency in

millet and sorghum. The country's principal export crops are groundnuts and cotton. Groundnut production occupies roughly 40 percent of the land under cultivation and employs an estimated one million farmers, whereas cotton covers close to a third of cultivated land. Both groundnut and cotton production levels have fallen markedly in recent years, and Senegal is increasingly losing its competitive edge in the export of these products to the United States. Further, groundnuts are progressively degrading the soil, and market prices have dropped significantly in recent years. Cotton prices have also plummeted, and farmers are increasingly switching to food crops that generate higher market prices. On a more positive note, exports of fruits and vegetables—the production potential of which is high, especially along the Senegal River valley—have been increasing to Europe in recent years , mostly in the form of green beans, cherry tomatoes, mangoes, and melons (Ndiaye 2007).

In 2005, Senegal's head of cattle was estimated to be more than three million, and sheep and goats numbered more than four million each. Most cattle-breeding systems are nomadic, and herders move throughout the country in search of pasture. Despite significant livestock population, Senegal remains a net importer of meat, especially (live) sheep during major holidays and religious events. Senegal's milk production is also far below its domestic needs. Poultry production has increased since the 2005 ban on the importation of chicken meat, and this subsector has great potential for further growth. Senegal exports large quantities of chicken meat and day-old chickens to neighboring countries (Ndiaye 2007). Most chicken feed inputs, however, are imported (maize and soy).

Senegal's fisheries subsector has historically been one of the country's largest sources of foreign currency. Seafood represents close to a quarter of Senegal's exports. Industrial fishing consists of sardines, tuna, and trawler harvests (shrimp, mullet, sole, cuttlefish, and so on). Artisanal catches are mainly destined for the local market, with a large proportion purchased for processing by local factories. The fishing industry is also a key subsector for employment. At the local level, thousands of families depend on fish as a nutritional staple. The European Union (EU) is the largest market for Senegal's seafood exports. Various agreements with the EU allow its fishing craft access to Senegalese waters, while setting export quotas and limits, and requiring that part of the catch, especially tuna, is supplied to local processing industries (Ndiaye 2007).

GOVERNMENT POLICY ON AGRICULTURE

Initiatives to Revive Agriculture

In recent years, the Senegalese government has launched various policy initiatives to revive the country's agricultural sector after decades of highly fluctuating production levels, underperformance, and stagnation. The three most-prominent initiatives are discussed below. The government also launched various sector-specific programs related to maize, cassava, sesame, hibiscus, rice, and sunflower as part of its production diversification strategy, and introduced a number of subsidy programs for seeds, fertilizer, and agricultural machinery with a view to modernizing the sector.

The Agriculture, Forestry, and Livestock Act (LOASP)

The Senegalese government adopted LOASP in 2004. The Act defines guidelines for the development of the agricultural sector and the reduction of poverty for a 20 year period, explicitly targeting the objectives of increasing agricultural exports and improving the quality of products destined for export, as well as establishing a system of incentives for private investment in agriculture and rural areas. In addition to strengthening farmers' land-use rights, the Act also secures their legal status, thereby allowing them to receive increased social security payments and attend a vocational training program tailored to their needs. Likewise, the State's role in agricultural research and sustainable soil management is strengthened under the Act. It must be noted, however, that the Act has received considerable criticism, not only by farmers' organizations, but also by public interest groups and some donors. Many people contend that

LOASP sets unrealistic targets and grants too much power to the government, and as such is detrimental to local communities (Mbaye 2005).

The Great Push Forward for Agriculture, Food, and Abundance (GOANA)

In April 2008, after two consecutive rainy seasons with low rainfall prompted the onset of high food prices and subsequent food riots, the President of Senegal launched GOANA with the objective of achieving food self-sufficiency for Senegal by 2015. To this end, the plan set ambitious yearly production targets for the country's main food and export crops, as well as for dairy and meat (Table 1). Rice production was set to grow by more than 250 percent in one year, while cassava production was targeted to grow nearly tenfold, and groundnut production was slated to triple. GOANA's 2009/10 targets were set at similar levels.

Table 1. Production targets for Senegal's main crops under GOANA, 2008/09

	Production in 2007/08	Target for 2008/09	Increase
Crop	Thousand metric tons		Percent
Rice	195	500	256
Maize	160	2,000	1,250
Millet	320	1,000	313
Sorghum	100	500	500
Fonio	1	25	2,500
Cassava	310	3,000	968
Groundnuts	330	1,000	303
Cotton	45	60	133
Horticultural crops	570	720	126

Source: Ministry of Agriculture 2009.
Note: Fonio is a small species of millet.

GOANA, valued at 345 billion CFA francs, provides farmers with equipment and heavily subsidized seeds (75 percent) and fertilizer (50 percent). The initiative also makes 500,000 hectares of so-called *Domaines agricoles partagés* or irrigated land available to farmers at no charge. GOANA promotes private-sector production of certified seed from several high-yielding varieties developed by the Senegalese Agricultural Research Institute (ISRA). Though targets were not reached for all crops, to date GOANA is generally regarded as a success. In 2009, cereal production was up 125 percent from the previous year, and the cultivated area of many crops had risen considerably: fonio, a small species of millet (242 percent), rice (56 percent), sorghum (60 percent), maize (51 percent), and millet (29 percent). In addition, the availability of higher quality seeds caused the per hectare yield of various crops to improve significantly: 67 percent for maize, 65 percent for millet, 56 percent for sorghum, 35 percent for rice, and 21 percent for fonio (Ministry of Agriculture 2009). Some critics argue that increased rainfall was the main reason for the productivity increases during 2008/09, whereas others assert that official government production levels have been grossly overstated. Nonetheless, the Secretary General of the United Nations, Ban Ki-Moon, cited GOANA as a model response to the global food crisis.

Return to Agriculture (REVA)

In response to increasing rural migration and emigration, the Senegalese government launched REVA in 2006 with the objective of developing agricultural infrastructure (constructing rural roads, rehabilitating wells, and connecting

electricity) and providing training and production tools and equipment to young farmers and female farmers, especially former illegal emigrants. This plan is gaining increasing support from donors.

Laws and Administrative Framework of Regulations in the Agricultural Sector

Senegal's agricultural sector is organized and administered through several ministries, including the Ministry of Agriculture; the Ministry of Mining, Industry, Agro-Industry, and Small and Medium Companies; the Ministry of Livestock; and the Ministry of Higher Education and Scientific Research. The Ministry of Agriculture oversees various directorates discussed in more detail below. One of the mandates of the Ministry of Mining, Industry, Agro-Industry, and Small and Medium Companies is to advance and increase the competitiveness of Senegal's agricultural industry. The Ministry of Livestock operates several services that delegate government support and control to the livestock, dairy, and poultry subsectors. The Ministry of Higher Education and Scientific Research administers biotechnology regulations and development, and oversees agricultural R&D carried out by the country's universities.

Three main bodies oversee food safety regulations, phytosanitary measures, and the control of crop and animal pests and disease. The Directorate of Domestic Trade is primarily responsible for the enforcement of food safety regulations and carries out phytosanitary inspections for food products that enter Senegal. Currently no regulatory system or institution is in place to approve or control the importation of biotech food products, although draft regulations require the labeling of biotech ingredients in feed and food. The Senegalese Standards Association is responsible for food standardization and a national system of certification. The Association develops and manages food and phytosanitary standards; provides information; raises awareness; and organizes training to industry on food-quality requirements, methods, and procedures to distributors, consumers, and government officials (USDA 2009). Through its Division of Phytosanitary and Quality Control, the Directorate of Plant Protection (DPV) enforces the application of measures and standards related to plant protection, pest control, and the prevention of plant quarantine diseases. DPV provides port and airport control services for all plant and seed materials entering Senegal. Other government services enforcing food-quality standards include the Directorate of Animal Husbandry, for animal products; the Directorate of Oceanography and Fisheries, for fish and seafood products; and the National Hygiene Service in association with the Ministry of Trade's Division of Consumption and Quality, for the control of hygiene and the protection of consumers (USDA 2009). Public agencies involved in food-safety assessments include ISRA, the Food Technology Institute (ITA), and the Pasteur Institute.

A large number of Senegalese laws and decrees regulate the quality control of food products, agricultural trade, competition, and seed registration and protection. However, some of these laws are not strictly enforced due to a lack of equipment and personnel. Among the most important laws and decrees are:

- Laws 66-048 and 68-507, specifying the conditions for controlling imports and measures for the use of food products;
- Law 68-508, setting the procedures for control, sampling, risk assessment, seizure, and repression of frauds;
- Law 94-038, regulating seed variety registration and protection;
- Law 94-063, which sets out competition rules;
- Law 94-081, setting the procedures for the inscription of varieties, seeds, and seedling production, certification, and trade;
- Decree 60-121, regulating phytosanitary measures applied to (parts of) plants entering or exiting Senegal;
- Decree 99-259, regulating quality control of horticultural products;
- Decree 69-891, which controls the quality of milk and other dairy products;
- Decree 89-543, regulating the sanitary and hygiene inspection of animal products used for meat production, meat, and meat byproducts; and

- Decree 62-132, regulating the sanitary and hygiene inspection of fish and seafood products.

Agricultural Innovation Policies

The Government of Senegal recently enacted policy reforms to improve agricultural productivity and stakeholder participation in the agricultural value chain. Key among the changes was market liberalization, paving the way for increased private-sector participation, which has led to the privatization of a number of state-owned enterprises. Increasingly, the State's role is becoming an a regulatory one focusing on agricultural statistics, soil protection, agricultural R&D, producer capacity, and seed-quality control and certification (Mbaye 2005).

Senegal is a member of World Intellectual Property Organization and of the African Intellectual Property Organization, which was established in 1977 under the Bangui Agreement among 16 francophone African countries: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Senegal, and Togo. The Organization's mission is to apply common administrative procedures to protect intellectual property in each member state. Trademarks, industrial designs, and patents are regulated by specific national legislation referring to the 1997 Banjul Agreement on trademarks, patents, and industrial designs (USDA 2009). The Ministry of Mining, Industry, Agro-Industry, and Small and Medium Companies supervises industrial and intellectual property rights in Senegal through its Industrial Property and Technology Service.

The Senegalese government is often criticized for lacking clear direction in the design and implementation of agricultural innovation policies. Critics assert that research coordination is dispersed across too many ministries, and linkages between ministries are weak, leading to the duplication of activities. The coordination of scientific research at the ministerial level underwent significant restructuring in recent years. For a short time, scientific research fell under the Ministry of Biofuels, Renewable Energy, and Scientific Research, after which it was moved to the Ministry of Higher Education, Universities, and Scientific Research, which has limited power in setting the country's agricultural innovation agenda. Though the Ministry of Agriculture and the Ministry of Higher Education, Universities, and Scientific Research have formally agreed to cooperate more closely, linkages between the two ministries have remained weak (Stads and Sène 2010).

Despite this lack of ministerial-level coordination, linkages among public agricultural R&D agencies and between the public and private R&D entities are closer. The 2000 establishment of the National Agricultural and Agro-Alimentary Research Fund (FNRAA), Senegal's principal mechanism for funding public agricultural research projects, promoted cooperation among the country's agricultural R&D agencies. The fund mandates collaboration by a minimum of two institutions, but more than 80 percent of projects approved during its first phase had at least three partners. FNRAA also promoted public–private research partnerships (Stads and Sène 2010). Laws 94-038, 94-063, and 94-081, described above, also stimulated private-sector innovation. In addition to the discussion that follows below, Appendix A provides a more complete overview of government policies and how they affect decisions relating to private research and innovation in Senegal. Although the country has numerous official policies in place, many of them are not actively pursued or enforced, so the impact of some policies remains limited.

Seed Policy

Until the 1990s, seed regulations in Africa were generally organized around public programs, and laws were mostly limited to restrictions on imports and exports. Little coordination occurred among countries, regulations were often heavily influenced by the respective financiers, and very little concrete action was taken. However, since the 1980s, trade liberalization combined with the actions of multinational seed companies eager to expand their businesses into a large number of countries have led to the rapid development of seed regulations and laws, which have been harmonized regionally to facilitate trade. In West Africa, a number of overlapping processes are taking place.

- The Economic and Monetary Community of West Africa (UEMOA) is preparing a seed regulations initiative. It could reach more countries if the proposed merger with the Economic Community of West African States (ECOWAS) eventuates.
- The International Institute for Tropical Agriculture coordinates the West Africa Seed Network, which develops model laws that participating countries can adopt.
- The International Fertilizer Development Center (IFDC) completed a two-year program for the United States Department of Agriculture and the Association of American Seed Trade Association that led to a national action program to support the enactment of laws to protect plant varieties and to facilitate regulations on genetically modified organisms and the harmonization of seed regulations in the region.
- The Committee on Drought Control in the Sahel (CILSS) prepared a regional catalog of seeds and a draft framework for the harmonized regulation of conventional and GM seeds. These processes are increasingly being integrated into relevant operations and political goals.
- The West Africa Seed Alliance streamlines and standardizes national seed laws and regulations in Benin, Burkina Faso, Mali, Niger, Nigeria, Senegal, and Togo (CNFA 2010).

These West African national processes will eventually form a compulsory regional catalog that harmonizes certification standards such that a seed variety registered in one country will automatically be approved in all UEMOA countries and potentially in all ECOWAS countries, if the two economic blocs merge (GRAIN 2005). Nevertheless, commitment to the implementation of seed regulations differs widely across countries; in some, implementation mechanisms are lacking, whereas in others regulations are not backed by law. In Senegal, regulations are legally implemented (Asiedu 2002).

The government strictly controls new varieties released in Senegal by local or foreign seed companies. Senegal's Seed Department (DISEM), under the Ministry of Agriculture, is responsible for controlling and certifying seed quality. ISRA tests newly released seed before it can be sold at local markets. This is strictly enforced for groundnut and millet varieties, as well as for potatoes and onions. Farmers who wish to import seeds from abroad must first obtain government authorization. In reality, however, unapproved or banned seed enters Senegal illegally, and some critics say that the government's enforcement of competition laws is too weak. Senegalese seed companies, which pay large sums of money for compulsory tests and wait years for official ISRA approval to release seeds, complain that corrupt government officials allow cheap imitation seed from China to reach the market, bypassing the rigorous testing process. DPV assesses which food imports are authorized, and a phytosanitary certificate is required for all plant imports. Quarantine is allowed only in sites approved by the Inter-African Phytosanitary Council.

As previously mentioned, GOANA subsidizes the cost of certain seeds. Groundnuts receive the highest subsidy, cutting the seed price by 75 percent, which has contributed to improved groundnut yields (a 36 percent increase during 2008/09). In 2008/09, an estimated 71,000 metric tonnes of subsized groundnut seeds were sold to farmers, and in 2009/10, the estimate was 50,000 metric tonnes. This, however, has only satisfied around 38 percent of the country's seed demand (Sylla 2009). Access to subsidized seed was particularly difficult for farmers in remote areas; some seeds were distributed late, and farmers complained that supplies of subsidized fertilizer were insufficient. Other farmers reported that they had no access to subsidized seed. For these reasons, the effectiveness of the groundnut subsidy program has been questioned (Ndiaye 2009).

Agrochemical Policy

Pesticides are a significant source of environmental toxins affecting both human and ecosystem health. In order to effectively manage pesticides (particularly their illegal transport), West African governments have put in place a number of subregional and bilateral initiatives. A Common Regulation for Pesticide Registration, which was established under

CILSS, covers all member countries (Burkina Faso, Cape Verde, Chad, Guinea Bissau, The Gambia, Mali, Mauritania, Niger, and Senegal). This common regulation provides for the registration of all pesticides entering the Sahel region to be performed by a central committee of experts, called the Sahelian Pesticide Committee. Harmonized tests and field trials have been established, and regional laboratories for conducting various pesticide-related analyses have been identified (UNEP 2010). Senegal also adheres to Codex Alimentarius pesticide residue standards and a few specific national standards for the assessment of food safety. The sale or distribution of agrochemicals that are not approved by the relevant government services is banned. DPV maintains a list of approved and banned pesticides. Pesticides to be commercialized in Senegal for use in food processing and treatment must first be registered and accepted by DPV (USDA 2009). All new pesticides, livestock breeds, and medications released in Senegal must be officially approved by the Ministry of Agriculture or the Ministry of Livestock. ISRA, as a member of Sahelian Pesticide Committee, needs to test each new seed and pesticide released into Senegalese markets. The approval process can take two to four years and costs companies between 4 and 10 million CFA francs per seed or pesticide.

The Food and Agriculture Organization of the United Nations (FAO) supports an ongoing project to harmonize national legislation on pesticide management in the nine CILSS countries. Additionally, the Joint Senegal–Gambia Initiative on Pesticide and Pest Control provides a framework for the joint monitoring of the countries' common borders for illegal entry of banned pesticides. This initiative also stipulates that Senegal perform residue analyses on pesticides for the two countries, while The Gambia is required to formulate analyses (UNEP 2010).

The Pesticide Initiatives Programme (PIP) was launched in December 2007 to support horticultural producers in African, Caribbean, and Pacific (ACP) countries, including Senegal, to meet European Union (EU) pesticide regulations. Set up by the EU at the request of the ACP Group of States, PIP, which was implemented by the Europe–Africa–Caribbean–Pacific Liaison Committee, has two overriding objectives: (1) to enable ACP companies to comply with European food safety and traceability requirements; and (2) to consolidate the position of small-scale producers in ACP's horticultural export sector (UNEP 2010).

Fertilizer Policy

No world region has been able to expand agricultural growth, and thus tackle hunger, without increasing fertilizer use. Africa's soils, which have become the poorest in the world, severely hinder Senegal's ability to achieve food self-sufficiency. Fertilizer regulation in Senegal has undergone a series of policy shifts over the decades. Until the late-1980s, fertilizer use in Senegal was heavily subsidized and controlled by the State, costing more than 3 percent of the country's government budget. Large fiscal deficits and debt led Senegal to accept structural adjustment aid from the World Bank and the International Monetary Fund. Market liberalization, privatization, and fiscal deficit reduction ended the country's State monopoly on fertilizer import and distribution. Fertilizer subsidies were phased out, and overall fertilizer use declined by more than 25 percent in the five years following the subsidy's elimination (Minot 2009).

After 1995, attention turned from fertilizer subsidies to developing fertilizer markets. Private agro-input dealers were trained, and professional associations and codes of conduct were developed with technical assistance supported by the United States Agency for International Development (USAID) and carried out by IFDC and CNFA, a nonprofit organization based in Washington, DC, that promotes public–private partnerships (Minot 2009).

In June 2006, the Special Summit of the Heads of State and Government of the African Union (AU) adopted the "Abuja Declaration on Fertilizer for the African Green Revolution." All AU member states resolved to increase fertilizer use to 50 kilograms of nutrients per hectare by 2015 from 8 kilograms of nutrients per hectare (the continent-wide average at the time of the declaration). In 2007, Senegal's fertilizer use was just 2 kg per hectare, which was among the lowest levels on the continent—though it was similar to the usage levels recorded by many of the country's neighbors, including The Gambia, Guinea, Mali, and Niger (NEPAD 2007).

Previous initiatives undertaken at the regional level to boost fertilizer use have been ad hoc, with limited structure and planning. Now, each of Africa's regional economic blocs has structured agricultural input programs with clear goals and objectives. In West Africa, ECOWAS and UEMOA clearly recognize that national agricultural input markets are too small to foster a dynamic and competitive environment. In 2009, these two organizations jointly launched a five-year project, Marketing Inputs Regionally Plus, or MIR Plus, to facilitate the development of a regional agricultural input market. The promotion of a broader regional market that permits the free movement of agricultural inputs within the region without endangering public health or the environment, is likely to increase farmers' access to a more diverse and competitive range of products. MIR Plus is projected to increase yields of maize and rainfed rice in Ghana and Nigeria, and of irrigated rice in Burkina Faso, Ghana, Nigeria, Senegal, and Sierra Leone by 20 percent in 2013 (IFDC 2010). Concrete steps still need to be taken to translate MIR Plus into substantive changes in terms of policy and regulatory reforms, lower fertilizer prices, and, ultimately, increased fertilizer consumption.

GOANA comprises a program that subsidizes 50 percent of fertilizer prices, mostly for groundnuts, maize, millet, sorghum, and cowpeas. Prior to GOANA, fertilizer prices had increased considerably, resulting in a decline in overall fertilizer use. Unsurprisingly, the government-subsidized fertilizers under GOANA are highly sought-after by farmers; however, like demand for subsidized seeds, demand for fertilizer exceeds supply. Certain remote regions were reported to have no access to GOANA–subsidized fertilizer for various logistical reasons (Faye 2010).

Livestock Policy

Until the turn of the millennium, livestock never featured prominently on Senegal's agricultural development agenda. The 2001 launch of the National Livestock Development Plan (PNDE), which is implemented by the Department of Livestock and is closely linked to the country's Poverty Reduction Strategy Paper and LOASP, was set to break this trend. In reality, however, PNDE largely relies on ad hoc interventions (artificial insemination and breeding programs for dairy cattle, measures to curb cattle theft called "safeguard livestock operations", short-term suspensions of the sale of imported chicken legs, and so son), resulting in little change from the pre–PNDE situation (ISRA et al. 2004).

ECOWAS developed an agricultural strategy adopted by its governing bodies in 1982. The strategy includes various livestock-related policies including (1) creating or strengthening eight community centers for the production of selected local breeds of cattle, (2) supporting animal health programs in member countries, (3) applying biotechnology in the area of livestock, and (4) abolishing restrictions on trade in animal products and implementing a liberalization scheme on raw products, including livestock. The second ECOWAS livestock meeting, held in 2004, adopted guidelines on (1) the use of animal genetic resources, (2) emerging transboundary diseases, (3) the role of livestock in enhancing food security and the fight against poverty, and (4) the prevention and resolution of conflicts related to transhumance (that is, the transfer of livestock from one grazing ground to another). Efforts by countries have led to the adoption of a program of sustainable resource management and the control of pastoral transhumance in West Africa (ISRA et al. 2004).

Fisheries Policy

Over the years, Senegal's fisheries policy has become focused less on the development of artisanal fisheries and more on granting fishing licenses to foreign vessels or on the large-scale export of fish. Nonreciprocal advantages under the Lomé Agreements, which provide an export subsidy of 25 percent on all fisheries products (upgraded from an initial 15 percent on tuna) and authorize the entry of Senegalese fisheries products into European markets exempt of customs duties, have enormously boosted the country's fisheries exports. Senegal signed various preferential treaties with the EU and Japan that were economically successful in the short run but have had various negative long-term side effects. The coastal demersal (deepsea fish) stocks with high (mostly export) market value are now fully and even overexploited, creating serious risk of local market shortages (Abaza and Jha 2002).

In order to redress these problems, in 2006 Senegal began developing a fisheries and aquaculture action plan to reduce overfishing and protect artisanal resources. As a result, the preferential treaty with the EU was not renewed. Additionally, in September 2010, the fisheries ministers of various African countries, including Senegal, endorsed the Banjul Civil Society Declaration, which highlights key issues facing the African fisheries sector and offers recommendations on how to advance the Plan of Action for Sustainable Fisheries and Aquaculture under the New Partnership for Africa's Development (NEPAD) (CAMFA 2010).

PUBLIC-SECTOR AGRICULTURAL R&D IN SENEGAL

The public sector has traditionally dominated agricultural R&D in Senegal. ISRA, the country's main public agricultural research agency is administered by the Ministry of Agriculture and was established in 1974, replacing various French agricultural research agencies conducting crop, livestock, fisheries, and forestry research. In addition to a secretariat based in Dakar, ISRA encompasses five national research centers and laboratories, and four regional research centers located across the country's various agroecological zones. The Institute's broad mandate encompasses crop, livestock, forestry, fisheries, and socioeconomic research, which is organized within 17 research programs (Stads and Sène 2010). In the 1990s, ISRA underwent substantial restructuring associated with a number of World Bank–led projects. Further, a 1997 law gave ISRA greater managerial autonomy and created a holding company through which the Institute could market commercial research outputs, either independently or in partnership with the private sector (Stads and Sène 2004, 2010).

Based in Dakar and founded in 1963, the Food Technology Institute (ITA) is another public agency charged with agricultural R&D. ITA falls under the responsibility of the Ministry of Mining, Industry, Agro-Industry, and Small-and Medium Enterprises. It conducts research on the storage, conservation, and processing of agricultural products; develops new local food products; and assists in the quality control of food products. Other public agencies involved in agricultural R&D include a number of faculties and departments under the Université Cheikh Anta Diop (UCAD), *Université Gaston Berger*, and the Advanced National School of Agriculture (ENSA) (Stads and Sène 2010).

Public agricultural R&D in Senegal derives funding from a variety of sources, including national government allocations, donor contributions, development bank loans, and the sale of goods and services. During 2006–08, the national government directly funded 61 percent of ISRA's and 65 percent of ITA's expenditures. Donor contributions and development loans accounted for about a quarter of each institute's total funding, whereas the sale of goods and services accounted for 12 and 9 percent of ISRA's and ITA's funding, respectively (Stads and Sène 2010). The government primarily supports recurrent expenditures, such as salaries and other routine nondevelopmental expenditures; donor-related research programs cover institutional development, research programs, and resource development and management. Total donor and development bank support to ISRA has significantly contracted since the early 1990s in absolute terms. Rather than redressing this gap, government support also diminished during this period. ISRA's most important donors during 2000–08 included the World Bank, EU, African Development Bank, USAID, Government of France, and various international agricultural research centers supported by the Consultative Group on International Agricultural Research (CGIAR). The World Bank has been ITA's most important contributor since 2000. It funded the Agricultural Services and Producer Organizations Program (PSAOP), which has had a large impact on public agricultural R&D in recent years. Since its inception in 2000, PSAOP has focused on substantially increasing smallholder productivity, production, and incomes through technological change. The program is currently in its second of three phases. Specifically, it aims to promote (1) institutional reforms to ensure that agricultural services are more accountable, demand-driven, and cost-efficient, and to increase the private sector's participation in functions previously executed by the public sector; (2) the generation and transfer of technologies to sustainably improve agricultural productivity; and (3) the empowerment and capacity-building of producer organizations (Stads and Sène 2010).

Linkages between public research agencies and private, for-profit companies are strong in Senegal. ISRA carries out demand-driven research for a large number of private companies. In 2008, direct funding from the private sector accounted for 13 percent of the Institute's budget (Stads and Sène 2010). ISRA also carries out compulsory tests of new seed and livestock varieties and pesticides entering the Senegalese market through local or foreign companies. ITA also plays a leading role in the storage, conservation, and processing of demand-driven solutions for agro-industrial companies. Furthermore, ITA launched a variety of new products and actively seeks companies interested in commercializing such products.

As previously mentioned, PSAOP included the establishment of the competitive National Agricultural and Agro-Alimentary Research Fund (FNRAA), which promotes farmer and private-sector interests in setting agricultural R&D priorities. The introduction of FNRAA has also significantly promoted the involvement of the private sector. A rigorous selection process has been established based on reviews by peers and a scientific and technical committee. The participation of producer organizations is encouraged at all stages of the process to ensure that programs are relevant. FNRAA received 92 proposals during Phase I of PSAOP (2000–05), of which 30 were approved. Nineteen projects were funded under ISRA's leadership (63 percent) and 5 under ITA's leadership (16 percent). ISRA has become less successful in attracting FNRAA funding over time, whereas the higher education agencies (notably UCAD), the private sector, and producer organizations have secured increasing shares. The relative role of FNRAA was strengthened under Phase II of PSAOP (2006–10) not least due to contributions by the African Development Bank and the EU. The World Bank's contribution to FNRAA will reduce over time as it is intended that the government, donors, and the private sector will progressively increase their contributions to the fund's endowment and its operating costs (Stads and Sène 2010).

Despite the implementation of policies promoting participation by the private sector in agricultural R&D in Senegal, the private sector's role in technological development and agricultural innovation remains unclear. Consequently, the purpose of this study is to provide information to guide policymakers, donors, and private firms in more effectively promoting private agricultural R&D in Senegal. Little reliable data currently exists on how much private agricultural R&D and innovation contribute to increasing agricultural production, farm incomes, social welfare, or environmental sustainability. This report, therefore, broadly examines privately led agricultural R&D activities and investments in Senegal and the policy environment within which these firms operate.

PRIVATE-SECTOR AGRICULTURAL R&D IN SENEGAL

Survey Method

In order to assess the role of the private sector in Senegalese agricultural R&D and innovation, both primary and secondary data were collected. Secondary data were obtained through a literature survey of various documents including research reports, government documents, and websites. Primary data was collected in two stages. Key informants from regulatory bodies, agricultural associations, and private organizations were contacted and asked to provide an overview of private involvement in Senegalese agricultural R&D. They were also asked to assist the authors in identifying firms that conduct agricultural R&D for inclusion in the survey. Key informants were drawn from ISRA; the West and Central African Council for Agricultural Research and Development (CORAF/WECARD); the (former) Ministry of Biofuels, Renewable Energy and Scientific Research; and the Fisheries Directorate.

A total of 15 sample companies were identified and selected to participate in the survey, all of which reacted favorably to our request to complete a survey form comprising six sections covering the following areas:

- General information, including company size, ownership, and product information
- Information on innovations realized by the agricultural input industry; farms and plantations; and processors, supermarkets, and other purchasers of agricultural products

- 2001–08 time series data on R&D personnel, education levels, female R&D staff, and support staff
- 2001–08 time series data on salary expenditures, operating costs, capital investments, and registration fees for research activities conducted in-house; expenditures on outsourced R&D activities; and R&D spending on behalf of third-parties
- Information on the distribution of research staff by commodity and research theme
- Information on the influence of government policies on private-sector R&D and proposed policy changes to encourage private-sector involvement in agricultural research

Company Classification

The selected 15 sample companies were classified into six subsectors: plantation crops, horticulture, agrochemicals, fisheries, livestock and fodder, and agricultural machinery (Table 2). These subsectors guided the research team in identifying firms to interview and in preparing checklists to facilitate discussions with key informants selected from each category. A general questionnaire was provided to guide the interviews, and checklists were developed at the cluster level. Based on interviews with some of the companies, ISRA, and ITA, it is estimated that the current survey sample covers approximately 70 percent of private-sector agricultural R&D investments and staffing. Spending and capacity totals should therefore be scaled up by 30 percent to account for R&D efforts by the missing private entities.

Of the 15 companies surveyed, 10 were Senegalese-owned and headquartered, 3 were completely foreign-owned, and 2 were hybrids—that is, jointly owned by the government, the private sector, and foreign interests.

Table 2. Number of organizations surveyed by type of organization and primary activity

Subsector	Sample size	R&D focus
Plantation crops	3	Varietal development, plant breeding, cultivar improvement, bioethanol production, disease and drought resistance, and food processing
Horticulture	3	Seed production, postharvest processing, and production methods
Agrochemicals	2	Varietal development, disease and drought tolerance, and pesticide and fertilizer development
Livestock and fodder	2	Dairy production, fodder and fruit production, and importation of exotic livestock breeds
Fisheries	4	Postharvest processing and production methods
Agricultural machinery	1	Cultivation machinery, postharvest machinery, and production methods

Source: Compiled by authors based on survey data.

Private Companies Conducting Agricultural R&D

A more detailed overview of the principal private companies conducting agricultural R&D in Senegal, along with the innovation challenges they face, is provided below by subsector.

Plantation Crops

As discussed, groundnuts and cotton are Senegal's principal export crops, and private groundnut and cotton growers are widely recognized as the country's most innovative crop producers. These companies play a more important role than Senegal's public-sector agencies in releasing new varieties and in promptly providing high-quality solutions to crop

diseases. For the majority of other crops, private companies are less innovative, relying instead on ISRA and the CGIAR to provide improved crop varieties, and on multinationals for fertilizer and pesticide.

Suneor is the largest groundnut oil–producing company in the world. It was established in 2005 when the government-owned *Société nationale de commercialisation des oléagineux du Sénégal*, its predecessor, was privatized (although 19 percent of the company remains government-owned). Suneor buys groundnuts from a large number of small-scale producers at a price fixed by a commission consisting of members of the company, producer organizations, and government agencies. Linkages between Suneor and ISRA are strong. For example, ISRA released three new parasite-tolerant and highly productive groundnut varieties in 2010, and it has also been carrying out important research on regenerating degraded soils.

Established in 1974, SODEFITEX is the country's largest cotton company. In 2003, the French multinational Geocoton purchased a 51 percent majority share in the company, leaving the Senegalese government with 49 percent. SODEFITEX provides seeds, fertilizers, and pesticides to cotton farmers across the country. Like Suneor, SODEFITEX buys cotton from producers (mostly in the Casamance region and the east of the country) at a guaranteed price. However, given that food crops are generating higher market prices, many farmers have shifted from cotton to food crops in recent years. As a result, SODEFITEX has been forced to diversify its range of products, recently releasing new sunflower, sesame, and maize seed. Before Geocoton's buy-in, SODEFITEX worked closely with ISRA, and the two entities jointly operated a cotton research center in Tambacounda. Currently, however, most of SODEFITEX's research is carried out in-house. Nonetheless, important three-way collaboration exists among ISRA, SODEFITEX, and the Industrial and Agricultural Products Company (SPIA), one of Senegal's largest agrochemical companies. For example, ISRA entomologists test various cotton pesticides that SODEFITEX has requested SPIA to produce.

The Senegalese Sugar Company (CSS) is Senegal's oldest and largest sugarcane company. It was established in 1971 and is wholly owned by the Swiss-headquartered Groupe Mimran. Unlike Suneor and SODEFITEX, which buy produce from a large number of small producers, CSS owns 8,700 hectares of land in the Senegal River Valley. Its yearly production is around 900,000 tons of sugarcane, which yields roughly 100,000 tons of sugar. In addition to sugar, CSS also produces methanol, a biofuel that accounts for roughly 10 percent of the company's sales. In the past, CSS contracted most of its research needs to ISRA, but since the establishment of its own research laboratory (with the help of International Center for Agricultural Research and Development [CIRAD]), most of the company's R&D activities are carried out in-house. In addition to a research laboratory, CSS operates a greenhouse for trials at ISRA's center in Bambey and has various fields to test seeds, pesticides, and fertilizers. CSS also maintains close linkages with a number of agrochemical companies.

Horticulture

Senegal's principal horticultural crops include green beans, fruit, potatoes, and tomatoes. These crops are mainly grown along the coast, north of Dakar, as well as in the Senegal River Valley. Established in 1995, TropicaSem is the country's largest vegetable seed company and the only private company in West Africa that carries out research on the genetic improvement of vegetables. In recent years, it released an important number of eggplant, carrot, okra, lettuce, and onion varieties that have undergone compulsory testing by ISRA. The company operates a research station in Dakar and a trial field in Khombol. It also maintains additional local research stations in Burkina Faso, Côte d'Ivoire, and Madagascar to cover a wide variety of agroecological zones. TropicaSem is one of the few companies in Senegal that has protected the property rights of all the new seed varieties resulting from its own R&D activities.

The Canned Food Company of Senegal (SOCAS), which has conducted tomato research in the Senegal River valley since 1979, provides seeds, fertilizers, and pesticides to the region's organizations for tomato producers. In return, the tomato growers sell their produce to SOCAS at a pre-arranged price. SOCAS imports tomato seeds from large

multinational seed companies, tests the varieties under Senegalese conditions (in collaboration with ISRA), and releases new varieties each year. In recent years, SOCAS diversified its activities to include green beans for the export market.

Grands Domaines du Sénégal is a French-owned company involved in fruit and vegetable exports to Europe and the United States. It has been active in Senegal since 2003, and in recent years has realized several new sweetcorn, pepper, asparagus, and green bean varieties through local research efforts. It has also introduced "hors-sol" production methods (a form of intensive farming) and innovative ways of fighting vegetable pests through the use of greenhouses.

In recent years, Senegal has made great progress in expanding the export potential of its horticultural subsector. To maintain the quality and increase the value of fresh produce, a new warehouse for fresh produce was built at Dakar's airport, along with other infrastructure to improve storage and transportation to Europe. The subsector nonetheless continues to face many logistical challenges and needs to improve package requirements for the European market. In addition, it will need to work with regional partners to harmonize phytosanitary standards and procedures; strengthen pest surveillance and detection capabilities, including border inspection operations; develop risk assessment capability; and overcome other bottlenecks related to regulatory issues and trade (Ndiaye 2007).

Agrochemicals

The Chemical Commercialization Company (SENCHIM) and SPIA, Senegal's main fertilizer and pesticide companies, produce and import fertilizers, pesticides, and herbicides for cotton, groundnuts, rice, tomatoes, and other crops. They also import vegetable seeds from abroad, treat them with pesticides or herbicides, and resell them locally. Some of the companies' pesticide and fertilizer research is outsourced to ISRA, whereas other research is carried out in-house. Few technologies are imported from abroad. SENCHIM and SPIA operate small research laboratories where they test the molecular composition of various fertilizers and pesticides. Despite its capacity to produce 250,000 tons of fertilizer per year, SENCHIM only produced 51,000 tons in 2008. As previously mentioned, fertilizers can be sold locally without major constraints, whereas pesticides are subject to rigorous, costly, and time-consuming tests. As a result, all rights of the pesticides released by SPIA over the past five years have been protected.

Fisheries

Fish is Senegal's principal export product; hence, a large number of (multinational) fisheries companies operate in the country. Much innovation has occurred in the subsector since the signing of Senegal's preferential fisheries treaty with the EU, previously discussed. Fish export companies now need to meet strict quality and hygiene regulations, and companies from China, France, Italy, and Spain—including Senegal Pêche, SOCAFROID, Sopasen, Blue Fish, Ikagel, and Marpêche—have introduced major improvements in shipping design, cooling techniques, packaging, and storage. Although these innovations are derived abroad, they gradually trickle down to Senegalese export companies.

According to FAO's definition, most of Senegal's innovations in the fisheries subsector are not considered "agricultural." ISRA is still the main agency involved in fisheries research, and fisheries companies operating in Senegal invest little in local R&D because most new technologies are generated elsewhere.

Artisanal production plays an important role in the fisheries subsector in Senegal, but because related innovations are particularly difficult to quantify, these products are excluded from further analysis in this report. In recent years, several large Senegalese fish processing companies have ceased operations because of Senegal's small and unproductive fishing fleet, the high costs of production, overexploitation and scarcity of high-value fish, and the lack of investment resources (Ndiaye 2007).

Livestock and Fodder

As with crops, agricultural R&D related to livestock is predominantly conducted by the public sector. ISRA is responsible for the majority of the country's livestock research (notably livestock genetic improvement and pest and disease control). The private sector plays only a limited role, but it does conduct research related to dairy cattle and the import of new and productive animal breeds from Europe. Saloum Agro-Élevage is a Senegalese-owned company that focuses mainly on livestock, but has limited involvement in the production of mango juice. The company exports animals to a number of countries in the subregion.

Unlike Saloum Agro-Élevage, Nouvelle Minoterie Africaine (NMA) is a multinational company mainly active in the field of fodder (and limited human food production). NMA operates a small laboratory to test fodder, but most of its R&D is outsourced to other companies. The company released a large number of new animal feeds in recent years, ther rights of which have all been protected.

Despite the recent increase in poultry production, no private companies were involved in poultry research.

Agricultural Machinery

Sismar is the largest company in Senegal involved in agricultural machinery. Its 1981 establishment was facilitated by the Senegalese government in order to contribute to the development of agricultural machinery and equipment, such as tractors, plows, harvesters, and threshers. Sismar produces machines locally and exports them to a large number of countries in the subregion. In recent years, Sismar has received increased competition from Chinese manufacturers. European manufacturers are not considered competitors because their prices are significantly higher. The company maintains close links with ISRA, AfricaRice, and SODEFITEX in developing its machinery. A recently developed maize milling machine was patented in Cameroon and widely adopted in the subregion.

PRIVATE-SECTOR CAPACITY AND INVESTMENT TRENDS

Human Resources for Agricultural R&D

The level of human resources allocated to agricultural R&D between Senegal's public and private sectors varies significantly. Many of the country's private companies operate with limited competition, a factor that discourages major R&D investment. Most companies lack long-term vision when it comes to the benefits of research, and many believe that investment is unnecessary because new technologies will come from the public sector or from abroad. Since private companies do not have extensive R&D infrastructure (laboratory facilities and scientists), only a few firms employ research staff, and only in small numbers. Many firms continue to rely on public-sector facilities (notably ISRA and ITA) for their research needs. Companies like Chocosen (chocolate), Satrec (dairy), and Kirène (bottled water), for example, outsource their research needs to ITA. ISRA maintains similar links with a large number of private companies and producer organizations. Unlike other African countries, large multinational seed companies do not play an important role in Senegal.

In 2008, the 15 private companies included in our survey sample employed a total of 38 full-time equivalent (FTE) agricultural researchers (Table 3), and more than a third of these researchers were employed at one of the three plantation crop companies (CSS, SODEFITEX, and Suneor). The four fisheries companies employed a combined total of 10 FTE researchers, and the two livestock and fodder companies (Saloum Agro-Élevage and NMA) employed a combined total of 8 FTEs. Private R&D capacity in the remaining subsectors was smaller; in 2008, the agrochemical companies, the horticultural companies, and the agricultural machinery company employed 5, 5, and 1 FTEs, respectively. (Note that all calculations of human resources are based on FTEs because they take into account the proportion of time staff spend on R&D activities, thereby excluding nonresearch-related activities; see Box 1 for more information).

Table 3. Long-term private-sector staffing trends in agricultural R&D, 2001–08

Subsector	2001	2002	2003	2004	2005	2006	2007	2008
	Full-time equivalent (FTE) researchers							
Plantation crops (3)	8.1	7.7	5.8	11.6	13.5	12.8	13.5	13.4
Horticulture (3)	3.7	2.3	2.3	2.3	2.5	3.6	4.6	5.0
Agrochemicals (2)	3.3	3.8	4.3	3.8	4.5	4.5	5.3	5.3
Livestock and fodder (2)	1.6	3.8	3.8	5.1	6.6	7.3	7.3	8.1
Fisheries (4)	9.9	9.9	9.9	9.0	8.1	8.6	9.5	9.5
Agricultural machinery (1)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total (15)	**27.5**	**28.4**	**27.0**	**32.7**	**36.1**	**37.7**	**41.1**	**42.2**

Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies included in each category.

Box 1. Measuring Agricultural R&D Resources

The Concept of Purchasing Power Parity (PPP) Prices

Comparing R&D data is a highly complex process due to important differences in price levels across countries. The largest components of a country's agricultural R&D expenditures are staff salaries and local operating costs, as opposed to capital investments, which are traded internationally. As examples, the wages of a field laborer or lab assistant at a research facility are much lower in Senegal than in any European country, and locally made office furniture in Senegal is considerably cheaper than a similar set of furniture bought in the United States.

Standard market exchange rates are the logical choice for conversions when measuring financial flows across countries; however, they are far from perfect currency converters for comparing economic data. At present, the preferred conversion method for calculating the relative size of economies or other economic data, such as agricultural R&D spending, is the purchasing power parity (PPP) index. PPPs measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. They are also used to convert current GDP prices in individual countries to a common currency. In addition, PPPs are relatively stable over time, whereas exchange rates fluctuate considerably (for example, the fluctuations in the US dollar–euro rates of recent years).

The Concept of Full-Time Equivalent (FTE) Researchers

ASTI bases its calculations of human resource and financial data on full-time equivalent staffing, or FTEs, which take into account the proportion of time researchers spend on R&D activities. University staff members, for example, spend the bulk of their time on nonresearch-related activities—such as teaching, administration, and student supervision—which need to be excluded from research-related resource calculations. As a result, four faculty members estimated to spend 25 percent of their time on research would individually represent 0.25 FTEs and collectively be counted as 1 FTE.

Sources: Beintema and Stads 2011; ASTI's website (www.asti.cgiar.org/methodology).

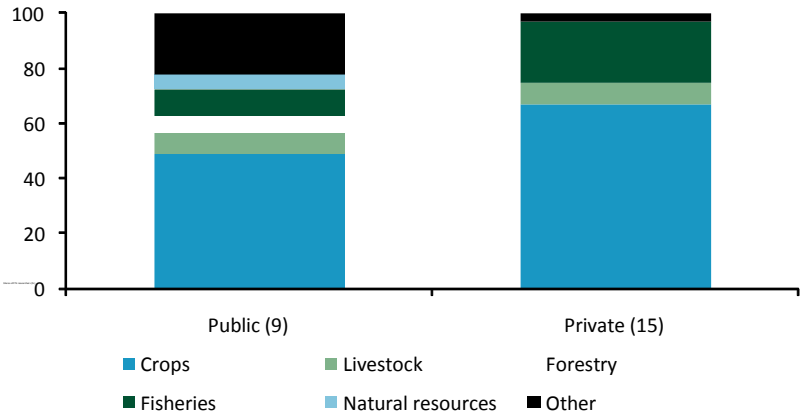
The total number of agricultural researchers employed by private companies grew by more than half during 2001–08. In 2001, the 15 sample companies employed a total of 28 FTE researchers, compared with 42 FTEs in 2008. Growth was particularly strong in the plantation crops and livestock and fodder subsectors and was largely driven by CSS and NMA, two companies that increased their in-house R&D capacities considerably after they opened new research laboratories.

Most of the growth in agricultural researcher numbers in the private sector in recent years was among those qualified to the MSc level. In 2008, the 15 private companies employed a total of 15 MSc-qualified scientists, compared with just 5 in 2003. The number of PhD/*doctorat*-qualified scientists increased from 16 to 18 FTEs during this period. As a result, the share of PhD-qualified researchers declined from 61 percent in 2003 to 44 percent in 2008.

Public- and Private-Sector Research Focus

Detailed information was collected on the number of FTE researchers working in specific commodity and thematic areas. In 2008, two-thirds of private-sector research focused on crops, with fisheries research accounting for close to a quarter, and livestock research for 8 percent of FTE researchers (Figure 1). Given the importance of the fisheries subsector as the major contributor to the country's exports, together with the growing presence of fisheries companies, it is not surprising that fisheries research accounts for a much larger share of private than of public agricultural research.

Figure 1. Public- and private-sector research focus by major commodity area, 2008



Source: Compiled by authors from survey data and Stads and Sène (2010).
Notes: Figures in parentheses indicate the number of agencies and companies in each category. "Other" includes postharvest research, socioeconomic research, agricultural machinery, and so on.

The Senegalese government actively prioritizes public research on food crops rather than export crops due to the importance it attaches to food security and food self-sufficiency. This priority is reflected in the contrasting shares of researchers by crop focus in the public and private sectors. In 2008, rice and millet accounted for 17 and 12 percent of all public crop and livestock research combined, respectively, while cotton and groundnuts accounted for 6 and 8 percent, respectively (Table 4). In contrast, the crops most researched by the country's private firms in 2008 were export and plantation crops, including sugarcane (23 percent), vegetables (16 percent), and cotton and groundnuts (14 percent each); food crops accounted for a very small share of private crop research.

Table 4. Crop and livestock research focus by major item, 2008

	Public sector (9)	Private sector (15)
Item	**Share of FTE researchers (%)**	
Crops		
Rice	17.3	2.5
Millet	12.3	0.2
Maize	8.9	8.4
Vegetables	6.7	15.7
Cotton	5.9	14.0
Bananas and plantains	6.3	—
Groundnuts	7.9	13.6
Cassava	5.9	0.0
Sugarcane	—	23.0
Other crops	15.4	12.1
Livestock	—	—
Beef	4.8	4.9
Dairy	4.8	3.0
Poultry	2.9	2.3
Other livestock	1.0	—
Total crop and livestock	100	100

Source: Compiled by authors from survey data and Stads and Sène (2010).
Note: Figures in parentheses indicate the number of agencies and companies in each category.

As previously discussed, Senegal has become increasingly competitive in the export of fruits and vegetables to Europe. In fact, a direct link may exist between increased exports and the doubling of R&D investments by the horticultural companies during 2001–08. In 2008, the horticultural companies accounted for more than 40 percent of total private investments in agricultural R&D in Senegal. This sharply contrasts 2001 levels, when the plantation crop companies (SODEFITEX, Suneor, CSS) dominated private R&D investments. In recent years, private-sector R&D on groundnuts and cotton has fallen, as have overall production values for these crops. The large increase in R&D investments over time by the livestock and fodder sector is also notable. NMA has considerably intensified its R&D efforts in recent years.

Table 5. Private-sector agricultural R&D expenditures, 2001–08

In-house expenditures	2001	2002	2003	2004	2005	2006	2007	2008
				Million 2005 CFA francs				
Plantation crops (3)	254.2	279.1	230.2	263.5	292.9	256.7	282.3	230.8
Horticulture (3)	153.7	168.6	213.2	217.4	281.1	329.5	329.9	357.2
Agrochemicals (2)	131.1	135.7	133.0	155.8	106.3	95.0	108.4	102.3
Livestock and fodder (2)	19.1	28.7	45.4	49.2	59.1	78.6	78.5	90.3
Fisheries (4)	14.1	14.4	16.7	16.4	20.6	18.6	19.7	17.1
Agricultural machinery (1)	7.7	7.3	7.2	7.2	7.4	8.4	8.7	9.9
Total (15)	**579.8**	**633.9**	**645.8**	**709.5**	**767.4**	**786.7**	**827.5**	**807.5**
				Million 2005 PPP dollars				
Plantation crops (3)	1.0	1.1	0.9	1.0	1.2	1.0	1.1	0.9
Horticulture (3)	0.6	0.7	0.8	0.9	1.1	1.3	1.3	1.4
Agrochemicals (2)	0.5	0.5	0.5	0.6	0.4	0.4	0.4	0.4
Livestock and fodder (2)	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4
Fisheries (4)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Agricultural machinery (1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total (15)	**2.3**	**2.5**	**2.6**	**2.8**	**3.0**	**3.1**	**3.3**	**3.2**

Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies in each category.

Looking at absolute numbers across sectors explains only so much. Another way of analyzing the relative power of organizations and sectors to innovate is by assessing the proportion of total sales revenues they invest in R&D. Sales figures were only available for 10 of the 15 sample companies and exclude Sodefitex, Sismar, and three fisheries companies. In 2008, Senegal's private-sector companies invested an average of 0.3 percent of their sales revenues in R&D (Table 6). Large differences existed across subsectors, ranging from 0.08 percent in the plantation crop subsector, to more than 1 percent at the agrochemical companies (SENCHIM and SPIA). The horticultural companies also allocated a relatively high share of their sales to R&D (0.94 percent). The relatively higher shares in the agrochemical and horticultural subsectors are not surprising given the need to continuously combat pests and improve fertilizers, on the one hand, and to comply with European sanitary laws on the other.

Table 6. In-house agricultural R&D expenditures as a share of total sales revenues, 2008

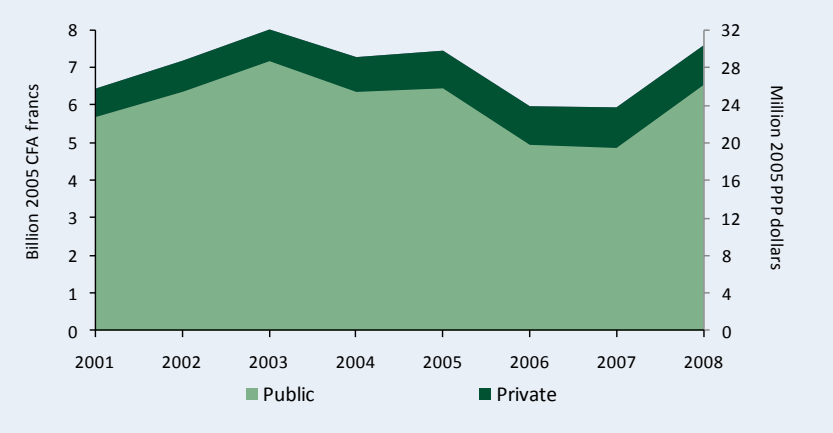
Subsector	Share (%)
Plantation crops (2)	0.08
Horticulture (3)	0.94
Seeds, fertilizer, and pesticides (2)	1.02
Livestock and fodder (2)	0.28
Fisheries (1)	0.11
Total (10)	**0.30**

Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies included in each category.

Public versus Private-Sector Agricultural R&D Spending

As previously mentioned, ISRA, ITA, UCAD, *Université Gaston Berger*, and ENSA are Senegal's principal public-sector agencies involved in agricultural R&D. Stads and Sène (2010) found that over the past few decades, public agricultural R&D in Senegal has relied heavily on donor funding, including consecutive World Bank-led projects. Reduced support by donors and the Senegalese government has led to a gradual drop in the country's overall agricultural R&D spending. In 2008, Senegal's public sector spent 6.5 billion CFA francs or 25.9 million dollars (both in 2005 PPP prices) on agricultural R&D (Figure 2). As explained above, it was estimated that private-sector spending levels should be scaled up by 30 percent to account for companies not included in our survey sample; doing so results in total estimated in-house expenditures of 1.0 billion CFA francs or 4.2 million dollars (both 2005 PPP prices) in 2008. Taking both public- and private-sector investments into account results in a grand total of 7.6 billion CFA francs or 30.0 million dollars in 2008 agricultural R&D expenditures (both in 2005 PPP prices). During 2001–08, the private sector's share of total agricultural research investments only increased marginally, from 12 to 14 percent.

Figure 2. Total Public and Private Agricultural R&D Spending, 2001–08

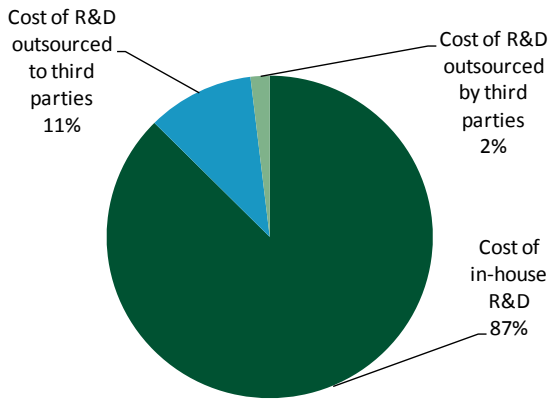


Source: Compiled by authors from survey data and Stads and Sène (2010).

The boundaries between public and private R&D investments are not always clear, however, as many companies outsource all or part of their research needs to public sector institutes on a contract basis. ISRA, for instance, reported that it conducts research on behalf of private entities, including SENCHIM, Suneor, Asprodep, SODEFITEX, CSS, DISEM, Sismar, TropicaSem, NMA, and SPIA, on an ongoing basis. This involves mandatory testing of seeds and pesticides, but many companies also outsource their R&D needs to ISRA, ITA, or one of the universities. ITA, for instance, plays a key role in postharvest research, food quality control, and the development of new products and technologies for a large number of private companies.

For the 15 sample companies, the bulk of R&D based on expenditures (87 percent) comprised in-house activities, while 11 percent represented research outsourced to third parties (mostly public agencies) (Figure 3). The remaining 2 percent represented research outsourced by one private company to be conducted by another. SOCAS, for instance, reported conducting (limited) research for Grands Domaines du Sénégal and Suneor, while Grands Domaines du Sénégal carries out some research on behalf of Syngenta. Similarly, Saloum Agro-Élevage outsources R&D to ITA, but also conducts research for livestock companies in The Gambia and Mali.

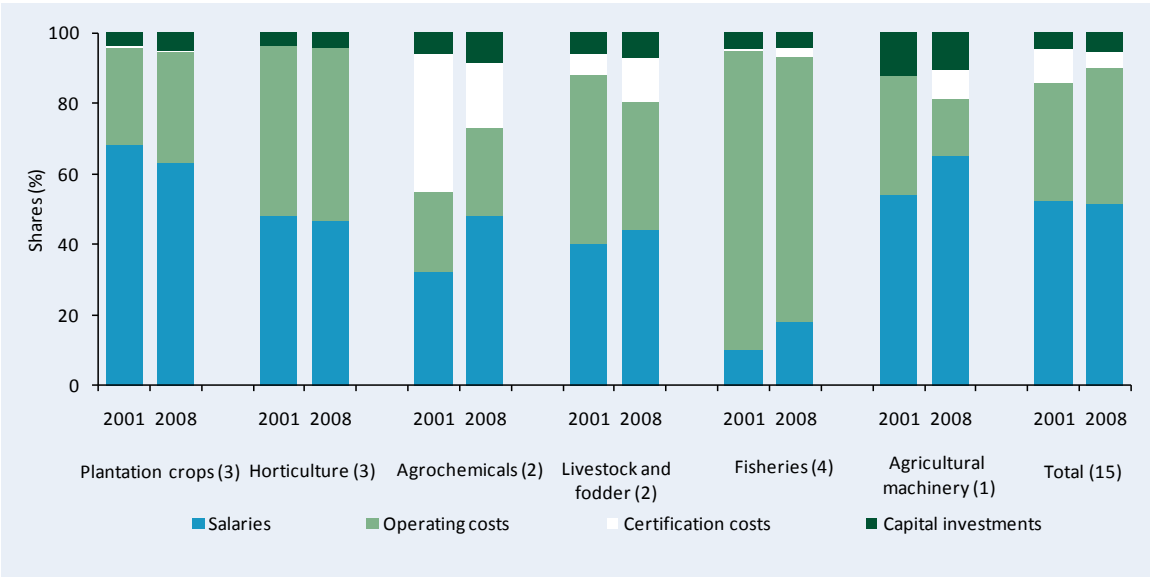
Figure 3. Private R&D spending by instigating party



Source: Compiled by authors from survey data.

The allocation of research budgets among salaries, operating costs, certification costs, and capital investments affects the efficiency of agricultural R&D, so detailed cost-category data were collected from the private agencies as part of this study. In 2008, salaries represented more than half of all private R&D expenditures by the 15 sample companies. Operating costs represented 39 percent; certification costs, 4 percent; and capital investments, 5 percent (Figure 4). These averages mask significant cross-sector variation. Salaries represented the highest share of costs in the agricultural machinery and plantation crop subsectors, whereas operating costs represented three-quarters of total R&D spending by the four fisheries companies. Certification costs were highest at the agrochemical companies, which is not surprising given the need for mandatory testing of every new seed or pesticide by ISRA. The share of certification costs has also risen in the livestock, agricultural machinery, and fisheries subsectors in recent years.

Figure 4. Cost-category shares by sector



Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies in each category.

Public–Private and Private–Private Partnerships

A key way to maintain and strengthen pro-poor research programs, given the climate of declining funding levels, is to promote research collaboration, partnership, and other forms of interaction between the public and private sectors to maximize synergies, promote innovation, and reduce duplication of effort. A new, diverse body of theoretical and empirical literature suggests that public–private partnerships are a constructive means of enhancing the production of goods, services, and technologies that would not otherwise be produced were either sector acting alone (Spielman and von Grebmer 2004). As previously mentioned, important collaborative linkages exist among private companies and between the public and private sectors, both at national and international levels. The 14 Senegalese companies for which data were available reported widespread collaboration with a large number of national and foreign public and private agencies. Eleven companies said they collaborated with ISRA or ITA or both (Table 7). Most of the plantation crop and agrochemical companies reported conducting joint R&D programs with ISRA, whereas the fisheries and livestock companies maintained closer linkages with ITA. Additionally, most companies (with the exception of those in the horticulture and agrochemical subsectors) worked closely with national universities. SODEFITEX, for example, reported close collaboration with ENSA in Thiès. International linkages (either with centers of the CGIAR or foreign private companies) were strongest in the livestock and fodder subsector. Saloum Agro-Élevage, for instance, has collaborative agreements with *Conseils et Compétences en Productions Animales* (France), Select Sires (United States), and S. A. Christensen & Co. (Denmark).

Table 7. Number of private firms collaborating with R&D organizations and firms

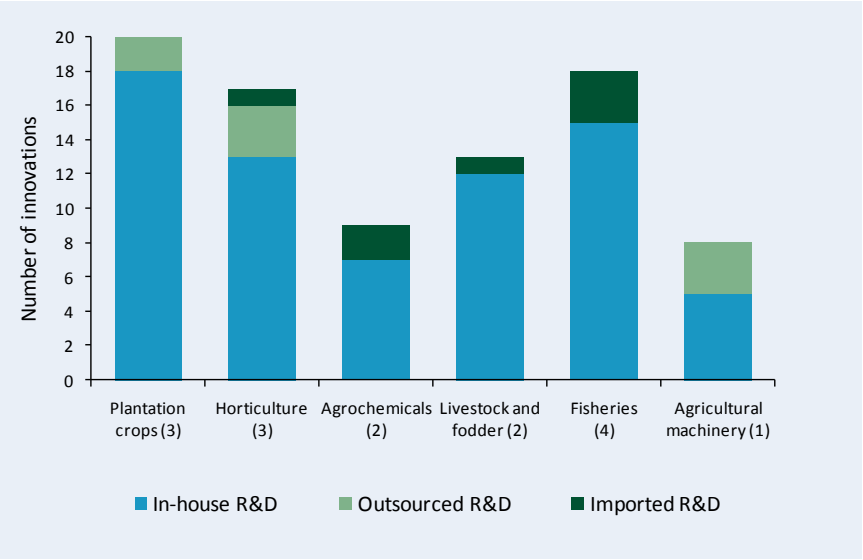
	Public				Private		
Subsector	National government R&D agencies	National universities	Other national agencies	Foreign government R&D agencies	Domestic companies	Foreign companies	Total
Plantation crops (3)	4	3	2	1	0	0	10
Horticulture (3)	1	0	0	1	2	3	7
Agrochemicals (2)	2	0	2	0	1	1	6
Livestock and fodder (2)	1	2	0	2	0	8	13
Fisheries (3)	4	2	0	1	3	1	11
Agricultural machinery (1)	2	2	0	1	0	1	6
Total (15)	**14**	**9**	**4**	**6**	**6**	**14**	**53**

Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies in each category.

Private-Sector Innovation

Each of the 15 firms included in our survey sample was asked to list at least five innovations (either new products or new technologies) introduced within the past five years (see Figure 6). A distinction was made between innovations resulting from the company's in-house R&D activities, R&D that was outsourced to third parties, and innovations that were imported from abroad. The number of reported innovations was highest among the plantation companies (23), the fisheries companies (18), and the horticultural companies (17) (Figure 5). Overall, innovations resulting from in-house R&D accounted for 80 percent of the total number of innovations reported; R&D from third parties accounted for 13 percent, and innovations through the importation of foreign technologies accounted for the remainder. Interestingly, the plantation crop and agricultural machinery companies reported that they imported no new foreign technologies; the agrochemical, livestock and fodder, and fisheries companies reported they did not outsource any of their R&D needs to third parties.

Figure 5. Sources of major innovation, 2005–10



Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies in each category.

The surveyed companies were also asked whether the innovations they reported had to be officially approved by the government, and whether they had been patented or otherwise protected. Once again, a significant degree of variation across subsectors emerged. Although the fisheries companies reported a large number of innovations, the majority of them did not require official government approval, and none of them had been patented (Table 8). Most of the innovations in the fisheries subsector were postharvest-related, including the peeling, cooling, storage, and packaging of fish. In the agricultural machinery subsector, all innovations had to be approved by the Senegalese government, and 2 of the 8 innovations reported by Sismar had been patented (a maize thresher and a maize processor). Government approval and patenting/certification are most common in the livestock and fodder and agrochemical subsectors. More than three-quarters of the innovations from the livestock and fodder subsector, and two-thirds of the innovations from the agrochemical subsector had been patented or protected. For example, SPIA's Fénical and Pyrical pesticides had been officially approved by ISRA and the Sahelian Pesticide Committee and the property rights thereafter protected. The approval process cost the company 4 million CFA per product and took four years. Similarly, the approval of SENCHIM's Neem and Malatrap pesticides took three years at a cost of 10 million CFA per product. Patenting and certification in the plantation crop subsector is less common; only CSS and Suneor reported having protected just a single type of sugarcane and groundnut seed each.

Table 8. Government approval and patenting/protection of innovations

Subsector	Number of innovations			Share of innovations	
	Produced	Government-approved	Patented/Protected	Government-approved	Patented/Protected
		Number		Percent	
Plantation crops (3)	23	6	2	26.1	8.7
Horticulture (3)	17	4	6	23.5	35.3
Agrochemicals (2)	9	8	6	88.9	66.7
Livestock and fodder (2)	13	10	10	76.9	76.9
Fisheries (4)	18	3	0	16.7	0.0
Agricultural machinery (1)	8	8	2	100.0	25.0
Total (15)	**88**	**39**	**26**	**44.3**	**29.5**

Source: Compiled by authors from survey data.
Note: Figures in parentheses indicate the number of companies in each category.

More than 70 percent of new cultivars registered in Senegal during 2005–09 were introduced by ISRA (Table 9). During this period, ISRA introduced 11 varieties of irrigated rice, 5 varieties of rainfed rice, 9 varieties of maize, 6 varieties of groundnut, and 6 varieties of sesame. The private sector, SODEFITEX, TropicaSem, SOCAS, and CSS in particular, played an important role in introducing cotton, sunflower, sugarcane, and horticultural varieties.

Table 9. Number of cultivars registered by the public and private sector for selected crops, 2005–09

Crop	No of cultivars registered	
	ISRA	Private sector
Maize	8	2
Rice (irrigated and rainfed)	16	–
Sugarcane	–	1
Cotton	–	2
Sunflowers	–	3
Groundnuts	6	–
Green beans	–	1
Tomatos	–	2
Sesame	6	–
Eggplant	–	1
Carrots	–	1
Okra	–	1
Lettuce	–	1
Onions	–	2
Total	**36**	**17**

Source: Compiled by authors from survey data.

MECHANISMS FOR CREATING A MORE ENABLING POLICY ENVIRONMENT FOR PRIVATE R&D

Each of the 15 companies included in our survey sample were asked what government policies would stimulate in-house innovation, what government policies would stimulate technology imports, and what government policies would stimulate in-house agricultural R&D (see Table 10 for a summary of the major recommendations by subsector).

Table 10. Recommendations on government policy to stimulate innovation, agricultural R&D, and the importation of new technologies

	Recommended government policies to enhance:		
Subsector	**In-house innovation**	**Importation of new technologies**	**In-house and outsourced agricultural R&D**
Plantation crops	• Increase seed and fertilizer subsidies to groundnut producers • Implement stricter quality control of groundnut oil imports to enhance quality of locally produced oil	• Organize more agricultural tradeshows	• Increase involvement of the private sector in the priority setting of research at ISRA and ITA • Establish a sustainable (competitive) fund that stimulates private sector R&D and interactions with the public sector
Horticulture	• Implement stricter enforcement of variety protection	• Reduce taxes on fertilizer, pesticide, and vegetable seed imports	• Shorten administrative procedures for seed and pesticide imports • Modernize subsidy policies on imports of agricultural inputs • Eradicate unfair competition caused by foreign companies selling unapproved seeds in Senegalese markets
Agrochemicals	• Implement stricter enforcement of environmental and health rules to prevent unapproved or banned agrochemical products from entering the market	• Implement subsidies to buy new technologies generated elsewhere.	• Enhance private-sector involvement of FNRAA–funded projects • Enhance involvement of private-sector in the priority setting of public-sector R&D • Cut taxes according to the size of a company's R&D budget
Livestock and fodder	• Cut livestock import subsidies, which are causing unfair competition	• Implement subsidies on imports of high-quality livestock semen • Enhance information on, access to, and training for livestock technologies available in developed countries	• Involve the private sector in public research priority setting. • Reduce Senegal's dependence on cereal imports could eventually increase locally conducted R&D on fodder.
Fisheries	• Cut taxes to stimulate R&D • Introduce an annual innovation award • Implement stricter enforcement of laws against overfishing.	• Lower taxes on technology imports • Keep closer watch of available technologies to enable Senegal's fisheries sector to become more competitive	• Increase involvement of fisheries companies in the priority setting of public-sector fisheries R&D
Agricultural machinery	• Reduce taxes on R&D equipment	• Enhance international cooperation in the field of agricultural machinery	

Source: Compiled by authors from survey data.

CONCLUSION

As in most developing countries worldwide, the private sector in Senegal is relatively underrepresented in the conduct of agricultural R&D. In 2008, private companies represented just 14 percent of the country's total agricultural R&D spending, with the public sector (mainly ISRA, ITA, and the universities) carrying out the vast majority. Since the turn of the millennium, the private sector's role has only marginally increased. The reasons for this limited private involvement in agricultural R&D in Senegal are manifold. Many private companies operate with limited competition, discouraging future R&D investment. Furthermore, most companies lack long-term vision when it comes to the benefits of research, and many believe that new technologies will eventually spillover from the public sector or from abroad, eliminating their need to invest their resources. A more enabling environment for private R&D needs to be created to change this perspective. A large number of companies mentioned that government policies and regulations (and their poor

implementation) hamper large-scale private R&D and innovation. Among those cited were the lengthy administrative procedures required to import agricultural inputs; the stringent regulations involved in registering and releasing new products; the lack of enforcement of laws to eliminate unfair foreign competition that disadvantages Senegalese companies; the widespread piracy of private innovations, and the lack of tax incentives to reward companies who invest in innovation.

Nonetheless, the Senegalese government has taken various measures in recent years to stimulate private participation in agricultural R&D and innovation. Regional seed, fertilizer, pesticide, and livestock regulations have been harmonized to reduce trade barriers in the subregion. Additional national initiatives, such as the establishment of the competitive fund, FNRAA, to stimulate private-sector involvement in R&D and the launch of the ambitious government plan to boost food production, GOANA, have provided tremendous opportunities to the private sector and have enhanced public–private partnerships in agricultural R&D and innovation. Though the Senegalese government identified food self-sufficiency as one of its top priorities, it is widely criticized for lacking a clear sense of direction in the area of agricultural innovation. Four different ministries are currently charged with setting the country's agricultural innovation agenda, and they often have overlapping and even conflicting mandates.

Despite the limited overall involvement of the private sector in agricultural R&D and innovation in Senegal, the private sector plays an important innovative role in key export areas. While the government sector dominates the country's agricultural R&D system when it comes to food crops, companies like SENCHIM, Suneor, SODEFITEX, and SPIA are major innovators in the groundnut and cotton subsectors, which provide Senegal with its principal export crops. In fact, these companies play a more crucial role than the public agencies in the release of new varieties and in providing timely, high-quality solutions to crop diseases. The horticultural and fisheries subsectors have also demonstrated their capacity to innovate in recent years. Innovations in food processing, storage, and packaging have enabled many Senegalese products to meet strict European quality and hygiene standards, boosting Senegal's exports in these areas. In addition, an increasing number of private innovations are being patented or protected otherwise, both locally and abroad.

The current study was the first of its kind to assess the role of the private sector in Senegal's agricultural R&D and innovation. Despite various limitations, the results provide a comprehensive overview of the private sector's role in generating and introducing new and improved agricultural technologies for Senegal's farmers and processors, as well as the policy considerations that need to be addressed if private technology generation is to be facilitated and enhanced. Nonetheless, more in-depth analysis is needed on the projected impact of changes in government policy on the level of private innovation, and on linkages between private innovation and improvements in food security and poverty levels. On this basis, an overarching recommendation arising from this study is for its existing dataset to be maintained over time, and for the number of sample companies to be expanded so that the dataset can continue to provide a useful source of information for the Senegalese government, donor organizations, private companies, and other stakeholders in setting both policy and priorities into the future.

REFERENCES

Abaza, H., and V. Jha. 2002. *Integrated Assessment of Trade Liberalization and Trade-Related Policies: A Synthesis Report. UNEP Country Projects—Round II.* New York and Geneva: United Nations Environment Programme.

Asiedu, E. 2002. *ATRIP: The African Trade Investment Program Policy Reform to Enhance Trade of Agricultural Inputs in West Africa.* Lomé and Nairobi: IFDC and AFSTA.

ASTI (Agricultural Science and Technology Indicators). ASTI Data Procedures and Methodology. <http://www.asti.cgiar.org/methodology>. Accessed December 2010.

Beintema, N. M., and G. J. Stads. 2011. *African Agricultural R&D in the New Millennium: Progress for Some, Challenges for Many*. Food Policy Report. Washington, DC: International Food Policy Research Institute.

CAMFA (Conference for African Ministers, Fisheries and Aquaculture). 2010. Banjul Civil Society Declaration. <http://www.camfa-cso.org/EN/docs/BANJUL_CIVIL_SOCIETY_DECLARATION_EN.pdf>. Accessed December 2010.

CNFA. 2010. CNFA expanding seed alliance to Senegal, Benin and Togo. <http://www.cnfa.org/news-a-resources/press-room/220-wasa-expansion?Itemid=109>. Accessed December 2010.

Faye, S. 2010. Des engrais fortement subventionnés mais insuffisants. <http://ipsinternational.org/fr/_note.asp?idnews=6123>. Accessed December 2010.

GRAIN. 2005. Loi sur les semences en Afrique: Un tapis rouge pour les sociétés privées. <http://www.grain.org/seedling_files/seed-05-7-6-fr.pdf>. Accessed December 2010.

IFDC (International Fertilizer Development Center). 2010. MIR Plus: Marketing Inputs Regionally Plus. <http://www.ifdc.org/Projects/Current/MIR_Plus>. Accessed December 2010.

ISRA, CIRAD, DIREL, and ODVS (Senegalese Agricultural Research Institute, International Center for Agricultural Research and Development, Department of Livestock, and Veterinary Society of Senegal). 2004. Pour des politiques d'élevages "partagées": Actes de l'atelier régional sur les politiques d'élevage. Dakar.

Mbaye, A. A. 2005. *Sanitary and phytosanitary requirements and developing-country agro-food exports: An assessment of the Senegalese groundnut subsector.* Agriculture and Rural Development Discussion Paper. Washington, DC: World Bank.

Ministry of Agriculture. 2009. GOANA. <http://www.agriculture.gouv.sn/index.php?option=com_content&view=article&id=86&Itemid=140>. Accessed December 2010.

Minot, N. 2009. Fertilizer subsidies in Sub-Saharan Africa. Presentation at the Fertilizer Policy Symposium of the COMESA African Agricultural Markets Programme (AAMP), Livingstone, Zambia, June 16, 2009.

Ndiaye, M. 2007. *Senegal Agricultural Situation: Country Report 2007*. Gain Report Number SG7001. Washington, DC: United States Department of Agriculture, Foreign Agricultural Service.

_____. 2009. *Senegal Agricultural Situation: Update 2009*. GAIN Report Number SG9001. Washington, DC: United States Department of Agriculture, Foreign Agricultural Service.

NEPAD (New Partnership for Africa's Development). 2007. *The Abuja Declaration on Fertilizers for an African Green Revolution: Status of Implementation at Regional and National Levels.* Policy Brief. Johannesburg.

Spielman, D., and K. von Grebmer. 2004. *Public–Private Partnerships in Agricultural Research: An Analysis of Challenges Facing Industry and the Consultative Group of International Agricultural Research*. EPTD Discussion Paper No. 113. Washington, DC: International Food Policy Research Institute.

Stads, G. J., and L. Sène. 2004. *Senegal*. ASTI Country Brief No. 26. Washington, DC and Dakar: International Food Policy Research Institute and Institut sénégalais de recherche agricole.

_____. 2010*. Senegal: Recent Developments in Public Agricultural Research.* ASTI Country Note. Washington, DC and Dakar: International Food Policy Research Institute and Institut sénégalais de recherche agricole.

Sylla, F. 2009. *Oilseeds and Products Annual Update 2009*. Gain Report Number SG9018. Washington, DC: United States Department of Agriculture, Foreign Agricultural Service.

UNEP (United Nations Environment Programme). 2010. Subregional Initiatives to Improve Pesticide Management in West Africa. <http://www.unep.org/dec/onlinemanual/Enforcement/InternationalCooperation/ConsistencyinLawsRegulations/Resource/tabid/1153/Default.aspx>. Accessed December 2010.

USDA (United States Department of Agriculture). 2009. *Senegal: Food and Agricultural Imports Regulations and Standards: Narrative.* GAIN Report Number: SG9013. Washington, DC.

APPENDIX A

Appendix Table 1. An assessment of government policies affecting private research and innovation decisions

Policies influencing innovation and R&D	Yes	No	Strong impact	Moderate impact	No impact
I. Regulations on Technology					
1. Plant varieties and biodiversity	X			X	
2. Seed quality control	X			X	
3. Biosafety regulations	X		X		
4. Pesticide regulations	X			X	
5. Farm machinery regulations		X			
6. Food processing regulations	X		X		
7. Food processing machinery regulations	X			X	
8. Poultry and veterinary health products regulations	X		X		
9. Labor regulations (agricultural and related)	X			X	
10. Food safety regulations (including labeling)	X		X		
II. Intellectual Property Rights					
1. Patents	X		X		
- Utility models	X		X		
- Petty patents	X		X		
2. Process patents					
3. Plant breeders rights	X			X	
4. Farmers' rights	X			X	
5. Trademarks	X		X		
6. Trade secrets		X			
7. Other					
8. Ability to enforce patents, trademarks, contracts in the judicial system (legal system present or infrastructure available?)	X		X		
III. Government financial support for private science					
1. Tax credits and subsidies for R&D processes		X			
2. Research parks and incubators	X			X	
3. Venture capital funds		X			
4. Any other innovative funding mechanisms?		X			
5. Infrastructure provision (export processing zones/special zones)	X		X		
IV. Trade and investment barriers on agricultural inputs and outputs					
1. Tariffs or other barriers on importation of machinery, chemicals, seeds, livestock, and so on	X			X	
2. Quotas/prohibitions on imports	X		X		
3. Most favored nation (MFN) status if any		X			
4. Technical standards on the importation of new technology	X			X	
5. Tariffs or other barriers on export of machinery, chemicals, seeds, livestock, and so on	X		X		
6. Quotas/ prohibitions on exports	X			X	
7. MFN status if any		X			
8. Technical standards on the export of new technology		X			
9. Restrictions on foreign investment in agr industry		X			
10. Government bans on exports or imports of the products that agr firms produce		X			

Appendix Table 1. Continued

Policies influencing innovation and R&D	Yes	No	Strong impact	Moderate impact	No impact
V. Government interventions in agricultural input and output markets					
1. State-owned enterprises for sales of inputs		X			
2. Commodity boards or state corporations for output purchase		X			
3. Government support price policies (for example, minimum support pricing)	X		X		
4. Government price controls on commodities	X		X		
5. Price controls on sales of inputs	X		X		
6. Antitrust policies/competition	X			X	
7. Government subsidies for farmer credit and purchases of agricultural inputs	X			X	
8. Government antimonopoly policy	X		X		
VI. Environmental regulations					
1. Air pollution standards	X			X	
2. Water pollution standards	X		X		
3. Carbon tax credits (caps and trade)		X			
4. Environmental and health regulations for new products	X			X	
5. Environmental and health regulations on the manufacturing or agricultural production practices	X			X	
6. Technical standards that governments require for introduction of new products	X			X	
VII. Nongovernmental certification systems					
1. Technology quality testing (ISO 9000 series)	X		X		
2. Organic certification		X			
3. Fair trade practices	X			X	
4. Sustainable certification		X			
5. Chlorofluorocarbon free	X				X
6. Animal friendly (testing)		X			
VIII. Universities provide training and adequate support to firms?					
1. Adequate scientist availability?	X			X	
2. Adequate technician availability?	X		X		
3. Adequate managerial capacity?	X		X		

Source: Devised by study team.

This paper on Senegal is part of a larger study on private agricultural innovation and R&D in eight countries of Sub-Saharan Africa and Asia that was undertaken during 2008–10 and was funded by the Bill and Melinda Gates Foundation. The study was collaboratively managed by the International Food Policy Research Institute (IFPRI), Rutgers University (United States), and McGill University (Canada). Other countries included in the study were Bangladesh, India, Kenya, Pakistan, South Africa, Tanzania, and Zambia.

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