AN EX POST ECONOMIC IMPACT ASSESSMENT OF BEAN/COWPEA CRSP'S INVESTMENT ON VARIETAL DEVELOPMENT IN SENEGAL

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ABSTRACT

AN EX POST ECONOMIC IMPACT ASSESSMENT OF BEAN/COWPEA CRSP'S INVESTMENT ON VARIETAL DEVELOPMENT IN SENEGAL

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The Bean/Cowpea CRSP has been funding the Institut Sénégalais de Recherches Agricoles (ISRA) since 1982 with the goal of developing improved varieties of cowpea. Cowpea is well suited to Senegalese production zones, and is a relatively inexpensive protein source. It can be eaten as both green pods, which are produced early in the growing season, or as dried seeds when harvested after full maturity. Yields of dry seeds are very low in Senegal, with an average yield around 340 kg/ha. ISRA has been working to develop improved higher-yielding varieties with resistance to drought, pests, and diseases. With this goal in mind, three improved varieties have been produced and extended among Senegalese farmers. A survey was commissioned in order to measure adoption rates for and yield improvements from the three varieties in the main cowpea producing regions of Diourbel, Thiès, and Louga. The sample adoption rate for CRSP varieties was 41.8%, with Louga having significantly higher adoption rates than the other regions. An economic assessment using regional adoption rates and yield improvements resulted in an IRR of 17.9% and an NPV of $78.6M. The benefit stream for the program largely comes from Louga, where the combination of high adoption rates, large yield improvements for improved varieties, and intensive production created benefit streams significant enough to offset costs early in the program life.

DEDICATION

To my parents, my wonderful girlfriend Elise, and the Diop family in Senegal.

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There are several people for whom I owe a debt of gratitude for the immense help that they have given.

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LIST OF ACRONYMS

ANCAR	Agence Nationale de Conseil Agricole et Rural
B/C CRSP	Bean/Cowpea Collaborative Research Support Program
CABMV	Cowpea Aphid Borne Mosaic Virus
CAEMC	Central African Economic and Monetary Community
CNRA	Centre National de Recherche Agronomique
DAPS	Direction de l'Analyse de la Prévision et des Statistiques
ECOWAS	Economic Community of West African States
ED	Enumeration District
FAO	Food and Agriculture Organization
IITA	International Institute of Tropical Agriculture
IMF	International Monetary Fund
IRR	Internal Rate of Return
ISRA	Institut Sénégalais de Recherches Agricoles
NGO	Non Governmental Organization
NPV	Net Present Value
WVI	World Vision International

CHAPTER I: INTRODUCTION

This chapter will present a short background for this following Plan B paper. The background will be followed by a description of the purpose of the study and the research objectives.

1.1 General Background

The Bean/Cowpea Collaborative Research Support Program (B/C CRSP), now known as the Dry Grain Pulses CRSP began in 1980, with the stated goal of collaborating with and providing funding for host country research institutes in order to develop improved common bean and cowpea varieties (Adams 2003). Since 1982, the B/C CRSP has been funding the Institut Sénégalais de Recherches Agricoles (ISRA) in the development of enhanced cowpea varieties. Cowpea is well suited to Senegalese production zones, where in-season drought is a common problem (Hall et al. 2003). The lack of adoption of improved cultivars in Africa is in part due to the fact that improved varieties will not express their potential in nutrient-limited soil (Sanchez 2002). Cowpea has been the focus of B/C CRSP in Senegal because cowpea is "a species well adapted to high temperature, drought and acid soil stress." (Graham et al. 2003, 108).

Cowpea is also important because it is relatively inexpensive compared to other protein sources (Mishili et al. 2009). Cowpea is also self-pollinating, meaning that it has a high carry-over rate, so farmers can maintain their own stock of seed grain for planting (Mazzucato and Ly 1994a, Tripp 2011). Additionally, cowpea cultivation is mainly undertaken by small-scale subsistence farmers (Coulibaly and Lowenberg-DeBoer 2002; Faye 2005), so benefits from improved varieties will largely be seen by poorer farm households.

The analysis in this paper is based on a survey conducted in the main cowpea-growing regions of Diourbel, Thiès, and Louga. In the 2010/2011 rainy season, the Direction de l'Analyse de la Prévision et des Statistiques (DAPS) in Senegal conducted a national survey on household income activities. The survey was very comprehensive in terms of obtaining information about cropping patterns, but while it collected information about aggregate cowpea yields, there was no differentiation between varieties beyond a question about whether the seed came from a labeled packet. In order to obtain more thorough information about cowpea varietal adoption patterns, cowpea farmers from the sample were re-surveyed, along with an additional sample of cowpea farmers from the same areas. These households were surveyed specifically on information related to their cowpea cropping patterns. This data will be used to document current adoption rates and welfare gains from improved varieties of cowpeas developed with B/C CRSP funding by Senegal's national research institute, ISRA.

While in the past ISRA has disseminated a number of varieties developed with resistance to local pests and diseases, three varieties have largely dominated extension efforts in the last two decades. Melakh and Mouride were created and disseminated in the early 1990s, and have been in use by Senegalese farmers for two decades. Mouride has a cream-colored bean and beige eyes, while Melakh has a white bean and a black eye (Boys et al. 2007). Both varieties have a short growth cycle (65 days for Mouride and 64 days for Melakh) (Cissé et al. 1997; Cissé et al. 1995), thus providing a harvest sooner than traditional varieties of cowpeas as well as staple cereal crops. Yacine, released in 2003, has a brown-colored bean, and was registered in 2005. Yacine is based on Melakh stock and has a slightly shorter 62-day maturity period (Cissé et al. 2005). This study will look at the adoption rates of all three varieties. Since Melakh and Mouride have been released for a significant amount of time, a literature exists addressing adoption rates and returns to research for B/C CRSP investment in Senegal regarding those two varieties (Boys et al. 2007, Schwartz, Sterns and Oehmke 1993). However, Yacine is relatively new and there is little-to-no available information about its adoption rate.

1.2 Purpose

The purpose of this paper is to measure the impact of B/C CRSP investment on the development and adoption of improved cowpea cultivars in Senegal. Analysis of survey results will provide answers regarding the adoption of improved varieties. Furthermore, these results will be used to calculate an Internal Rate of Return (IRR) and Net Present Value (NPV) for B/C CRSP investments. The adoption of improved varieties of cowpeas has significant implications in terms of program returns. Successful rates of return have been found in previous studies of B/C CRSP involvement in Senegal (Boys et al. 2007; Schwartz, Sterns, and Oehmke 1993). Presentation of the benefits will also provide a measure of value, both in terms of economic surplus generated and increased quantity produced, to the Senegalese economy from the program.

It is hoped that this will not only provide accountability for B/C CRSP investment, but will also contribute to the knowledge base. Accurate knowledge about farmer usage of varieties can not only help to assess the impact of funding, but also to guide future research and extension decisions by determining which varieties have the most adoption potential.

1.3 Research Objectives

There are several research questions that this paper intends to answer. The over-arching question is: what has been the impact of the B/C CRSP investment in Senegal? The main data points that must be investigated in order to answer the main research questions are: 1) How much of the total land devoted to cowpeas can be attributed to improved varieties? 2) How much of the total cowpea grain production is attributed to improved varieties? And finally 3) what is the yield gain from growing improved varieties of cowpea? The degree to which improved varieties have supplanted traditional varieties is important for informing both the success of extension efforts as well as net economic gains.

Additionally, reporting of descriptive data will allow an examination of what factors affect adoption of improved varieties. This includes household factors and farmer preferences regarding varieties. The answers to these questions can help inform whether varieties have been developed and targeted in a way that makes them desirable to farmers and improves the chance of adoption.

The adoption rate of a new variety is the most influential variable on the rate of return to a research program (Mazzucato and Ly 1994a, Walker et al 2008). In terms of performing an economic impact assessment, the rate of adoption recognized by the model defines adoption in terms of total area attributed to a variety. This is not to say that adoption on a per farmer basis is not an important consideration, and these will be presented along with area adoption rates. The Adoption rates (as a share of area planted), and the supply shift parameter (K), are calculated from a farm-level survey to conduct an economic impact assessment of B/C CRSP investment on cowpea research. This will help to establish the degree to which research on varietal improvements has contributed to the Senegalese economy and how efficiently.

CHAPTER II: BACKGROUND CHARACTERISTICS

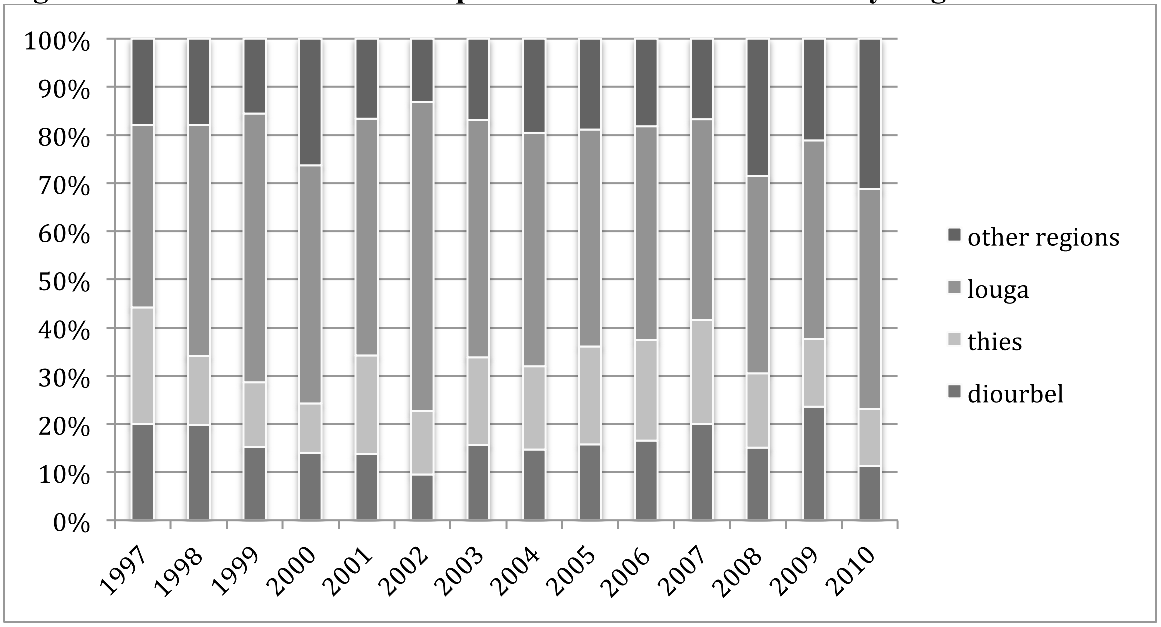
This chapter will be broken down into several sections explaining the characteristics of the cowpea sector in Senegal and the results of the literature review. The first section will define the geographic and climatic conditions of Senegal that contribute to crop patterns and farmer decisions in the study regions. The second section will describe the Senegalese market conditions and how they impact cowpea market and trade throughout the country. Section 3 will explain the process behind research and dissemination of improved varieties. Section 4 will describe the three main varieties released by ISRA and provide information from the literature on yield gains.

2.1 Senegal – Geographic and Climatic Conditions

The climate in Senegal is somewhat variable depending on the region. The south has a tropical climate, with the north being more arid. Peanuts are the main agricultural crop, both in tonnage and dollars. The largest concentration of peanuts is in the Peanut Basin in Central Senegal, which includes all or parts of the regions of Louga, Diourbel, Thiès, Kaffrine, Kaolack, and Tambacounda. Rice paddies are found in the wetter southern regions of Kolda, Kedougou and Ziginchour. Millet, maize, sorghum and cowpeas make up other field crops grown in the country. Senegal has a population of 12.53 m (2009), with 69.89% of the labor force in agriculture, and a landmass of 196.7 thousand sq. km (UNdata/United Nations; FAOSTAT/FAO).

Cabral (2010) found that small farmers in the peanut belt had the highest degree of food insecurity in Senegal, and living in the peanut belt had a statistically significant effect on increasing food insecurity. The Peanut Belt is where the large majority of cowpea in the country is grown, with Louga, Diourbel and Thiès accounting for 71.2% of countrywide production (34,814 t of 48,880 t) on 68.7% of the area (88,150 ha of 128,244 ha) in 2010 (CountrySTAT/FAO).

Figure 2.1: Annual Share of Cowpea in Total Area Harvested by Region



Source: FAO/countrySTAT

Cowpea can be an important tool in promoting food security because despite its low yield compared to cereal crops, it has the ability to function as a household food product, a cash crop, livestock fodder, and a nitrogen fixer (Tarawali et al. 2002). Cowpea can also help improve soil fertility, whether it is a sole crop or intercropped with another crop such as sorghum or maize (Olufowote and Barnes-McConnell 2002).

Figure 2.2: Map of Senegal

Source: http://mapsopensource.com

2.1.1 Louga

The Northern part of Senegal, encompassing Louga, is a Sahelian climate zone with sandy soil. It averages less than 300 mm of rainfall per year, lower than the more southern regions of the country. From 1970 to 1988, average rainfall was only 267 mm in Louga (Hall et al. 2003). Louga has around 6% of the country's population, on 12% of the landmass.

Income in Louga is more diversified than in the Central and Southern regions, with livestock being more important as a share of household income than in other regions (Kelly 1988). This has a very positive effect of increasing food security (Cabral 2010). Louga is the largest cowpea-producing region in Senegal, with 45.6% (58,487 ha) of all the cowpea area in 2010 and 40.0% of 2010 production. Average yield was 288 kg/ha between 1997 and 2010, with an average of 75,116 ha planted (CountrySTAT/FAO).

2.1.2 Thiès

The Thiès region is the second most populated region, with about 13% of the inhabitants of Senegal. It is a coastal region, with cooler temperatures and sandy soil, and averages 300-500 mm rainfall per year. The amount of land devoted to cowpeas has fluctuated in the last 15 years, with 11.9% of the 2010 area and 22.2% of 2010 production. Average yield from 1997-2010 was 306 kg/ha, and the average hectares planted were 27,919 ha. The 2010 yield was unusually high at 711 kg/ha (CountrySTAT/FAO).

2.1.3 Diourbel

Diourbel is the region west of Thiès, and is located in the center-west area of the peanut basin. Moderately high temperatures and sandy soil characterize the region. Rainfall averages 300-500 mm per year. In 2010, it held 11.2% of cowpea area and 9.0% of production. Average yield from 1997 to 2010 was 269 kg/ha with an average of 27,000 ha planted (CountrySTAT/FAO).

2.2 Cowpeas in Senegal – Production, Marketing, and Variety Characteristics

Since the 1980s, cowpeas have been slowly replacing peanut cultivation as rainfall has declined and government involvement in peanut marketing and extension has declined (Coulibaly and Lowenberg-Deboer 2002, 357). In 2010, Senegal produced 48,880 MT of dry grain on 128,244 ha, placing it at number thirteen in terms of global dry grain cowpea production (CountrySTAT/FAO). From 2006-2008, Senegal held 1.86% of the area devoted to cowpeas in the world (Akibode and Maredia 2012). While production appears to fluctuate significantly between years, 2010 production was largely average in terms of past production levels. While dry grain production is available by region, information on green pod harvesting is unavailable. Available data suggests that harvesting of dry pods is significantly higher than that of green pods, around a 1 to 8 ratio (Boys et al. 2007, 20).

Cowpea is grown as both a mono-crop as well as intercropped with cereals such as millet and corn, or with peanuts. Cowpea leaves are a nitrogen-fixer for the soil, and the dried plants produce valuable hay for animals. Green pods, which are edible within less than two months of planting, also serve as a source of income and food in the hunger season, before the harvest starts in late September and October.

According to farm budget estimates the costs, revenue and profits from a hectare of cowpeas in 1999 were $117, $237 and $121 respectively (Faye 2001, cited in Langyintuo et al. 2003). Faye (2005) calculated two methods of production costs for a farm in Senegal using two methods, the first assuming high quality inputs and pesticides, with the second involving only seed costs as well as well as harvesting and storage. Costs for first method in 2003 were $152 with 600 kg/ha produced, and the second at $15, with 167 kg/ ha produced. The price received for cowpeas changes depending on the season; average price in the highest price period ranges from 18 to 44% more than the price received in the main harvest month of November (Langyintuo et al. 2003).

Small-scale farmers in Senegal usually bring cowpeas to market to sell to wholesalers or traders (Faye 2005). Village buyers assemble cowpeas bought from farmers into 100 kg bags, and sell to merchants who transport and store the cowpeas (Coulibaly and Lowenberg-Deboer 2002). These village collectors do not sell to consumers, and instead sell to wholesalers and retailers, with the wholesalers selling to retailers and processors. The large majority of movement within the market happens between the collectors, wholesalers and marketers (Faye et al. 2000).

2.3 Cowpea Varietal Research and the Seed Value Chain

Improved varieties of cowpea seeds in Senegal are developed by ISRA. Crosses are created and selected based on resistances to pests and diseases, as well as for specific quality traits. Breeder seed is created in the Centre National de Recherche Agronomique (CNRA) in Bambey and supplied by ISRA. This breeder seed, defined as a pure line created by the breeder, is used to produce foundation seed, with the first generation produced by ISRA and farmer organizations taking over for the second generation (Tripp and Rohrbach 2001, 154; Ndjeunga, Kumar and Ntare 2000, B/C CRSP 2012). Currently ISRA only produces breeder seed for Melakh and Yacine, as well as two forage varieties, 5574 and 6635. ISRA also provides training on seed production. Demand for Seed exceeds supply, with ISRA production able to supply around 80-85% of the demand for breeder seed (Diatta 2012).

This foundation seed is then used to produce certified seed that can be distributed to farmers. Demand for foundation seed consistently outpaces supply, and the lack of foundation seed is a bottleneck preventing increased production of certified improved seed (Diatta 2012, B/C CRSP 2011). In 2010 alone, CNRA produced 1.113 T of Yacine and 1.379 T of Melakh breeder seed, and ISRA combined with farmer organizations produced 23.5 T of foundation seed, only 67% of the annual need (Diatta 2012, B/C CRSP 2012). The lack of available seeds has led to the formation of producer organizations under the guidance of NGOs, public Senegalese institutions such as ISRA, the national extension agency, Agence Nationale de Conseil Agricole et Rural (ANCAR), and the World Bank (De Janvry and Sadoulet 2004, Diatta 2012). World Vision International (WVI) has been an early partner in pre-release extension (Cissé et al 1995, Cissé et al. 1997).

Efforts are being made to move towards a more supply-and-demand-based model, with certified seed producers filling requests by organizations for certified seed, as opposed to ISRA (B/C CRSP 2011). This movement means that much of the certified seed is now produced by Producer Organizations (POs). Diatta (2012) summarized the ways in which these POs fit into the seed system, explaining that these organizations are not only a way to train farmers in seed production but also act as an intermediary between local producers and international actors. These organizations range from a diversified group of individual farmers with a loose arrangement, to community organizations that pool resources heavily. The seed is only certified if the farmer producing the seed follows the recommended production process. Farmers growing seeds for the POs do not necessarily closely follow the recommended process for producing seed, and so the amount of improved seed produced by the POs is not equivalent to the amount of certified seed that the PO produces. Because of this, the informal seed sector is fairly large, and there are no real official outlets where farmers can buy improved seed.

Nearly all of the cowpeas produced in Africa are traded within Africa (Langintyou et al. 2005). Unlike most other West African countries, Senegal is a net exporter of cowpeas, being the main supplier for Mauritania, Gambia and Guinea Bissau (Langyintuo et al. 2003), although Faye (2005) found that only around 1% of the cowpeas produced in Senegal were exported. Senegal is constrained by trading with the major markets of Ghana and Nigeria by the cost of transportation and inefficient market links (Coulibaly and Lowenberg-DeBoer 2002). Additionally, Senegal has a fairly developed cowpea-processing industry, with several companies producing cowpea-based products (Coulibaly and Lowenberg-DeBoer 2002).

In Senegal, cowpea is eaten in several ways. It can be ground down and fried in balls or pancakes. This is often eaten for breakfast, and is sold in markets by women. It can also be cooked into a soupy mixture, which is then poured onto millet or rice, or eaten with bread. This is often sold in the market for breakfast and to a lesser extent dinner. Women commonly mix cowpeas into lunch dishes, which is usually rice based and mixed with fish and vegetables, or peanut paste[1]. Green pods are eaten boiled, though green pod consumption is less common than dry grain consumption

There are several pests that cause significant damage to cowpeas in Senegal, among them the Cowpea Aphid and Thrips, both of which damage the plants prior to harvest and decrease yields. The Cowpea Weevil appears around harvest time and during storage if the grain is not properly stored. All three pests can severely impact the grain available to farmers both to sell and eat. Efforts to create improved pest-resistant varieties are important both for increasing yields and decreasing use of pesticides that are harmful to humans (Byerlee 1996). Among the diseases that affect cowpea are the Cowpea Aphid Borne Mosaic Virus (CABMV), Bacterial Blight, and Striga, a parasitic weed that has been common in recent years.

2.4 B/C CRSP Varieties

2.4.1 Mouride

Mouride is based on a cultivar originating from Podor in the north, as well as an improved International Institute of Tropical Agriculture (IITA) line. ISRA released Mouride in 1991, and in the summer of 1993 WVI distributed seed to 1000 farmers in Northern Senegal (Cissé et al 1995). The variety has resistance to the Cowpea Weevil as well as bacterial blight, CABMV and Striga. The variety flowers at 33 days with maturity at 65 days (Cissé et al. 1995). Mouride has a tested mean seed weight of 199 mg (Hall et al. 2003). In village trials, Mouride had a mean yield of 747 kg/ha (B/C CRSP 2001).

[1] Information on cooking methods are drawn from the author's personal experience, as well Faye (2005)

2.4.2 Melakh

Melakh was created from a similar breeding line to Mouride. It was pre-released in 1993 to 1000 farmers in Northern Senegal by WVI, and ISRA released the variety countrywide in 1996 (Cissé et al. 1997, Hall et al. 2003). The variety has resistance to the Cowpea Aphid, CABMV and bacterial blight, with partial resistance to cowpea thrips. It reaches maturity at 64 days (Cissé et al. 1997). Melakh has shown to be better resistant to late-season drought compared to Mouride, while Mouride is more resistant to mid-season drought (Hall 2004). Melakh has a mean tested seed weight of 243 mg, higher than that of Mouride as well the variety Ndiambour (Hall et al. 2003), an earlier improved variety. Farmers have rated Melakh seeds higher than Mouride (Hall 2004). In village trials, Melakh had a mean yield of 790 kg/ha (B/C CRSP 2001).

2.4.3 Yacine

Yacine is the most recently released of the major improved varieties. It was released by ISRA in 2003. Selected for resistance to the Cowpea Aphid, CABMV, and bacterial blight, it reaches maturity at 62 days (Cissé et al. 2005). Families rate Yacine as having a good taste, and its brown color is highly desired for cooking, a trait present in many traditional varieties (Diatta 2012, Cissé et al. 2005). The seeds produced are larger than Melakh seeds (Cissé et al. 2004).

2.4.4 Yield Potential and Profitability

Cowpea is grown in West Africa for grain and fodder; in the rest of Africa it is mainly grown for its leaves (Faye 2005). Yields in West Africa average 300 kg/ha, slightly lower than the Africa-wide average of 340 kg/ha (Faye 2005). On-farm yields of improved varieties have been reported as between 750 kg/ha and 1000 kg/ha (Cissé et al 2005). Cissé, et al. (2004) found in a study using six selective farms in the Thiès and Diourbel region that cowpea yields were very low, with only one farm producing more than 500 kg/ha with cowpeas. On-farm yields tend to be much lower than experimental yields since input and environmental factors are not as precisely controlled.

The B/C CRSP released varieties have higher potential yield than traditional varieties. Melakh has a reported 40% yield advantage over the variety Ndiambour (Boys et al. 2007). In pure culture, Yacine yields were similar to the yields of Melakh, for which reported on-farm yields are 750 to 1,000 kg/ha (Cissé et al. 2005).

Information on the production of green pods is not as readily available as the information for dry grain. Estimates of green pod harvest compared to dry grain harvest range from “1 to 8” to .21 kg green pods for every kg of dry grain (Boys et al. 2004, 20; Schwartz, Sterns and Oehmke 1993). While green pods can be an important contributor to food security due to their early availability, they are largely consumed in the household, and as such information on production and yields is limited.

CHAPTER III: REVIEW OF IMPACT ASSESSMENT LITERATURE

This chapter will present the literature necessary to understanding theoretical model used in this analysis. The first section will describe the impact pathway model that sets a model for program analysis. The second section will explain the literature background for measuring technology adoption, and converting it into measurable outcome and impacts. The third section will provide a summary of the relevant cowpea adoption studies available.

3.1 The Impact Pathway

The Economic Impact assessment used for the analysis in this paper follows the research impact pathway. Douthwaite et al. (2003) explain that the research impact pathway is a two-stage model for evaluating development projects. The first stage involves self-evaluation using a series of projected outcomes; the second stage is an independent ex post impact assessment (Douthwaite 2003). Maredia (2009) defines the pathway as a four-step process, with the first stage involving inputs and program outputs, and the second stage impact assessment measuring both outcomes and impacts. This is largely a tool for evaluating research projects, and much of the research on impact assessment has been used to evaluate projects involved in developing and disseminating new technologies. Assessments made in the first stage, before the program has had a long enough lifetime for outcomes to be established, are considered as ex ante. An assessment in the second stage, after outcomes and impacts have been realized, is an ex post impact assessment (Masters et al. 1996, Maredia 2009). The literature also presents ex post scenarios in which benefits from a research program have been evaluated up to a specific study year, and then projected for future years in an ex ante method (Maredia and Raitzer 2006).

The ex ante and ex post distinction is particularly important for evaluating returns based on technology adoption, as there is a lag between development and adoption, a "research-impact lag." (Mazzucato and Ly 1994a, 47; Alston et al. 1996) Griliches (1958) pioneered the use of an S-curve, in which technology adoption begins very slowly, eventually reaching a period of quick growth and ending in a plateau level (Boys et al. 2004, 14-15). Griliches used an economic surplus model based on the net production increase from a 'with' and 'without' comparison to measure the effects of a program (Schwartz, Sterns and Oehmke 1993, Griliches 1958).

3.2 Technology Adoption

In terms of evaluating returns to technology development projects, the adoption rate is necessary to measure of the impact of a new technology. Shuh and Tollini (1978, 8) argue that measuring research "in terms of innovation generated can be misleading", and that measuring adoption helps determine if a technology has met the market test. Byerlee (1996) defines two types of changes with modern variety adoption: Type A, where a modern variety replaces a traditional variety and leads to a sudden increase in productivity, and type B, where a modern variety replaces an earlier-generation modern variety, and leads to a more conventional incremental improvement (Byerlee 1996, Morris, Dubin and Pokhrel 1994, Tripp 2011). Tripp (2011) notes that in addition to yield improvement, improved varieties can change production patterns in positive ways.

Farmer adoption rates are the most significant influence on the rate of return for research investments (Mazzucato and Ly 1994a). The economic surplus method has been widely used to assess the impact of technology adoption through rate of return analysis. As outlined in Masters et al. (1996) and Alston et al. (1996), this method involves using adoption rates to estimate the social gain from a technology, using a 'with' and 'without' comparison. Adoption of a successful technology decreases the marginal cost of production, shifting the supply curve down and to the right through the decrease in production cost. The supply shift is then used to calculate the welfare gains from a technology. These net gains are used to perform a benefit-cost analysis of a given research program. This is a partial equilibrium analysis, holding other product and markets constant under *ceteris paribus* assumptions (Alston et al. 1996).

An impact can be estimated at an individual level, on the program level, or even for a whole system; Maredia, Byerlee, and Anderson (2000) and Alston et al. (1996) argue that the most appropriate level is the program level. The authors explain that the shift in a supply curve, or the *K*-factor, is one of the most important variables that determine returns to research. Shuh and Tollini (1978) posit that a focus on the supply shift provides a flexible method for determining impacts, but only if the technology involved can be attributed to a specific program or set of programs.

3.3 Review of Relevant Cowpea Adoption Studies

While much of the research on benefits to cowpea research in Senegal has focused on storage benefits, several authors have also studied benefits stemming from the development of improved cultivars. Schwartz, Sterns and Oehmke (1993) measured returns to Operation Cowpea, an early B/C CRSP program in Senegal that involved the extension of the Californian varieties CR-5 and 58-57 along with modern inputs and cropping practices. The authors used the Griliches procedure in order to approximate benefits. Increased grain production and area planted under the extended varieties led the authors to determine a rate of return of 31%, with the number jumping to 92% when green pod estimations were considered.

Boys et al. (2007) conducted a survey of villages in the North-Central Peanut Basin in Senegal. Melakh and Mouride accounted for 3.578% and 0.006% of production in a weighted average of mini-kit and randomly selected villages. The analysis looked at benefits from varietal development and extension of improved storage technologies, but found that when only considering the benefits of the breeding program, IRR was 12.8% (Boys et al. 2007)

Aitchedji (2001, found in Coulibaly and Lowenberg-DeBoer 2002) reported in a study of several types of improved cowpea technologies in Benin that only combinations using improved varieties were profitable. Alene and Manyong (2006) studied farmer-to-farmer diffusion of improved cowpea varieties among farmers in Nigeria, and found yield variation was due to different input and management packages, with the unknown information about cereal-cropping pattern accounting for much of the variation.

David et al. (2002) list three paradigms important to adoption as:" the socio-economic and farm determinants of technology adoption… access to information… (and) the importance of farmers' perception of technology attributes and innovation conditions" (David et al. 2002). The authors furthermore note that seed access and lack of variety promotion slowed the spread of improved bean varieties in Tanzania. Byerlee (1996) writes that in areas where there is little adoption of modern varieties, it may be that yield improvements are outweighed by culturally desired varietal characteristics (i.e., price discount offsets the yield advantage of the variety). He also notes that farmers may place a high value on traditional varieties due to non-crop byproducts, such as hay and fodder production or quality.

According to Langyintuo et al. (2003)*,* Seasonality, grain size, color and insect damage account for 97% of price variability in Senegal. Consumers are willing to pay a premium for larger grains and will discount the price of grains with high bruchid damage (Langyintuo et al. 2003, Faye et al. 2004). Consumers prefer larger grains for their sauce and rice, and processors prefer larger grains because they result in more flour per grain (Faye et al. 2004). In the northern Mpal market, consumer favored white-speckled grains, and consumers in the central Bambey market favoring black-speckled varieties (Langyintuo et al. 2003).

CHAPTER IV: SURVEY DESIGN AND METHODOLOGY

This chapter will provide a description of the data sources and the methodology used. The first section will describe the survey data used for the descriptive analysis and the estimation of adoption rates and yield advantages. This section covers the initial survey, the follow-up survey, and the merging and cleaning required for analysis. The second section will describe sources for aggregate national production data as well as the research costs attributable to the program. Section 3 will describe the manner in which the data is presented, and the methodology behind the impact assessment model used.

4.1 Survey Data

4.1.1 2010-2011 DAPS Survey

The DAPS survey was conducted beginning in the summer of 2010. The survey was developed to comprehensively measure the income-producing activities of Senegalese households, including a comprehensive survey of agricultural cropping activities. The sampling was based on a selection of seven households from Enumeration Districts (ED) within each region, with a goal of 6,300 total households from all regions. EDs were comprised of a village, town, or group of close villages.

The geographic sampling was based on a 2002 population census. While the survey was more thorough than the previous year's survey, there were still anomalies and some EDs that were not surveyed. As a result, weights were computed for use in the analysis, with a first step of calculating weights if all 6,300 households had been sampled, followed by another round to calculate weights for the actual households surveyed as well as population growth. The survey was broken down into several sections:

- **Questionnaire Parcel (QP)** – This section obtained parcel-level information. For each field, data on size, location, crop grown and planting information were collected. Planting information in this section included sex of the primary person responsible for the field, planting method, fertilizer and plowing information. Notably, variables were included to track cases where more than one crop was grown on a single field, allowing a record of intercropping.
- **Questionnaire Rendement** – This section obtained parcel-level information pertaining to production and yield. This section was not used for analysis in this assessment, due to lack of variety-level information and the fact that similar information was obtained in re-surveying
- **Questionnaire Menage –** This was an individual-level file, which obtained information on members of the surveyed households. The only information used from this section was characteristics of the household head.

4.1.2 The Follow-Up Survey

While the survey was comprehensive in its measurement of data about the specific crops, there was no variety-level information obtained for separate crops. Farmers were asked whether the seeds planted came from a labeled package, but this is only captured the practice of purchasing seed from the formal sector and did not provide information on the use and adoption of specific improved varieties, which could have been sourced from own seed stock (from previous harvest) or accessed from the informal seed sector (e.g. other farmers or purchased as grain). Therefore, a follow-up survey was conducted after the 2010 harvest, with the goal of obtaining data about the specific cowpea varieties planted on each parcel, and harvest information for those parcels. The follow-up survey was commissioned in the main cowpea-growing regions, which were the north-central regions of Thiès, Diourbel and Louga. The survey followed up with respondents from the original round who reported growing cowpeas on one or more fields.

Each respondent in the original round that did not report growing cowpeas was replaced by another farmer randomly selected from the same village or town that grew cowpeas, with the goal of having 7 cowpea farmers from each ED. With a complete sample, this would have resulted in 1,365 households. The actual sample reached was 1,310 households, due to coordination problems. The information covered in the original DAPS survey was obtained from the new households along with the new survey information. The survey was administered to the head of the household.

The sections on the new survey were as follows (See appendix II):

- **Section A:** An identification section, with information about location. Additionally, characteristics of the household head (age, sex, education level) as well as household size were obtained. This was a household-level section. This section was covered in the original DAPS survey and thus was only administered to new households in the second round.
- **Section L:** A section on specific field plots, obtaining field size, location, sex of the primary person responsible for the field, planting, fertilizer, and plowing information. This was a parcel-level section. This section was measured in the original DAPS survey and thus was only administered to new households in the second round.
- **Section C:** The section on harvest information, including: cowpea variety grown, seed source, kilograms harvested in both dry seeds and green pods, amount sold, and price received. This was a parcel-level section. It was administered to both DAPS households

and new households, as harvest and variety-specific information for parcels was not obtained in the DAPS survey.

- **Section D:** A section obtaining farmer opinions on variety advantages and disadvantages, as well as future decisions regarding growing the same variety. This was a household-level section, separated by variety type. It was administered to both DAPS households and new households.
- **Section E**: A section separated into two subsections: (1) a section on rainfall, pest incidence, and disease incidence during the season, according to the farmer's perceptions, and (2) a section on the contribution of cowpea to household consumption over the past 5 years, as well as the ability of the farmer to produce desired amounts. This was a household-level section. It was administered to both DAPS households and new households.
- **Section F:** A section about the specific varieties Melakh, Mouride and Yacine. It was asked of farmers for each variety that they did not grow; the section obtained information on whether farmers have grown the varieties in the past, and why they were not grown in the past or currently. This was a household-level file, separated by variety. It was administered to both DAPS households and new households.

4.1.3 Data Merging and Cleaning

Before the data were analyzed, cleaning was needed to address data collection issues. There were households for which **Section A** data were not collected, either in 2010 or 2011. This resulted from (a) new households mistakenly being given the survey for original households, or (b) information for old households missing from the available DAPS data. These households were removed from the sample immediately. This left a sample of 1,257 households of the original 1,310 surveyed.

The development of the data involved working with both parcel-level data as well as household-level data. The parcel-level data encompassed **Section C** and **Section L** in the survey. These files were merged together based on an ED Number (A01), a household identifier number within the ED (A10), and a parcel-level identifier (L01), in order to obtain yield and adoption information. The other sections of the survey were merged together at the household level, based on the ED and household identifier numbers.

As there were two different rounds of surveying, there were challenges that arose from fitting the information from the different rounds together. There were 163 parcels that shared a parcel number (A01) with another parcel. In this circumstance it was assumed that more than one cowpea variety was planted on a field, in an intercrop arrangement. These were aggregated together in order to form a field-level yield. The area of each field attributed to a specific variety could not be determined from the file, so the adoption and production information from these fields were labeled as either a mix of CRSP varieties or a CRSP and traditional variety mix. If the parcels were identified as the same variety, they were aggregated together to form one parcel. Merging these files together resulted in 72 parcels from the original 163.

A problem developed from the fact that cowpea households from the DAPS survey were only surveyed for information not available from the **QP** file. The **QP** section featured both cowpea and non-cowpea crops, and were identified by a plot number, K0A. This meant that cowpea plots from the same household had varied, non-consecutive parcel numbers. In the second round, when obtaining field and production levels in **Section C** and **Section L**, enumerators measured only cowpea fields, and numbered them sequentially starting at 1. This meant that in order to match field information (**Section L)** with production information (**Section C**) for households from the DAPS survey, plot numbers from the QP section had to be renumbered sequentially. This led to mismatches in some cases.

Additionally, in some cases there were more cowpea fields listed for a household in **Section C** than had been present in the **QP** data; the opposite was also true, with more fields in **QP** than were measured in **Section C**. This may have arisen out of enumerators arriving at a village and finding that a farmer had more fields, or the farmer not going over a field with the enumerator due to another family member having been the person responsible, or any number of other issues. It may have been that a farmer grew more than one variety on a field, and the enumerator mistakenly renumbered by the *parcel-level (L01)* when the number should have been the same for measurement of a second variety (i.e., two parcels from the same field were given different L01, when it should have been the same in order to tie them both to the same field). Unfortunately, as the exact circumstances are unavailable, these cases had to be eliminated from the sample used to determine adoption and yield, as fields could not be reliably matched between the rounds. If the number of plots or the numbering could not be matched between the first round and the second, that household was deleted from the sample used to calculate yield and adoption, as a partial match would be unreliable. While the original **Section C** file has **N=1,812** parcels, the file used to calculate adoption and yield was reduced to only 978 of the original parcels, with the aggregation of intercropped parcels resulting in **N=915** parcels for 795 households.

Sections D, E, and F were all household-level files that only needed to be matched to household-identifying information from the DAPS survey. The only information measured of new households that was not present in the **QP** section was age of household head. This was taken from the **QM** survey by simply matching the ED and household identifier between the files.

Households that were removed from the adoption and yield file *were not* removed from the household-level files, as the matching problem was not an issue on the household level. This resulted in a sample difference between the 1,257 households in the household levels **Section D, E, and F**, and 795 Households (915 parcels) in the merged **Section C and L** file. Information in the **Section C** and **Section L** files that did not depend on merging was still used, as it could be reliably matched to the household.

4.1.4 Sample Weights

While the numbers of sampled households were evenly selected across each survey ED, the actual population distribution is not evenly distributed, meaning that households within the sample require weighting in order to accurately reflect both the population distribution as well as the distribution of cowpea-growing households. While the use of FAO statistics for aggregate regional production means that the weights were not needed for scaling up of estimates, they were needed in order to properly weight households so that the adoption rate reflected proportionality between regions within the country.

The weight was calculated in a two step process, with the first step reflecting the weight calculated for the original DAPS survey, and the second step reflecting the adjustment in sample weight to account for cowpea growing households selected for the survey. This meant calculating a second-step weight accounting for both the proportion of cowpea growing households within a district, as well as data missing from the final file due to data cleaning.

The weight calculated for the DAPS survey (Megill 2012) accounted for proportionality, missing households, and population growth after the 2002 census, as the population distribution for the calculations was based on 2002 census population figures. The initial weight is calculated at the ED level by

$$\textbf{Equation 4.1: } W_h = {}^{M_h \,*\, M_{Ah}}\!/_{n_h \,*\, M_h \,*\, m_{Ah}}$$

where:

W_h = Weight for each household at the ED level

M_h = Households identified in the department in 2002

M_{Ah} = Agricultural Households identified in the ED in 2010

n_h = EDs identified in the department

M_h = Households identified in the ED in 2002

m_{Ah} = Households selected in the ED 2010

This initial cluster weight (W'_h) is then adjusted by multiplying it by a weight calculated to account for missing households (W_s) and for intercensal population growth between 2002 and 2010 ($Pro.$) This weight (W'_h) is calculated by

$$\textbf{Equation 4.2: } W'_h = W_h * W_s * Pro.$$

Where W_s is calculated with

$$\textbf{Equation 4.3: } W_s = {}^{n_h}\!/_{n'_h} * {}^{m_{Ah}}\!/_{m'_{Ah}}$$

where:

n'_h = EDs enumerated in the department

m'_{Ah} = Households enumerated in the ED in 2010

$Pro.$= Intercensal projection from 2002 to 2010

This produces the weight for each household for the DAPS survey that is calculated at the ED level and then applied to each household. This weight then needs to be adjusted again to account for the differences between the DAPS survey, which is meant to represent agricultural households, and the cowpea survey, which is meant to represent cowpea-producing households. The Final weight for cowpea-producing households (W_C) is calculated using

$$\textbf{Equation 4.4: } W_C = W'_h * W_{cl} * W_{sc}$$

where:

W_C = Final weight for each cowpea household within an ED

W_{cl} = Number of farmers projected as growing cowpea in each ED

W_{sc} = Weight for missing clusters

The weight for the farmers based on number of cowpea growers per cluster is calculated by using the proportional number of farmers in each district that grew cowpeas in the DAPS survey. This is calculated by

$$\textbf{Equation 4.5: } W_{SC} = \frac{\left(M_{Ch}/m'_{Ch}\right)}{\left(M_{Ah}/m'_{Ah}\right)}$$

where:

M_{Ch} = Households in the ED growing cowpeas in the DAPS survey

M'_{Ch} = Cowpea households enumerated in the ED

As data issues meant that a significant amount of data was removed, the weight needed to be adjusted for the missing data. While data missing within an ED is accounted for by the nature of an ED weight, there were missing clusters due to the data issues, and this affects the proportionality. The weight to adjust for missing clusters was calculated using

$$\textbf{Equation 4.6: } W_{sc} = n'_h/n'_{ch}$$

where:

n'_{ch} = EDs enumerated in the B/C CRSP survey

These calculations were used to produce the weights for the data used for the analysis in this paper. The sample weights used for parcel-level analysis to estimate adoption rates and the sample weights used for household-level analysis were both calculated using these equations, but as there were a significantly different number of households between the files due to the already elaborated matching error in the parcel-level file, the weights produced were different.

4.2 Senegal Production and Financial Statistics

4.2.1 Price Data

Producer price data is gathered from the Agence Nationale de la Statistique et de la Démographie (ANSD), which has data from 1990-2009. Price information for 2009 and 2010 is taken from the Food and Agriculture Organization (FAO). **Section C** of the survey questioned farmers on the prices they received for their cowpeas, though this data only applies to the 2010 season. The median price in Section C is similar to the FAO price, though, with the FAO price being 235 FCA/kg and the price from the data being 250 FCA/kg. Notably, the prices from ANSD are slightly different than those provided by the FAO. The aggregate country price will be used for each region, as regional prices are not available for the majority of the study period.

4.2.2 Area/Production Information

There are several sources for information regarding cowpea production and area. ANSD has information on production and area devoted to cowpeas, both on an aggregate national level and by region, back to 1997. Information before 1997 is only available on an aggregated national level.

The FAO has the same data, though FAO considers the information to be unofficial estimates. One note is that the convention for naming years is different between FAO and ANSD, with the FAO labeling information for the 2008 growing season as 2008, while the ANSD labels information as 2008/2009, likely to include late harvest and gardening that continues into early 2009. It is also important to note that cowpeas are sometimes intercropped with other crops, often grains, and this may lead to overestimation of area and underestimation of yields (Akibode and Maredia 2012).

4.2.3 Research and Extension Costs

Research costs for the B/C CRSP program in Senegal represent direct and indirect transfers to ISRA in Senegal. The B/C CRSP Management office at Michigan State University has provided budget figures. Annual budget figures are available that run from the accounting period of October to September of the following year. In order to perform analysis, budget figures have been assigned the period for which the majority of the transfer falls, meaning that figures for October 2007 to September 2008 have been assigned to 2008 for analysis purposes.

Figures for the years 2005 through 2007 were only available as an aggregated three year total, so all costs for that period were assigned in the first period year, 2005, to avoid underestimating costs through over-discounting.

The Exchange rate between CFA and US$ is the period average for each year from the International Monetary Fund (IMF) Financial Statistics. The Consumer Price Index for the United States is also taken from the IMF, with 2005 as the base year.

Research spending for ISRA was only available from 1982 until 1996, sourced from Boys et al. (2004). Funding for the period after 1996 has been computed as an average of the last three years available. The lack of a reliable estimate for the research program costs will be handled by doing significant sensitivity analysis on ISRA costs.

Extension costs by ISRA are assumed to be covered by available budget figures. Extension costs for outside organizations, though, are not a part of these figures. Diatta (2012) found that in 2011, farmers planted 130.5 ha of improved cowpea seed, coordinated through producer organizations for the purpose of producing improved cowpea seed. The majority of this area was in Louga, with 110.5 ha in Louga, 12 ha in Thiès and 8 ha in Diourbel. The author also produced a standard budget for production of a hectare of improved seed. This included a specific breakdown of extension costs for seed.

While this allows an easy calculation of extension costs for the 2011 season, with a simple multiplication of extension costs for a hectare planted by the number of hectares planted, the area planted is only available for the 2011. In order to approximate the number of hectares planted by producer organizations, the number of hectares planted has been pegged to regional adoption by a multiplier that is a ratio of the adoption rate in the given year over the adoption rate in 2011. The equation for the Extension Cost Multiplier *ECM* for year *i* is thus

Equation 4.7: $ECM_i = {}^{Adoption_i}/_{Adoption_{2011}}$

So the Extension Cost Multiplier is applied to the extension costs from 2011 to obtain extension costs for a given year. This is not a perfect approximation, but should generally approximate the area planted.

4.2.4 Adoption Costs

The B/C CRSP varieties are determinate varieties, for which the planting densities suggested are significantly denser than suggested for indeterminate traditional varieties. The suggestion for improved determinate varieties is 50cm x 25cm, while the suggestion for traditional varieties is around 80cm x 80cm (Cissé 2012). The amount of seed required for a field planted at 50cm x 25cm is 20kg (Diatta 2012), so a field planted at 80cm x 80 cm requires around 5.8 kg. The cost of buying more seed to plant improved varieties represents the adoption cost for a farmer growing improved varieties.

4.3 Methodology and Presentation of Data

4.3.1 Demographics

Demographic variables determined from both the original DAPS sample, and the second round survey, will be presented first. These variables will explain some of the characteristics of farmers in the three study regions as well as the country as a whole. This will be followed by a demographic breakdown of the farmers in the study sample, and will expand on other characteristics of the sample.

4.3.2 Adoption Rates

Current adoption rates for varieties will be determined from the second round survey devoted to cowpea farmers in the Louga, Diourbel and Thiès regions. Adoption rates will primarily be determined by land devoted to each variety as a proportion of land in the total sample. For the purposes of calculating adoption rates, the top 5% and bottom 5% of fields, by hectares, were eliminated from the sample in order to remove outliers that would significantly bias the resulting adoption rates.

These adoption rates are fundamental to determining research impact. While many functional forms are also used to approximate adoption, including linear functions, polynomial lags, and trapezoidal lags (Alston et al 1996), adoption rates over time will be modeled using a logistic adoption curve, a method first described by Griliches (1958) for calculating adoption of hybrid corn varieties in the USA. This choice of form follows Sterns (1993), Boys et al. (2007), and (Reyes 2012) in their analyses of adoption of B/C CRSP cowpeas and beans. The equation used to model adoption in those literature as well as here is

Equation 4.8: $A_t = {A^{Max}}/{1 + \beta e^{-t}}$

where A_t = Adoption rate at time t, A^{Max} = maximum, or plateau adoption rate, and β is an equation parameter. Using the adoption rate estimated in Boys et al. (2007) and the adoption rate estimated in this study allows two combinations of A_t and t, to estimate the parameters of the adoption curve using the

Equation 4.9: $A^{Max} = A_t + A_t * \beta * e^{-t}$

As adoption rates for Yacine have not been estimated in the previous literature, the adoption rate of Yacine in year 1 will be assumed to be 0.1%. Alston et al. (1996) argue that the assumption of a low adoption rate in year 1 is a reasonable assumption for adoption estimation.

4.3.3 Handling of Intercropping Rates

One problem that arises with calculating yield and adoption results from cowpeas is that they are often intercropped with other crops such as millet, sorghum, or peanuts. Data on intercropping is available for households surveyed in the first round, but unavailable for replacement households. Additionally, the information available does not specify the type of intercropping arrangement or the amount of land devoted to each crop, thus making differentiation between intercropped and mono-cropped fields difficult.

Since intercropped fields cannot truly represent complete field adoption, these cases were weighted in order to accurately capture adoption rates and not result in overestimation. Data on usual intercropping patterns with cowpeas was not available, so fields with another crop grown on it were valued at a rate of 50%, with one exception. Fields intercropped with the flower bissap (a species of Hibiscus) were not weighted, as bissap is grown in fields as a border crop.

The DAPS survey collected information on whether there was another crop grown on the selected parcel. For households surveyed in the second round, though, this information was not collected. In order to approximate an intercropping rate for second-round households, the percentage of intercropped fields for each variety in each enumeration district was determined from the DAPS sample, and this proportion was combined with the 50% value for intercropped fields to create an adjustment factor that was applied to every second-round household in the same enumeration district. This was done in order to avoid counting all second-round parcels as mono-cropped fields.

4.3.4 Yield Advantages

Yield improvement will primarily be determined from yield information calculated from the first and second survey rounds. This will allow a breakdown of yield differences by variety and region. Theoretical yield improvements from on-farm testing can be informative, but cannot completely reflect the real world situation. The use of yields from the sample means that impacts will be measured using actual yields, those seen by farmers, as opposed to the "best practice" yield, which would be obtained by farmers using the best available technology; this means there will be a sort of extension gap between the theoretical benefits from using reported test yields and the benefits seen here from using actual yields (Evenson 2001). This study uses the median yields to determine the yields used in the baseline analysis, which are less affected by outliers in the data.

4.3.5 Economic Surplus Model

Adoption rates will be used with yield analysis and price data to perform an ex post economic impact assessment, as outlined in Masters et al. (1996). The model used is a partial equilibrium economic surplus model, holding other market factors at constant. Yield change and price data will be combined with aggregate production levels in order to calculate the supply shift, *k*, from adoption. The factor *k* is computed using

$$\textbf{Equation 4.10: } k = {}^{\mathrm{j}}/_{\varepsilon} \text{ - c}$$

Where:

J = Proportional change in production from improved varieties

ε = Elasticity of Supply

c = Proportional change in costs from adoption of improved varieties

The change in production is calculated by

$$\textbf{Equation 4.11: } dQ = {}^{Q_t \,*\, \varepsilon \,*\, e \,*\, k}/_{\varepsilon \,*\, e}$$

Where:

Q_t = Total production in year *t*

e = Elasticity of Demand

After producing the gain in production, *dQ*, from adoption if improved varieties, the social gain is computed with

$$\textbf{Equation 4.12: } (k * P_t * Q_t) - (0.5 * k * P_t * dQ)$$

Where:

P_t = Real cowpea producer price in year *t*

This process is calculated modeling a parallel shift of a linear supply curve as a result of adoption. Since Senegal is a net exporter (Langyintuo et al. 2003), with only around 1% of production exported (Faye 2005), the effect of international trade on the model is negligible. The implication of this is that external demand will not influence prices or supply and demand elasticities. Thus, international trade will not have a significant effect on social welfare calculations, nor will production improvements affect international price. As such, the assessment is performed using a closed economy model.

The impact analysis was performed in two separate sections. Benefits from 1991 (the first year of Mouride's release) to 1997 were calculated using aggregate national production data, due to the unavailability of production and area data for separate regions. Adoption prior to 1997 was calculated by multiplying regional adoption rate by the average of that region's share of total national crop area for 1997 to 2000. Yield was calculated using an average of the three regions. One issue with this approach is that it uses post-adoption production values to measure regional shares, when these rates may be slightly distorted by adoption in the later years (1997-2000 vs. 1991-1996). As the adoption rates are still quite small in the 1997-2000 period, and the benefits seen in 1991-1996 are also quite small, the effect of this distortion is surely minimal.

Benefits from adoption post-1997 were calculated separately for the three study regions, in order to accurately capture benefits. As adoption and yield gains differ between regions, this gives a more accurate picture of impacts. As research costs are an aggregated number, the benefits for the three regions were then summed together for each year in order to perform an aggregated social welfare analysis.

Benefits for post-2011 were projected until 2020 with the goal of understanding future gains from the program. As most of the gains from a project come late in the project life due to adoption lags, these future returns are important in establishing actual program returns. Values for future years were obtained by taking the average of the three previous years for each non-fixed aggregate country-level value (i.e. production, area planted, prices) and projecting them at a constant level until 2020.

4.3.6 IRR

The Internal Rate of Return (IRR) to the project will be calculated according to

Equation 4.13: $0 = \sum_{t=1}^{n} \quad {B_t - C_t}/{(1+i)^t}$

where B_t and C_t are benefits and costs at time, t, and *i* is the interest rate. The IRR is defined as the interest rate at which the present value of costs is equal to the present value of benefits. Any rate greater than the opportunity cost for the dollars spent on the program represents a positive gain on investment.

4.3.7 NPV

The Net Present Value is calculated in a similar manner to the IRR, with

Equation 4.14: $NPV = \sum_{t=1}^{n} \; {B_t - C_t}/{(1+r)^t}$

Where B_t is benefits at time *t*, C_t represents costs at *t*, and *r* is an assumed discount rate. The NPV simply presents estimated cash value to the entire program in present dollars. Alston et al. (2000) argue that when using real costs and benefit streams (as opposed to nominal values), it is appropriate to use a real-risk free interest to discount benefit streams. Benefits have been converted into real terms by converting the cowpea price to US $ with the annual exchange rate, and weighting by the USA CPI. Research costs, already in US $, have been converted into real terms using the USA CPI. Calculations of NPV will use the 2010 Senegal discount rate of 4.25% (IMF eLibrary).

4.3.8 Elasticities

The selection of elasticities used for the economic impact assessment is important for accurately calculating the rate of return. Faye (2005) used an Almost Ideal Demand System model to compute the demand elasticity of cowpeas in Senegal as -1.23, with the expenditure elasticity as -0.93. This study will adopt -1.23 as the baseline demand elasticity as this is the only Senegal-specific econometrically estimated demand elasticity found in the literature.

Previous studies of the Rate of Return regarding B/C investment in Senegal have estimated the supply elasticity at 0.8 (Schwartz, Sterns and Oehmke 1996; Boys et al. 2007), due to the lack of available information regarding the supply elasticity of cowpeas in Senegal. Oehmke and Crawford (2002) argue that the returns to research are sensitive to the value of supply elasticity, particularly when using a parallel supply shift, and that sensitivity analysis is not satisfactory for dealing with uncertainty regarding supply elasticities. While the inability of the empirical research to provide an estimate regarding the supply elasticity of cowpeas in Senegal is a problem, there are ways to approximate the value using nearby countries as proxies. Langyintuo (2003) compiled supply elasticities for eight Economic Community of West African States (ECOWAS) countries and three Central African Economic and Monetary Community (CAEMC) countries, finding all elasticities between the values of 0.06 and 0.28. The elasticity of supply will be projected at value that produces the most conservative values, 0.28.

4.3.9 Cost and Benefit Projections

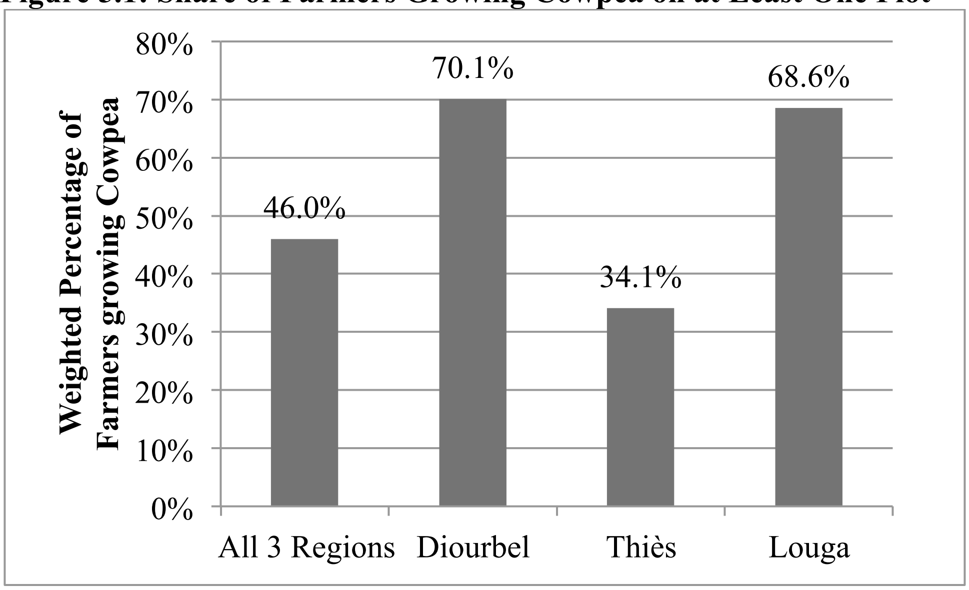
In order to fully understand project benefits, future values have been projected for both costs and benefits. Calculating the IRR minus future values would mean assuming that adoption rates decreased to zero in the year immediately following the end of the analysis. This is clearly not a reasonable assumption; therefore, future values have been projected in order to better reflect the true social welfare gained through the project. The projection of benefits beyond the study changes study parameters of the study from an ex post scenario to a mix of ex post and ex ante analysis. While it is methodologically sound to include these benefits, the IRR and NPV with and without projected benefits will be included in order to differentiate between a simple ex post analysis time frame and a more mixed analysis frame.

CHAPTER V: VARIETAL ADOPTION AND RELATED CHARACTERISTICS

5.1 General Characteristics

Nearly half of the farmers in the three study regions grow cowpea on at least one field, though the fraction of farmers growing cowpea is significantly lower in Thiès than Diourbel and Louga. There is fairly significant difference between Thiès and the other two regions, especially considering that Thiès and Diourbel had similar numbers of hectares planted as cowpea in the 2010 season (14,391 ha in Diourbel to 15,272 ha in Thiès).

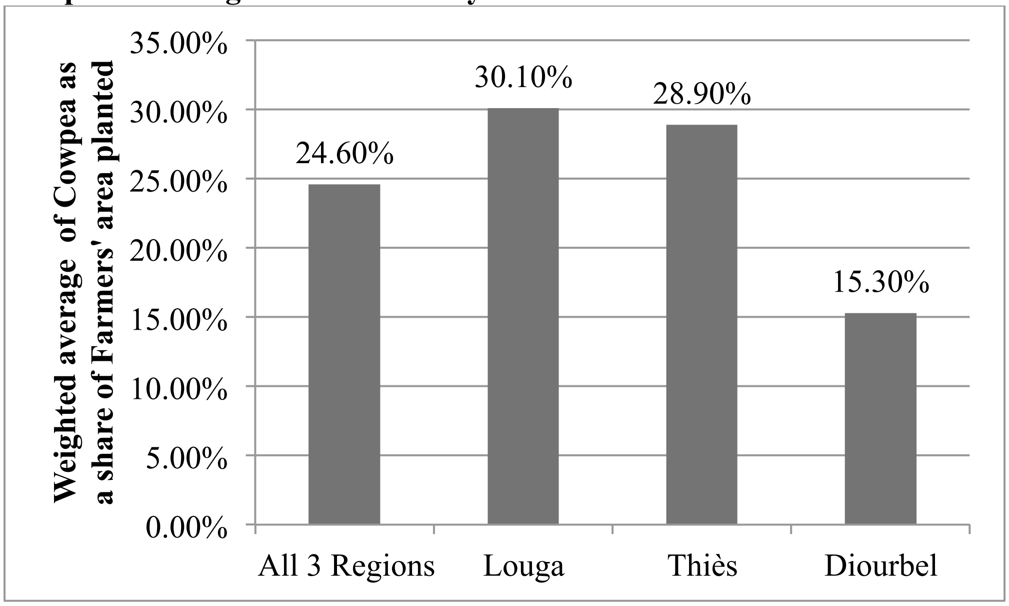
Figure 5.1: Share of Farmers Growing Cowpea on at Least One Plot



N=1,472
Source: DAPS survey

The difference between these numbers can be explained in part by the difference in cowpea as a share of each cowpea farmers' total cropping distribution. Farmers in Louga and Thiès grow cowpea on a higher share of their land than in Diourbel. So while over 70% of farmers in Louga grow cowpeas on 30% of their land, Thiès has significantly fewer farmers (34.1%) growing cowpea on a similar share of their land, and Diourbel has a similar number of farmers growing cowpea on a much smaller share of their land (15.3%).

Figure 5.2: Weighted Average of Cowpea as a Share of Total Area Planted, Cowpea Growing Households Only.



N=1,472

Source: DAPS Survey

Additionally, there appears to be differences between regions in terms of the land-holding characteristics between cowpea and non-cowpea growing households. In the total sample, cowpea growing households on average appear to hold more land than non-cowpea growing households, though this is largely influenced by the disparity in Louga, where cowpea farmers grow on an average of 5.8 ha, while non-cowpea farmers grow on an average of 3.8 ha. Diourbel and Thiès have a much smaller difference between the land holdings of the different farmers.

Table 5.1: Average Land Holdings for Farmers (ha)

	All 3 Regions	Diourbel	Thiès	Louga
Cowpea Growers	5.0	5.3	3.3	5.8
Non-Cowpea Growers	3.6	5.9	2.9	3.8

N=1,457
Source: DAPS survey

5.2 Demographics

5.2.1 Gender

There are two different measures of gender in the sample, that of the head of the household and that of the person responsible for the cowpea plot. Of the sample, 94.9% of household heads were male.

Table 5.2 Sex of Household Head

	Percent
Male	94.9
Female	5.1

* 54 missing cases
N = 1,203
Source: Cowpea survey

This is an unsurprising result, as the head of household is almost exclusively a male position in Senegal, except in cases of death or divorce. The more interesting result comes when analyzing the gender of the family member responsible for plot. A male household member manages only 66.9% of the parcels in the sample.

Table 5.3 Sex of Parcel Manager

	Percent
Male	66.9
Female	33.1

*17 missing cases
N= 898
Source: Cowpea survey

5.1.2 Age

The average age of head of household in the sample is 52.4 years old. The average male head of household is 53.0 years old, while the average female head of household is 43.8 years old. The disparity between male and female heads may be due to the fact that a male's first marriage is on average later than female's first marriage, and combined with the fact that an older son will often become the head of household. Usually, it is only younger widows that would be considered the household head. There is not a significant average age difference between the regions.

5.2.3 Family

The average household in the sample has 12.6 members. The average household size does vary slightly between regions, with Diourbel, Thiès and Louga having 12.8, 13.8, and 11.4 members per household on average.

Table 5.4: Sample Household Sizes

Size	Percent
1-5	10.8
6-10	35.5
11-20	43.5
21-30	7.5
31+	2.7

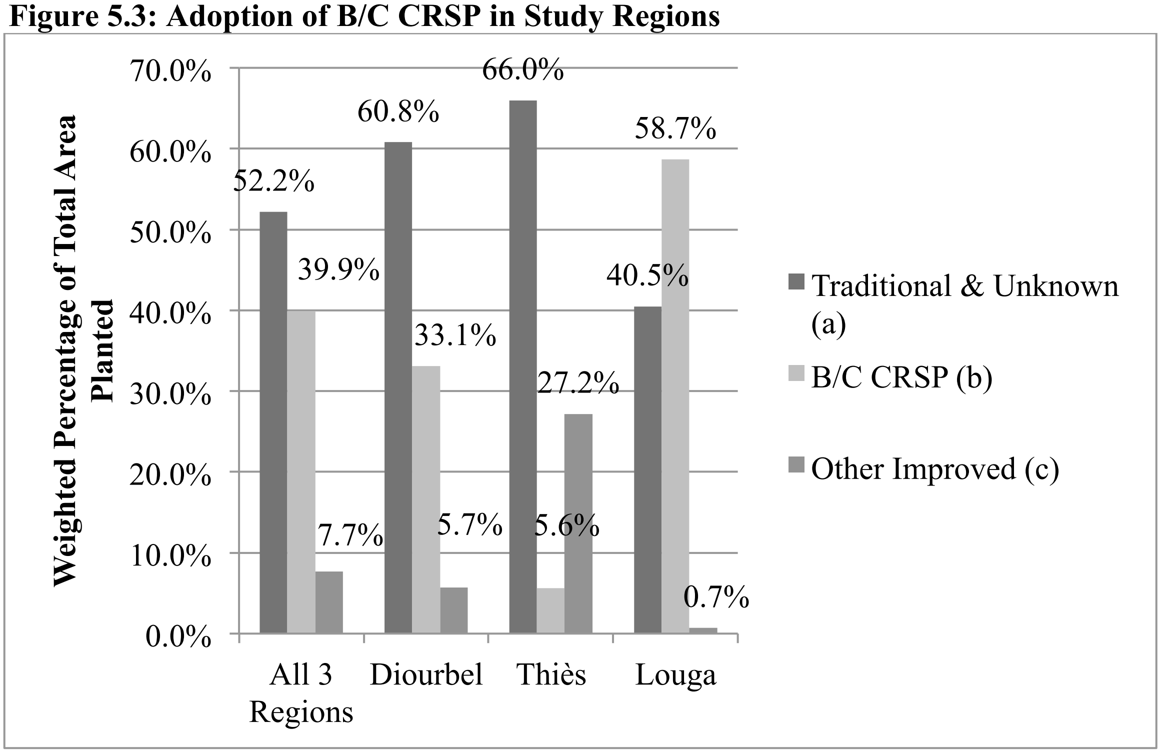
* 2 missing cases
N=1,255
Source: Cowpea survey

5.3 Adoption Rates

It is important to provide a definition regarding varietal categories. Varieties that are considered B/C CRSP varieties are varieties developed after the onset of B/C CRSP support/funding to ISRA. These are the varieties Melakh, Mouride, and Yacine. Improved varieties include the B/C CRSP varieties, as well as the varieties Bambey-21, Bambey-22, Diongoma, and Ndiambour. Additionally, farmers surveyed identified their crop not only by the variety, but by the type as well, choosing 'improved', 'traditional', or 'unknown'. A significant number of plots in Thiès were identified as an 'other' variety that was 'improved'.

Adoption rates vary widely by variety and region. Adoption rates of improved varieties have significantly surpassed the plateau rate of 3.58% determined by Boys et al. (2007). The adoption rate for improved B/C CRSP varieties in the entire sample is very high at 41.8%, with the adoption rate of all varieties identified as improved being even higher. Including varieties listed as 'other' 'improved' increases adoption of improved varieties in the sample to 47.8%. Nearly all of the varieties identified as other improved were found in Thiès; a discussion of this will follow in regional sections.

Figure 5.3: Adoption of B/C CRSP in Study Regions



a. All plots marked as 'traditional' 'other', 'unknown' 'other', and CRSP & Other variety mix
b. Yacine, Mouride, and Melakh
c. All plots marked as Bambey 21, Diongoma, Ndiambour, and 'other' 'improved'

N=817

Source: Cowpea survey

There does not appear to be a difference in adoption between the gender of the parcel manager, nor does the sex of the household head appear to make a difference with roughly the same percentage of adoption between the two. There does appear to be a slight adoption trend towards younger farmers

Table 5.5: B/C CRSP Adopters by Age of Head

Age of HH Head	Adopters	Total #	Adoption (%)
20 or younger	2	4	50.0
21 to 40	148	273	54.2
41 to 60	251	557	45.0
61 or older	152	356	42.7

N=1,190
*67 households missing
Source: Cowpea survey

When looking at adoption on a per-farmer basis, adoption does appear to be slightly higher, specifically in Thiès and Diourbel. This biggest difference noticeable in this approach is that adoption on a farmer-by-farmer basis is significantly higher for farmers in Diourbel than on a basis of area planted. Meaning that while many farmers are planting B/C CRSP varieties, they are planting them on less area than B/C CRSP varieties.

Table 5.6: B/C CRSP Adopters by Region

Region	Adopters	Total #	Adoption (%)
Total Sample	587	1,257	46.7
Diourbel	235	373	63
Thiès	60	402	14.9
Louga	292	482	60.6

Source: Cowpea survey

Page 40 features a breakdown of adoption rates for each variety in the sample, for each region. These adoption rates were computed using a sample of **915 parcels** from the 3 regions, and is notably smaller than the sample used for the household-level analysis, due to the elimination of parcels due to matching error. Of note for adoption calculations is that a number of parcels, mostly in the Louga region, were identified as an improved B/C CRSP variety but also identified as a traditional variety. These plots were converted to 'other' traditional in order to avoid overestimating adoption.

Table 5.7: Sample Adoption Rates by Region

Region	Full Sample		Diourbel		Thiès		Louga	
Variety	**Hectares(a)**	**Percent**	**Hectares(a)**	**Percent**	**Hectares(a)**	**Percent**	**Hectares(a)**	**Percent**
Melakh	8,911	13.8%	845	4.3%	256	1.9%	7,810	24.7%
Mouride	10,474	16.3%					10,474	33.1%
Yacine	6,395	9.9%	5,607	28.8%	491	3.7%	297	0.9%
Bambey 21	3	0.0%			3	0.0%		
Diongoma	1,111	1.7%	1,111	5.7%				
Ndiambour	15	0.0%	15	0.0%				
Traditional	29,141	45.2%	9,311	47.8%	7,084	52.9%	12,747	40.3%
Other Improved	3,859	6.0%	4	0.0%	3,635	27.2%	220	0.7%
Other Unknown	2,306	3.6%	547	2.8%	1,759	13.1%		
B/C CRSP mix (b)	55	0.0%	55	0.0%				
CRSP & Other variety mix (c)	2,192	3.4%	1,984	10.2%	152	0.0%	58	0.2%
Total	64,462	100.0%	19,478	100.0%	13,380	100.0%	31,605	100.0%

a. Hectares devoted to each variety are scaled up using weights, but do not represent an estimate of total regional production
b. This represents a mix of B/C CRSP varieties
c. This represents a mix of B/C CRSP varieties and 'other' varieties
N=817
Source: Cowpea survey

5.3.1 Diourbel

Adoption of B/C CRSP varieties in Diourbel is at 39.1%, and most of this adoption is attributed to the newer variety Yacine, for which adoption is 28.8%. This is likely the result of extension efforts focused on Yacine since its release in the early 2000s. 4.3% of the area in Diourbel is cultivated under Melakh, which has also been a focus of extension efforts since its release. None of the sample in Diourbel was cultivated under Mouride, a result that suggests that as extension efforts for Mouride waned, farmer organizations did not pursue their own production of seeds. Also of note is that 10.2% of the area cultivated is grown as a mix of a B/C CRSP variety and another variety.

5.3.2 Thiès

Adoption rates for Thiès in the sample are very low compared to the other regions. Adoption of B/C CRSP varieties in Thiès is only 5.6%, oddly low not only compared to the other surveyed regions but also because a large amount of extension efforts have been undertaken in Thiès by the government and NGOs, especially with Yacine extension.

On the other hand, 32.8% of the area in Thiès is listed as grown under improved variety, due to a strangely high number of farmers reporting growing an improved variety other than those in the survey (27.2% of the sample). As the number of non-ISRA developed improved varieties in Senegal should be close to zero, this implies that these are a mix of ISRA varieties that the farmer cannot identify and traditional varieties misidentified by the farmer. This is the belief of the main cowpea breeder in Senegal as well (Cissé 2012).

While the baseline analysis does not consider ‘improved’ ‘other’ varieties as B/C CRSP varieties, it should be noted that adoption rates of improved CRSP varieties in Thiès, especially for Yacine, are likely underestimated,. The source of this error is likely a combination of enumerator and farmer lack of knowledge in being able to properly identify varieties.

5.3.3 Louga

While adoption rates in Thiès were low, Louga is the opposite, with adoption rates far beyond any previous plateau predictions. 58.8% of the area in Louga is identified as cultivated under a B/C CRSP variety. Of the three main B/C CRSP varieties, 24.7% is Melakh, 33.1% is Mouride, and 0.9% is Yacine. The prevalence of Melakh and Mouride in Louga is a large contrast with Diourbel and Thiès, but can be partially explained by the fact that as a Northern region it may be influenced by Mauritanian consumption patterns, which favor white-colored beans (Langyintuo et al. 2003). Melakh and Mouride are white-colored and cream-colored respectively. Additionally, farmer organizations have been present in Louga longer than the rest of the country, contributing to the high adoption rate for the two older of the improved varieties.

5.3.4 Intercropping

In the original DAPS survey, parcels were measured with each crop grown on the parcel. This allows us to calculate percentages of intercropping for the original DAPS households present in the survey. The majority of these arrangements are cowpea grown with a cereal such as millet or sorghum, or sometimes with peanuts as well. Cowpea cropped with bissap is another common method found in the QP sample, but bissap is a flowering plant grown as a border crop, and should not impact adoption rate in any significant way.

Diourbel has the highest percentage of intercropping in the DAPS sample, with 39.0% of the area in the un-weighted sample intercropped with cowpea and another crop. Thiès and Louga have 17.4% and 8.9% of area intercropped, respectively.

Table 5.8: Intercrop Rates by Region (DAPS Sample)

	Intercropped (%)
Diourbel	39.0
Thiés	17.4
Louga	8.9

N=1,472
Source: Cowpea survey

5.4 Advantages and Disadvantages to Varieties

In **Section D** of the survey, farmers were asked to list three advantages and three disadvantages of the varieties they grew. These categories will be presented by percentage of farmers that listed each category as an advantage or disadvantage. For full results see **Appendix I.** For every variety grown, 99% of farmers reported that they planned to grow the variety again, suggesting that farmers are very happy with the available varieties.

5.4.1 Yield Improvement

There was a split between the three regions on the yield improvements of the improved varieties, with farmers in Diourbel being significantly less likely to list yield improvement as a varietal advantage.

5.4.2 Dry Grain Yield

Nearly 90% of farmers in both Thiès and Louga listed improved dry grain yield as an advantage of Melakh, while only 23.9% of farmers in Diourbel agreed. Outside of Diourbel, every improved variety had over 80% of farmers report high yield, with the exception of Yacine in Thiès, for which only 50.7% reported high yield.

5.4.3 Leaf Yield

It is logical that 'other' varieties have more farmers reporting high leaf yield than the improved varieties in both Diourbel and Thiès. As all three B/C CRSP varieties are determinant, they produce less leaves than traditional varieties which are indeterminate and do not terminate leaf growth prematurely. In Louga, on the other hand, Mouride has nearly

70.6% of farmers report that it has a high leaf yield. This is notably odd result, as Mouride is a determinate variety and not designed to produce high leaf yield. Yacine, on the other hand, has the lowest percentage of farmers reporting high leaf yield, at 21.5%.

5.4.4 Seed Attributes

Seed color does not appear to be a strong motivator for farmers, though over 40% of farmers in Diourbel list seed color as an advantage of Yacine. Nearly every variety in all three regions has a high percentage of farmers reporting taste as an advantage, though Melakh has lower marks in both Thiès and Louga, particularly in Louga.

5.4.5 Disease, Insect and Drought Resistance

Across all regions and all varieties, farmers do not report disease, pest, or drought resistance as an advantage. Farmers are much more likely to list varieties as having a disadvantage in regards to disease and insect resistance, though the more susceptible varieties appear to vary across regions. No variety in any of the three regions has less than 69% of farmers reporting pest resistance as a disadvantage. This implies that improved varieties, while they may have better resistance to pests and disease, are still susceptible to them.

5.4.6 Crop Cycle

The short cycle of improved varieties provides the clearest evidence of advantages over traditional varieties for farmers. In all three regions Melakh receives the highest percentage of farmers reporting short cycle as an advantage, while less than 17% of farmers report the same for ‘other’ varieties.

5.4.7 Seed Availability

Farmer opinions of seed availability provide some fairly interesting results. Despite the high adoption rates in the sample, over 30% of farmers in Louga report that seed availability is a disadvantage for Melakh, Mouride and Yacine, suggesting that even with high adoption rates there is enthusiasm for more seed. Farmers in Diourbel appear to be content with the availability of improved varieties, while farmers in Thiès report some dissatisfaction with the availability of Melakh and Yacine.

5.4.8 Price

In all three regions, price received for Yacine is higher than any other variety. Also of note is the fact that farmers in Louga appear to be very pessimistic about the prices received for improved varieties, with over 38% of farmers reporting Melakh and Mouride as having a disadvantageous price received.

5.5 Seasonal Characteristics

5.5.1 Rainfall

The large majority of farmers reported being satisfied with the rainfall levels in the 2010 season. At least 83% of farmers in every region reported that they were completely satisfied with the rainfall. Less than 10% reported being dissatisfied or very dissatisfied in Diourbel and Thiès. In Louga, 12.6% reported being very dissatisfied with the rainfall.

Table 5.9: Farmer Perceptions of Rainfall in the 2010 Season

	Diourbel (a)	Thiès (b)	Louga (c)
Very unsatisfactory	5.2%	3.4%	12.6%
Unsatisfactory	3.2%	1.9%	1.5%
Moderately satisfactory	7.8%	9.7%	0.7%
Satisfactory	83.8%	84.8%	85.2%
Total	100.0%	100.0%	100.0%

N=1,164
a. 21 missing cases
b. 56 missing cases
c. 16 missing cases
Source: Cowpea survey

5.5.2 Disease Incidence

The highest rate of disease incidence in the sample was in Diourbel, where 62.8% of farmers reported high or medium pest incidence in their crops. Disease rates in the other two regions were high as well, though, with 44.2% of farmers in Diourbel and 36.2% of farmers in Louga reporting medium to high incidence.

Table 5.10: Farmer Perceptions of Disease Incidence in the 2010 Season

	Diourbel (a)	Thiès (b)	Louga (c)
High	8.8%	9.7%	3.7%
Moderate	55.0%	34.5%	32.5%
Low	15.9%	24.5%	42.8%
None	20.2%	24.7%	20.7%
Did not know	0.00%	6.6%	0.24%

N=1,164
a. 22 missing cases
b. 55 missing cases
c. 16 missing cases
Source: Cowpea survey

5.5.3 Pest Incidence

Farmers reported very high rates of pest incidence for the 2010 growing season. The highest reported rate was in Diourbel, with 75.3% of farmers reporting medium to high pest incidence. 53.7% of farmers in Thiès and 56.5% of farmers in Louga reported the same. Over 8% of farmers in each region reported no pest incidence.

Table 5.11: Farmer Perceptions of Pest Incidence in the 2010 Season

	Diourbel (a)	Thiès (b)	Louga (c)
High	24.5%	16.5%	38.4%
Moderate	50.8%	37.2%	18.1%
Low	13.3%	35.5%	35.3%
None	11.4%	10.9%	8.1%

N=1,164
a. 22 missing cases
b. 55 missing cases
c. 16 missing cases
Source: Cowpea survey

5.6 Cowpea Contribution to the Household

5.6.1 Contribution of Cowpea to Income

Farmers were asked about the contribution of cowpea cropping to their income over the previous 5 years, For the overall sample, farmers did not report cowpea as being a large share of their income, with 65.6% of the sample reporting cowpea as making up more than a quarter of their income. There is a significant difference, though, between the shares seen in Diourbel and Thiès on one hand, and Louga on the other.

90.2% of farmers in Thiès reported cowpea as making up a quarter or less of their income. 43.2% of farmers in Diourbel reported the same, with 49.1% of farmers reporting that it made up between 1 and 2 quarters of their income. Cowpea appears to make up a significantly larger share of income in Louga, where over half of farmers report cowpea as making up more than a quarter of their income, with almost 30% reporting it as making up a half or more of their income.

Table 5.12: Contribution of Cowpea to Household Income

	Diourbel (a)	Thiès (b)	Louga (c)
1/4 or less	43.2%	90.2%	40.6%
Between 1/4 and 1/2	49.1%	6.0%	30.0%
Between 1/2 and 3/4	7.4%	3.6%	20.3%
More than 3/4	0.4%	0.1%	9.1%

N=1,156
a. 21 missing cases
b. 64 missing cases
c. 16 missing cases
Source: Cowpea survey

The contribution of cowpea to household income appears to be highest in Louga, and lowest in Thiès, similar to the adoption rates of B/C CRSP varieties in the regions. One interesting implication in the numbers concerns the low contribution of cowpeas to income in Thiès. There is a significant difference between reported adoption rate of B/C CRSP varieties and the reported adoption rate of improved varieties, which was surprisingly large. The implication of this is not quite clear. Farmers may be less inclined to remember variety specifics of a crop that is not a large part of household income. On the other hand, the improved varieties they are growing may be improved indeterminate varieties, which contribute more to livestock feed than grain and pods. Farmers may be less likely to consider this a contribution to income.

5.6.2 Contribution of Production to Seed

Farmers were asked what the contribution of their production was to their need for seed over the previous five years. The reporting between farmers in Louga and Diourbel was similar, with over 74% in both regions stating that their own production filled over a third of their needs. Thiès was a different story; with 60.3% of farmers staying that less than a third of their needs were filled by their own production. This may help explain the lower adoption rates in Thiès compared to the rest of the sample, as the gap between farmer supply and demand is higher, specifically with regard to the variety Yacine. This suggests a need for extension efforts and for expanded production of certified seed to expand.

Table 5.13: Contribution of Cowpea to Household Need for Seed

	Diourbel (a)	Thiès (b)	Louga (c)
1/3 or less	19.8%	60.3%	25.7%
Between 1/3 and 2/3	57.9%	25.9%	32.2%
More than 2/3	22.3%	13.8%	42.0%

N=1,159
a. 21 missing cases
b. 61 missing cases
c. 16 missing cases
Source: Cowpea survey

5.6.3 Production of Cowpea Hay

One attribute of cowpea not valued in the impact assessment, due to the difficulty of measuring it, is the production of animal feed through cowpea hay. Farmers were asked how much of their required hay was produced by cowpea, in thirds. Similar to farmer responses regarding seeds, farmers in Thiès were less likely to have had their hay needs filled by cowpeas than their counterparts in Diourbel and Louga. 58.6% of farmers listed cowpea as filling a third or less of their needs. Only 21.5% of farmers in Thiès had cowpea fill more than two-thirds of their needs for hay.

In contrast, 22% of farmers in Diourbel and over 50% of farmers in Louga filled over 2/3 of their hay needs with their cowpea crop. Less than 30% of farmers in both regions had only a 1/3 or less filled by the cowpea harvest. This is specifically important in Louga, where animal ownership is a much larger share of income than in Thiès or Diourbel (Kelly 1988).

Table 5.14: Contribution of Cowpea to Household Need for Hay

	Diourbel (a)	Thiès (b)	Louga (c)
1/3 or less	29.2%	58.6%	32.8%
Between 1/3 and 2/3	48.6%	19.9%	16.5%
More than 2/3	22.2%	21.5%	50.6%

N=1,161
a. 21 missing cases
b. 58 missing cases
c. 17 missing cases
Source: Cowpea survey

5.6.4 Contribution of Green Pods

Information on usage of green pods in Senegal is limited. With this in mind, the survey asked farmers to rate the importance of green pods to their household, whether it was an important part of their consumption, or it contributed to their revenue, or both.. The answers reveal that farmers consider green pods to be a significant contributor to their family food consumption. A full 87.1% of farmers in the sample view green pods as an important source of food before the cereal harvest. 80.0% of farmers view it as an important way for them to diversify their family's food consumption. 20.5% of farmers in the sample state that it is an additional revenue source, though this differs somewhat between regions, with 8.1% and 18.8% reporting in Diourbel and Thiès, and a larger percentage of 32.9% reporting in Louga. Very few farmers in the sample, less than 1%, report that they do not harvest green pods. This reveals a part of the impact of cowpeas that is not measured in the impact assessment, the contribution of cowpeas to household food security in the hungry season, before the cereal crops are ready to harvest.

Table 5.15: What is the Contribution of Green Pods to the Household Consumption and Revenue?

	Diourbel (a)	Thiès (b)	Louga (c)
Very important as a contribution to household consumption before the cereal harvest	94.8%	85.9%	80.9%
Important mainly to diversify household consumption	87.0%	75.5%	76.8%
Additional revenue	8.1%	18.8%	32.9%
Do not consume green pods	0.3%	1.16%	0.3%

N=1,165
a. 21 missing cases
b. 55 missing cases
c. 16 missing cases
Source: Cowpea survey

The conclusions drawn from this section hold up in analysis of Section C, where farmers reported the share of green pods sold from their total harvest. Eighty four percent of the sample reported selling none of their green pod harvest. Farmers appear to value green pods significantly more for their own consumption than as an income source.

Table 5.16: Percentage of Green Pods Sold by Sampled Farmers

	Percent
1/4 or less	84.0
Between 1/4 and 2/4	10.2
Between 2/4 and 3/4	3.1
More than 3/4	1.9
The entire Harvest	0.8

N=570
Source: Cowpea survey

5.7 Seed Sources

For every variety of cowpea, the large majority of seed came from either personal reserve or from cowpeas bought at the market. The other possible sources were 1) given the seeds by a neighbor, 2) given by the state or an NGO, 3) bought from a neighbor, 4) bought from a trader, or 5) an undefined other origin.

5.7.1 Melakh

48.8% of farmers reported Melakh seed came from personal reserve, and 19.1% reported it coming from the market. 11.3% reported it coming from an NGO or the state, implying that a NGOs and the government are active when it comes to distributing Melakh seeds.

5.7.2 Mouride

The seeds for 98.4% of the Mouride parcels in the survey came from one of personal reserves, the market, or a neighbor. This helps to explain how adoption of Mouride is so high despite the focus of extension by NGOs and the government on the more recently developed varieties of cowpeas. Farmers have strong personal reserves of the variety (56.7% of farmers report using personal reserves) and variety appears to be widely disseminated in the market.

5.7.3 Yacine

Only 5.8% of Yacine parcels have government or NGO origin, a less than expected result. Additionally, 54.8% of parcels were reported with market origin, a higher result than would have been expected. The 33.1% reported as originating with personal reserve is the lowest among the varieties in the sample, which is a more expected result.

5.7.4 'Other' varieties

For varieties listed as 'other' 'traditional', 75.8% were reported as coming from personal reserve or the market. 3.3% report the variety coming from an NGO; it is very likely that some of these NGO-sourced parcels represent improved varieties.

For varieties listed as 'other' 'improved', there is no clear source for the varieties. 54.7% of the parcels are listed as personal reserve. The rest are a mix of neighboring producers, NGO and agricultural trader sourced seeds. It is hard to draw a specific conclusion from this, but likely these parcels represent both improved B/C CRSP varieties and misidentified traditional varieties.

90.2% of parcels listed as ‘other’ ‘unknown’ come from personal reserves and the market. This suggests that these parcels are likely a mix of traditional and improved, with the majority likely being traditional.

Table 5.16: Seed Sources

	Melakh	Mouride	Yacine	Traditional	Other Improved	Unknown
Personal reserves	48.8%	56.7%	33.1%	35.6%	54.7%	42.3%
Given by a neighbor	5.3%	21.9%	2.9%	1.9%	1.0%	4.4%
Given by the state or NGO	11.3%		5.8%	3.3%	4.3%	1.2%
Bought from a neighbor	13.4%		1.1%	9.8%	21.4%	4.1%
Bought from a commercial trader	0.2%	1.6%		9.2%	10.5%	
Bought at the market	19.1%	19.9%	54.8%	40.2%	8.1%	46.9%
Other origin	1.9%		2.3%	0.0%		1.1%

N=978

Source: Cowpea survey

CHAPTER VI: ECONOMIC IMPACT ASSESSMENT

6.1 Assessment Background

This Chapter will present several measures in order to give an accurate accounting of all scenarios. The IRR and NPV will both be presented. The baseline projection will be presented in two sub-scenarios, both as an ex post + ex ante analysis with costs and benefits projected through 2020, as well as an ex ante scenario with only benefits through 2010. The projection of future benefits is methodologically sound in terms of future adoption decisions by farmers, but as they are not actual tangible benefits, benefits through only 2010 will be presented as an alternative approach.

6.2 Baseline Analysis

The baseline scenario is an analysis using only dry seed yield gains from improved varieties, and presents a profitable IRR for both scenarios. The IRR is 12.9% when using only benefits through the 2010 season, and 17.9% when projected through 2020. This is significantly higher than an opportunity cost investment, and allows us to conclude that B/C CRSP investments into improved varieties in Senegal appear to have been successful. NPV for the scenarios are $78,636,607 and $14,173,573 respectively.

While all three of the regions receive welfare benefits from the project, the majority of benefits are seen in Louga. This is due to the combination not only of high adoption rates, but also the significant share of countrywide production that is concentrated in the region. The fewest welfare benefits are seen in Thiès due to the low adoption rate of B/C CRSP varieties. The benefits estimated for the Thiès region are almost assuredly under-estimated due to the large proportion of ‘other’ improved varieties in the region, which, if attributed to B/C CRSP varieties, would increase the benefits, and therefore the IRR, even more.

There is an important caveat to add to these numbers. The B/C CRSP research was devoted not only to varietal improvement, but also to developing improved storage technology for cowpeas. Boys et al. (2007) found a highly positive number when including this storage technology, and likely if those gains were included in this study returns to B/C CRSP investment would be significantly higher, as there would be no estimated additional costs to the program. Additionally, Schwartz, Sterns and Oehmke (1996) found very high returns to Operation Cowpea, which was instituted with B/C CRSP funds, and whose benefits (as well as extension costs) were not considered in this analysis. On its face, though, the program has been profitable even without gains from other program activities considered. A breakdown of the costs and benefit streams is in Appendix I.

6.2.1 Benefit Stream

Due to the nature of technology adoption, with the benefits coming much later than costs, the program does not begin to show a profitable benefit stream until 1999. Post 1999, benefits begin to increase rapidly as the adoption rate increases, leading to a very quick recuperation of costs. Benefits are only projected through 2020 for this analysis, but conceptually they could be projected for future years with a dis-adoption trend, which would increase the benefits of the program even further. One note is that the projection of a dis-adoption curve in Thiès combined with adoption costs means that benefits appear to be negative in later years for Thiès.

6.2.2 Projection of Adoption Rates

Using **Equations 4.7** and **4.8**, annual adoption numbers as well as a plateau rate were estimated. Adoption rates of Melakh are projected to have nearly reached a plateau rate in each Diourbel and Louga, with the plateau rates being 4.3% in Diourbel and 25.1% in Louga. The survey found no Mouride in Diourbel and Thiès, and so the adoption rates are projected with a disadoption trend to have reached zero; in Louga, though, adoption seems to have increased measurably from the 2004 analysis, with a projected plateau rate of 59.5% using the current data. Due to the more recent release of Yacine, the variety has not reached its estimated plateau rate in any of the three regions, with a very high rate of 39.0% in Diourbel, and significantly lower rates of 3.8% in Thiès and 1.0% in Louga. Of note is that Melakh is projected to have started a disadoption trend in Thiès, since the adoption rate in 2010 is lower than the adoption rate from the 2004 study (Boys et al. 2004). As the high rate of 'improved' 'other' varieties in Thiès implies under-reporting of improved varieties, which would include Melakh, this disadoption trend may not actually exist; unfortunately in this case the trend is constrained by the survey results.

Table 6.1: Projected Plateau Rates

	Diourbel	Thiés	Louga
Melakh	4.3%	0.0%	25.1%
Mouride	0.0%	0.0%	59.5%
Yacine	39.0%	3.8%	1.0%

*0% adoption is projected disadoption

6.2.3 Total Value of Production

The baseline estimate does not include an accounting of benefits accrued from improved green pod yields, for several reasons. Aggregate production information on green pod harvest is unavailable. Green pod harvesting was measured in the follow-up survey, but due to the lack of measured green pod yields, the data was not statistically significant for either yield differences between varieties, or for price differences. While the harvest of green pods is significantly lower than that of dry grain, the harvest is still significant. For example, annual green pod to dry pod production in Diourbel was estimated to be 0.41 kg green pods for 1 kg dry pods.

Table 6.2: Ratio of green pod harvest to dry grain harvest

	Ratio
Diourbel	0.41
Thiès	0.21
Louga	0.31

N=915

Source: Cowpea survey

The exclusion of any benefits from green pod harvesting likely excludes benefits stemming from green pod harvest. The B/C CRSP varieties are determinate varieties, which In order to provide explanatory value in terms of the full impact of improved variety adoption, the total value of production for the 2010 rainy season was produced, defined as the total dollar value of the variety on a per hectare basis, including green pod harvest, dry grain harvest, and a subtraction of adoption costs from the higher planting density for improved varieties.

Table 6.3: Total Value of Production by Variety

	Total Value of Production (US$/ha)
Melakh	300
Mouride	498
Yacine	186
Traditional (a)	171

N=817

a. Defined in the survey as 'other' 'traditional varieties'

Source: Cowpea survey

One note is that this represents only profits, and excludes any gain from fodder production. Additionally, it is likely that green pod harvests are underestimated; not only would green pod harvests have been much earlier in the harvest, as the large percentage of cowpea was consumed within the household, the harvests were likely not measured. It is notable, though, that there is a clear gain in terms of dollars per hectare, to planting improved varieties. The same pattern holds as with dry grain harvest, with Yacine showing very modest gains compared to the other two varieties.

6.3 Sensitivity Analysis

In order to account for gaps in the available data, as well as possible problems stemming from survey error, it is important to perform sensitivity analysis that ensures that benefits are neither over nor underestimated. IRR and NPV for these scenarios will only be presented with the projected benefits, but the other sub-scenario, with only benefits through 2010, is presented in Table 6.5.

6.3.1 Adoption Rates

While the adoption rates calculated from the survey data are the best estimation of adoption available, it is also useful to estimate benefits related to a larger or smaller adoption rate. In order to test this, the rate will be estimated assuming a 25% increase and 25% decrease in adoption measured by the 2010 survey. Assuming a 25% decrease in adoption for each variety in each region in 2010, the IRR drops to 16.8%, with an NPV of $58.0M, still a significantly higher value than the opportunity cost of capital. An increase of survey measured adoption rates in the other direction has a similarly small effect on the IRR, increasing it to 18.7% with an NPV of $98.0M. The effect of adoption rate manipulation is small largely because the effect is more significant on projected revenues than early period benefits, and as projected benefits are discounted heavily compared to early project dollars, the effect is minimal.

6.3.2 Intercrop Rates

The estimated share of an intercropped field that is attributed to cowpeas impacts the estimation of adoption rates. The baseline level for this analysis was set assuming cowpea planted on 50% of an intercropped field, but it is possible the share is more or less of each field. Analysis was performed with this value set at 25%, as well as 75%, in order to gauge the impact of this value on the analysis. The setting of intercrop rates at either value has no effect on the IRR; the value remains at the same. The reason for this is fairly simple; nearly all of the social benefits stem from adoption in Louga, and the rate of intercropping in Louga is low. Additionally, the intercropping is spread between varieties in a way that the low intercropping rate combined with low impact on adoption estimates results in a negligible difference.

6.3.3 Yield Gain Estimates

Table 6.4: Yields By Variety (kg/ha)

	Melakh	Mouride	Yacine	Traditional (a)	All varieties
Diourbel	218		206.2	146.6	200.0
Thiés	460.7**		144	123.1	137.2
Louga	393.9**	687.8**	400.3	267.8	395.8
All 3 Regions	400	687.8	215.1	165.6	240.5

Source: Median yields from cowpea farmer survey in 2010 season
a. Defined in the survey as 'other' 'traditional varieties'
** Difference from traditional varieties significant at the 1% level in Mann-Whitney Test
Source: Cowpea survey

The baseline scenario uses these yields from the cowpea survey (improved variety vs. traditional variety) to measure yield gains for each improved variety. These yield gains from improved varieties over traditional varieties are an interesting case for this paper. Notably, the average yields in each region did not match up with the average yield found in the aggregate production and land statistics from the FAO, specifically with lower yields in the sample compared to FAO statistics for Thiès.

Yield improvements are not significant in all cases. In the case of Yacine in Thiès and Louga, and Melakh in Diourbel, this is due to the small sample size of improved varieties (<15 in each instance). The sample of Yacine parcels in Diourbel, though, lacks significance due to the small yield difference between Yacine and traditional varieties. This has the effect of creating no benefits accruing in those instances.

While the baseline scenario uses the survey yields, a sensitivity scenario has also been performed with yield improvements set at the rate of 40% (Boys et al. 2004) over the yield from traditional varieties. The sensitivity scenario analysis using a 40% yield gain over the traditional variety yield has the effect of reducing the IRR to rate of 13.4%, with an NPV of $25.7M. This value that is still very profitable even when counting a 40% as opposed to the gains from the survey. While under this scenario the benefits from Thiès and Diourbel increase, the yield increases in Louga are lower, resulting in a reduction in benefits due to the large share of cowpeas grown in Louga.

6.3.4 Elasticity Estimates

While the elasticity of demand for cowpeas in Senegal is available as an econometrically estimated value, the elasticity of supply is not available in similar form. While the elasticity of supply was estimated at a value of 0.28 in the baseline estimate, for comparison values the estimation has been performed with the value set at 0.1, and 1.2.

A scenario with elasticity of supply at 0.1, an extremely inelastic supply curve that is still higher than in both Mali and Niger (Langyintuo 2003), increases the program IRR to 223.0% and an NPV of $233.6M. While this is an extremely inelastic curve, the general inability of the seed sector to fill demand could imply very low supply elasticity.

Raising the elasticity of supply to 0.8 (the rate used in previous studies by Boys et al. (2004) and Sterns (1993) in evaluating B/C CRSP programs), an inelastic demand, but significantly more elastic than in the baseline estimation, reduces the IRR to 12.2% with an NPV of $20.3M. This reflects a situation where supply is slow to respond to product price changes, but less so than in the baseline estimate. This elasticity may be more comparable to the situation in Thiès and Diourbel, where farmers are less likely to report seed availability as a disadvantage of varietals.

Raising the elasticity to 1.2, which assumes an elastic supply where a change in price brings a more significant change in production, reduces the IRR even further to 9.4%. It is unlikely that the elasticity of supply is this high; it would be *significantly* higher than any other country in the region. Additionally, farmers in Louga, where most of the benefits flow from, already sell a significant share of their dry grain production, reducing their inability to quickly respond to price hikes. This is important as an explanatory piece of information, though, confirming that even a very high estimation of supply elasticity is unlikely to change program impacts enough to lead to negative conclusions regarding program success.

6.3.5 Research Costs

As program costs were projected for much of the study period, it is important to introduce other sources of costs to measure the impact of under-representing research costs. In order to produce a different source for program costs, the costs were estimated using ASTI estimates regarding R+D costs per researcher. Estimates are available for per researcher agricultural R + D spending. Possible cowpea expenditures were estimated two ways: the first simply assumed annual investment of 3 full time equivalent researchers on cowpea research, with future spending per researcher projected with an exponential trend line. This is much higher than the ISRA cost estimates in the baseline estimate and reduces the IRR to 13.2%. The NPV drops to $71.0M as well.

The other method relies on a report by Alene and Mwalughali (2012), which calculates the number of full time equivalent researchers in Senegal working on cowpea. This estimate was then projected for previous years using the change in government sector research staff per year. Costs were projected for future years using an exponential trend line. This estimate of research costs is significantly higher than even the assumption of 3 researchers, as real costs in the early 1980s are calculated to be significantly higher than in more recent years. This reduces the IRR to 8.8%. This is significantly lower than the baseline scenario, but even with what is an extremely high estimate of research costs, the IRR still exceeds the opportunity cost of capital under the ex post scenario.

6.3.6 Cowpea Price

In order to test the effect of price differences on the model, the economic assessment was performed with the annual price set at a plus/minus 25% level. This does have a small effect on the IRR. When the annual CFA/kg is reduced by 25%, the IRR decreases to 16.8%. Even a price reduction on the order of 25% does not decrease the valuation of the program as a good investment. Likewise, when increasing price by 25%, the IRR jumps to 29.0%.

6.3.7 Summary of Sensitivity Analysis

While all of the factors tested in sensitivity analysis excepting intercropping rates have an effect on the IRR, research cost changes and the supply elasticity are the only factors that significantly lower program returns. Even with research costs significantly higher, the sensitivity scenarios in IRRS that are still acceptable. Additionally, even with the assumption of highly elastic supply, the program still has a rate of return higher than he opportunity cost of capital under the ex post scenario with projected benefits.

The lack of significant effects from the other factors is the result of two specific factors. The first is that the sensitivity calculations are affecting benefit flows in Thiès and Diourbel more than in Louga. The majority of welfare benefits seen from the program stem from cowpea production in Louga, due to the combined factors of a high adoption rate and the concentration of production in the region. The second is that these sensitivity calculations are largely affecting the program in later years. Due to discounting, these figures are a less significant part of realized benefits. The alternate research costs scenarios have a large effect precisely because they increase costs significantly in the earlier years. Table 6.4 is a summary of the effects of the sensitivity calculations

Table 6.4: Sensitivity Scenarios

Parameter	Scenario	IRR		NPV (i=4.25%)	
		Ex Post (a)	Ex Post + Ex Ante (b)	Ex Post (a)	Ex Post + Ex Ante (b)
Baseline		12.9%	17.9%	14,173,573	78,636,607
Yield Improvements	40%	8.3%	13.4%	4,002,821	25,734,295
Supply Elasticity	0.1	19.1%	23.0%	50,594,905	233,642,946
	0.8	5.3%	12.2%	802,038	20,283,460
	1.2	0.8%	9.4%	-1,683,133	8,928,135
Research Costs	3 researchers	7.2%	13.2%	7,004,126	71,054,571
	IITA est.	1.6%	8.8%	-10,591,589	53,207,523
Price	-25%	11.0%	16.4%	9,008,331	55,792,412
	25%	14.3%	19.0%	19,334,746	101,449,852
Adoption Rates	-25%	12.2%	16.8%	11,882,186	57,983,536
	25%	13.4%	18.7%	16,133,681	97,956,070

a. This sub-scenario represents only benefits through 2010

b. This sub-scenario represents benefits projected through 2020

CHAPTER VII: CONCLUSION

The first section of the chapter will provide a summary of the research findings. The second section will describe knowledge gaps, and the third section will present the implications of the results for continued research in Senegal as well as policy regarding cowpeas.

7.1 Summary of Results

Using the adoption rates from the survey sample, combined with yield gains from improved varieties, investment from the B/C CRSP on varietal development appears to be profitable, with an IRR of 17.9%. This is encouraging both for the research direction of B/C CRSP and for varietal development undertaken by ISRA. In keeping with previous studies regarding B/C CRSP involvement in Senegal, the rate of return to research shows that varietal improvement efforts have been a worthwhile investment in terms of welfare gains produced for the Senegalese economy.

One important note is that this economic assessment has considered solely the benefits from varietal research. A full accounting of B/C CRSP research in Senegal would also include two other factors: research involving storage techniques, and extension of the varieties CB-5 and 58-57 in 1985 and 1986 under Operation Cowpea. While costs and benefits from these efforts do not fall under the umbrella of the varietal adoption study undertaken for this paper, inclusion of impacts from these projects would impact the IRR. While the effect is not quantified in this report, both programs showed a positive IRR in previous studies (Schwartz, Sterns, and Oehmke 1993; Boys et al. 2007).

The conclusion from this study, then, is that even without the other program elements included in the analysis, the program has been decidedly positive.

7.2 Knowledge Gaps

There are some gaps in the knowledge not addressed in the economic assessment performed here. The welfare gain measured in the assessment is an economy-wide gain. It does not measure the household impact in dollar terms. The yield gains from improved varieties represent a reduction in per-unit production costs, and the combination of social welfare gains as well as the ability of farmers to consume green pods in the hunger season show clear benefits for households from growing improved varieties.

Furthermore, this analysis is not designed to present best practices in terms of which varieties to grow or research investment strategies. As an ex post analysis, it is designed to evaluate B/C CRSP expenditures on varietal development. While the fact that it is successful can be used to weigh the effectiveness of program management, and the success of collaboration between University of California-Riverside and ISRA, it is only a case study and should be taken as such.

Another issue is that any adoption costs beyond higher seed planting density are not considered. Adoption of other inputs (fertilizer, pesticide) that increase yield beyond gains solely associated with the variety, are not considered. There is no indication, though, that there is a large-scale input distribution program in place or use of other inputs in cowpea production.

The issue of improved varietal adoption rates in Thiès calls for further investigation. The high number of improved varieties listed as 'other' varieties is perplexing, and follow-up to determine the exact situation would clear up the confusion. A more accurate picture of the actual varieties present in Thiès would help in future decision-making.

This paper deals only tangentially with the issue of the seed system in Senegal. The difference in adoption rates between Louga on the one hand and Diourbel and Thiès on the other is striking. More knowledge regarding the seed production and distribution system, and how improved seeds are multiplied and distributed to different regions, would be worthwhile in terms of studying why adoption in the other two regions seems to lag behind Louga and what the implications are for efforts to increase adoption in other regions. Louga shows significantly higher adoption of B/C CRSP varieties, as well as higher yield gains from these varieties. Further study of exactly why these differences exist may help provide a framework for the rest of the country.

7.3 Research Implications

Certainly, the high adoption rates and welfare gains imply that cowpea varietal improvement research has been successful in Senegal. There are implications, though, for research direction in the future. While the long time frame since the release and low adoption of Melakh and Mouride suggest that those varieties have reached a plateau, Yacine particularly has potential for higher adoption rates. While the projected plateau rate is quite low, farmers noted seed availability as a constraint, suggesting more demand than supply in terms of seed. Enhanced extension efforts in Thiès may yield higher adoption rates in Senegal's second most populated region. According to Diatta (2012), there is significantly more improved varietal seed production by producer organizations in Louga. This would seem to be consistent with the higher adoption rates of improved varieties in Louga. But it is worth researching whether these are a cause or an effect of the high adoption rates in Louga. Research into the extension efforts and farmer practices in regards to cowpea cropping in the Diourbel and Thiès regions would be valuable for establishing a pathway for improved welfare gains even beyond those established.

Another issue worth examining relates to the sample yield rates. Outside of Louga, yield gains from improved varieties were not nearly as high as experimental and on-farm yield tests. Possible yield gains are reported as 2 to 3 times more in experimental and on-farm yield trials (Diatta 2012; Cissé et al. 2005; B/C CRSP 2011), whereas the yield gains seen in the sample are significantly smaller. Additionally, while Yacine yields were larger than traditional variety yields in all three regions, the gains were smaller than seen in Mouride and Melakh, and the results were not significant due to small sample size in Thiès and Louga, and the small margin in Diourbel. This implies a possible extension gap between possible yield with best practices and the yields that farmers are seeing in actuality.

The data issues have some implications for future survey research following similar lines. The assumption had been that the second survey would be performed by the same enumerators that performed the DAPS survey. This did not happen, leading to the data matching issues between different parts of the survey. The take-away from this is that the assumption of having skilled enumerators performing analysis does not override the importance of providing training, particularly when the type of data collected differs between households surveyed. Similarly, better coordination would have helped to alleviate the errors involved in the mismatches between data collected from DAPS households in the DAPS survey and the second cowpea survey.

It is notable that even with the likely under-estimation of benefits in Thiès, the IRR was still higher than the opportunity cost of capital. This speaks to the success of not only the development efforts undertaken, but the cowpea itself, which is a formidable crop both well suited to the Senegalese environment as well as full of potential for expanded production. While the adoption improvements in Louga have led to profitable gains, the lack of significant yield gains in Diourbel and questions about adoption in Thiès speak to the need for further research not only into farmer adoption patterns but the success of the program as a whole.

APPENDIX I

TABLES

Table A7: Percentage of Farmers listing trait as advantage by region and variety

Region	Variety	High Yield	High Leaf Yield	Seed Color	Seed Taste	Cooking Time	Disease Resistance	Pest Resistance	Observations (n)
Diourbel	Melakh	23.9	13.2	8.2	81.3	30.3	0.0	0.0	69
	Yacine	25.9	8.5	43.0	82.2	16.3	0.0	0.8	205
	Other	37.9	41.9	2.4	66.8	22.9	2.3	1.5	296
Thies	Melakh	87.3	35.7	8.5	30.2	14.3	0.0	0.0	42
	Yacine	82.4	20.1	6.6	73.0	11.2	4.0	0.0	28
	Other	64.0	54.5	6.6	73.0	9.1	3.2	2.6	374
Louga	Melakh	91.0	70.6	1.3	24.9	4.7	3.4	1.2	229
	Mouride	98.5	68.1	1.3	59.8	8.9	1.4	2.8	147
	Yacine	50.7	21.5	9.6	48.7	52.2	0.0	0.0	19
	Other	55.6	67.4	15.8	73.7	2.9	0.6	1.3	313

Table A7 Cont'd

Region	Variety	Drought Resistance	Short Cycle	Seed Availability	Price Received	Other Advantage	Observations (n)
Diourbel	Melakh	0.2	50.2	3.7	27.4	17.0	69
	Yacine	.9	12.8	1.2	56.8	23.0	205
	Other	2.1	8.9	6.5	19.6	26.4	296
Thiès	Melakh	0.6	68.6	6.8	5.8	27.2	42
	Yacine	0.0	42.1	3.0	34.3	9.6	28
	Other	3.9	16.1	27.2	16.1	6.1	374
Louga	Melakh	6.6	82.4	2.8	8.5	1.4	229
	Mouride	1.4	24.2	0.0	31.4	0.0	147
	Yacine	29.0	37.9	10.2	40.2	0.0	19
	Other	9.4	4.0	4.8	47.7	7.0	313

Table A8: Percentage of Farmers listing trait as disadvantage by region and variety

Region	Variety	Low Yield	Low Leaf Yield	Seed Color	Seed Taste	Cooking Time	Disease Susceptible	Insect Susceptible	Observations (n)
Diourbel	Melakh	6.7	30.5	2.0	1.2	0.0	76.3	86.0	69
	Yacine	2.1	17.0	0.04	0.2	0.0	52.7	84.9	205
	Autre	3.3	7.2	9.6	0.3	0.6	55.3	87.3	296
Thiès	Melakh	0.0	23.1	0.0	3.5	9.6	38.4	81.2	42
	Yacine	3.4	39.0	11.3	0.0	0.0	64.6	88.6	28
	Autre	6.9	8.4	1.2	0.6	2.8	47.7	83.2	374
Louga	Melakh	3.0	3.8	10.6	16.4	0.0	31.6	69.4	229
	Mouride	3.2	4.0	0.9	.7	0.0	51.1	94.0	147
	Yacine	0.0	13.6	2.4	13.9	0.0	45.7	91.4	19
	Autre	2.7	3.0	1.3	0.6	1.9	6.9	97.1	313

Table A8 Cont'd

Region	Variety	Drought Susceptible	Long Cycle	Seed Availability	Price Received	Other Disadvantage	Observations (n)
Diourbel	Melakh	2.3	0.6	2.9	5.8	4.72	69
	Yacine	0.6	0.0	1.1	0.5	9.49	205
	Autre	2.2	1.8	0.0	5.9	5.24	296
Thiès	Melakh	10.9	6.0	17.7	8.2	3.95	42
	Yacine	11.7	9.2	35.5	4.7	13.94	28
	Autre	15.6	19.9	14.5	11.3	15.62	374
Louga	Melakh	16.4	1.0	64.8	55.7	6.54	229
	Mouride	42.2	4.5	55.9	37.1	0.00	147
	Yacine	19.9	9.4	31.1	4.6	0.00	19
	Autre	5.5	12.0	4.6	10.6	1.08	313

Table A9: B/C CRSP and ISRA Costs

Year	CRSP to HC D+I(a) Nominal $	ISRA Research Costs (c) Nominal $	Extension Costs (d) Nominal $	Total Nominal $	USA CPI (b) (2005=1)	Total Costs Real $
1982	35,174	105,042		140,216	0.494	283,762
1983	117,499	105,042		222,541	0.510	436,349
1984	75,078	105,042		180,120	0.532	338,556
1985	156,888	105,042		261,930	0.551	475,397
1986	61,269	97,839		159,108	0.561	283,508
1987	59,637	106,981		166,618	0.582	286,184
1988	50,242	110,305		160,547	0.606	265,127
1989	66,520	87,583		154,104	0.635	242,768
1990	78,661	75,952		154,612	0.669	231,095
1991	81,922	74,546		156,468	0.697	224,367
1992	76,171	112,780		188,951	0.718	262,980
1993	89,356	85,687	1	175,045	0.740	236,641
1994	60,375	41,430	1	101,806	0.759	134,133
1995	72,132	45,405	9	117,547	0.780	150,646
1996	42,310	40,357	21	82,689	0.803	102,955
1997	82,000	42,397	45	124,443	0.822	151,403
1998	94,904	42,397	112	137,413	0.835	164,627
1999	46,142	42,397	261	88,801	0.853	104,110
2000	61,499	42,397	499	104,395	0.882	118,395
2001	50,177	42,397	883	93,458	0.907	103,077
2002	60,645	42,397	1,357	104,399	0.921	113,347
2003	40,047	42,397	2,057	84,502	0.942	89,708
2004	60,645	42,397	2,798	105,840	0.967	109,430
2005	109,613	42,397	3,824	155,835	1.000	155,835
2006	0	42,397	5,959	48,357	1.032	46,846

Table A9 Cont'd

2007	0	42,397	11,001	53,399	1.062	50,295
2008	50,000	42,397	19,178	111,575	1.102	101,205
2009	23,500	42,397	26,348	92,246	1.099	83,971
2010	38,750	42,397	33,723	114,870	1.117	102,879
2011	48,604	42,397	47,292	138,293	1.152	120,066
2012	36,951	42,397	60,660	140,009	1.152	121,555
2013	36,951	42,397	72,642	151,991	1.152	131,958
2014	36,951	42,397	79,599	158,948	1.152	137,998
2015	36,951	42,397	82,744	162,093	1.152	140,729
2016	36,951	42,397	84,001	163,350	1.152	141,820
2017	36,951	42,397	84,478	163,826	1.152	142,234
2018	36,951	42,397	84,654	164,003	1.152	142,387
2019	36,951	42,397	84,719	164,068	1.152	142,443
2020	36,951	42,397	84,742	164,091	1.152	142,464

a. This represents direct and indirect transfers to Host country institution ISRA. Figures come from the MSU CRSP Accounting Office. Figures for 2005-2007 were unavailable disaggregated. The entire period has been assigned to 2005.

b. Consumer Price Index figures come from the IMF Financial Statistics Online

c. Figures for ISRA spending could not be obtained. Costs from 1982 through 1996 come from Boys (2005). Figures 1997-2020 are projected as 2/3 of CRSP HC D+I transfers

d. Extension costs were not available at the time of writing

* Figures in gray represent projected future figures

Table A10: Cowpea Prices

Year	Nominal Price (a) CFA/kg	Exchange Rate CFA to US$	USA CPI (b) (2005=1)	Real Price US$/kg
1990	80	272	0.621	0.473
1991	118	282	0.610	0.686
1992	100	265	0.609	0.620
1993	72	283	0.606	0.420
1994	78	555	0.801	0.175
1995	120	499	0.865	0.278
1996	153	512	0.888	0.337
1997	207	584	0.904	0.392
1998	235	590	0.914	0.436
1999	148	616	0.922	0.261
2000	123	712	0.929	0.186
2001	247	733	0.957	0.352
2002	344	697	0.979	0.504
2003	306	581	0.978	0.538
2004	245	528	0.983	0.472
2005	300	527	1.000	0.569
2006	252	523	1.021	0.472
2007	366	479	1.081	0.707
2008	265	448	1.143	0.518
2009	212	472	1.131	0.397
2010	235	495	1.145	0.414
2011	237	472	1.185	0.424
2012	237	480	1.185	0.417
2013	237	480	1.185	0.417
2014	237	480	1.185	0.417
2015	237	480	1.185	0.417
2016	237	480	1.185	0.417
2017	237	480	1.185	0.417
2018	237	480	1.185	0.417
2019	237	480	1.185	0.417
2020	237	480	1.185	0.417

a. Prices come from Senegal ANSD. 2009 and 2010 price come from FAOSTAT
b. CPI from IMF Financial Statistics Online
* Projected prices in gray

Table A11: Production and Benefits 1982-1997

Year	Acreage (a) ha	Production (a) t	Mean Yield kg/ha	Parameter "k"	Increase in Production kg	Social Gain US$
1982	45,886	10,889	237	0.00	0	0
1983	39,433	12,858	326	0.00	0	0
1984	52,498	15,795	301	0.00	0	0
1985	120,716	65,966	546	0.00	0	0
1986	117,607	54,863	466	0.00	0	0
1987	71,480	28,625	400	0.00	0	0
1988	70,687	24,405	345	0.00	0	0
1989	64,809	26,350	407	0.00	0	0
1990	45,334	12,242	270	0.00	0	0
1991	50,744	16,679	329	0.00	-11	0
1992	73,653	16,833	229	0.00	-10	-17
1993	118,432	43,993	371	0.00	-139	-210
1994	91,504	28,980	317	0.00	-362	-938
1995	97,479	41,911	430	0.00	-421	-386
1996	88,623	20,626	233	0.00	4,957	11,574
a. Figures come from FAO countrySTAT						

Table A12: Production and Benefits in Diourbel, 1997-2020

Year	Acreage (a) ha	Production (a) t	Mean Yield kg/ha	Parameter "k"	Increase in Production kg	Social Gain US$
1997	25,329	3,450	136	0.00	107	184
1998	24,335	6,916	284	0.00	386	738
1999	24,335	6,916	284	0.00	619	708
2000	20,540	5,512	268	0.00	877	715
2001	13,422	4,906	366	0.00	3,929	6,061
2002	12,561	675	54	0.06	8,901	19,553
2003	22,815	6,752	296	0.02	24,711	58,203
2004	27,773	396	14	0.04	37,307	76,788
2005	34,964	15,629	447	0.02	63,571	158,202
2006	32,053	8,309	259	0.03	65,317	134,628
2007	33,643	6,197	184	0.08	116,264	356,765
2008	40,938	13,944	341	0.06	188,170	424,163
2009	50,899	17,730	348	0.07	298,020	514,227
2010	14,391	4,387	305	0.13	125,362	224,433
2011	35,409	12,020	339	0.13	362,283	664,033
2012	35,409	12,020	339	0.14	386,589	696,185
2013	35,409	12,020	339	0.14	396,524	713,777
2014	35,409	12,020	339	0.15	400,335	720,519
2015	35,409	12,020	339	0.15	401,766	723,051
2016	35,409	12,020	339	0.15	402,303	724,002
2017	35,409	12,020	339	0.15	402,506	724,361
2018	35,409	12,020	339	0.15	402,586	724,502
2019	35,409	12,020	339	0.15	402,612	724,549
2020	35,409	12,020	339	0.15	402,622	724,566

a. Figures come from FAO countrySTAT

Table A13: Production and Benefits in Thiès, 1997-2020

Year	Acreage (a) ha	Production (a) t	Mean Yield kg/ha	Parameter "k"	Increase in Production kg	Social Gain US$
1997	30763	4343	141	0.04	36,240	62,083
1998	17778	9881	556	0.02	47,036	89,629
1999	21500	8600	400	0.05	97,245	110,541
2000	15035	5262	350	0.08	93,729	75,768
2001	19982	4519	226	0.16	162,099	245,695
2002	17480	839	48	0.81	155,949	312,806
2003	26500	6434	243	0.16	241,031	558,100
2004	32483	424	13	3.03	292,802	396,441
2005	45079	15880	352	0.11	413,274	1,017,159
2006	40340	11994	297	0.13	362,455	738,694
2007	36045	8231	228	0.18	336,621	1,021,410
2008	42218	20339	482	0.08	350,959	789,614
2009	30396	12135	399	0.07	200,048	345,234
2010	15272	10852	711	0.03	69,845	126,446
2011	29295	14442	493	0.02	69,749	133,962
2012	29295	14442	493	0.01	26,045	47,358
2013	29295	14442	493	0.00	6,190	11,528
2014	29295	14442	493	0.00	-2,330	-4,331
2015	29295	14442	493	0.00	-5,741	-10,607
2016	29295	14442	493	0.00	-6,816	-12,655
2017	29295	14442	493	0.00	-7,290	-13,519
2018	29295	14442	493	0.00	-7,471	-13,844
2019	29295	14442	493	0.00	-7,446	-13,810
2020	29295	14442	493	0.00	-7,455	-13,823

a. Figures come from FAO countrySTAT

Table A14: Production and Benefits in Louga, 1997-2020

Year	Acreage (a) ha	Production (a) t	Mean Yield kg/ha	Parameter "k"	Increase in Production kg	Social Gain US$
1997	47961	9215	192	0.00	164	283
1998	59088	14922	253	0.00	570	1,089
1999	89148	29796	334	0.00	1,976	2,259
2000	72432	22006	304	0.00	3,919	3,196
2001	48134	17132	356	0.00	9,389	14,487
2002	85132	8426	99	0.02	47,708	105,199
2003	71685	15166	212	0.03	104,262	245,179
2004	91316	2101	23	0.66	317,900	607,683
2005	99960	41199	412	0.09	826,080	2,039,320
2006	85979	20615	240	0.29	1,341,839	2,686,298
2007	70064	19783	282	0.45	2,011,481	5,914,087
2008	111207	55147	496	0.41	5,206,868	11,258,904
2009	89024	36276	407	0.85	6,998,323	11,003,118
2010	58487	19575	335	1.65	7,365,030	10,860,182
2011	86239	36999	429	1.71	14,432,727	22,367,394
2012	86239	36999	429	1.96	16,551,381	24,330,588
2013	86239	36999	429	2.08	17,519,689	25,319,905
2014	86239	36999	429	2.12	17,908,474	25,703,625
2015	86239	36999	429	2.14	18,056,355	25,847,548
2016	86239	36999	429	2.15	18,111,439	25,900,872
2017	86239	36999	429	2.15	18,131,797	25,920,540
2018	86239	36999	429	2.15	18,139,299	25,927,783
2019	86239	36999	429	2.15	18,142,061	25,930,448
2020	86239	36999	429	2.15	18,143,077	25,931,429

a. Figures come from FAO countrySTAT

Table A15: Aggregate Benefits and Net Social Gains

Year	Real Total Costs US$	Real Total Benefits US$	Net Social Benefits US$
1982	283,762	0	-283,762
1983	436,349	0	-436,349
1984	338,556	0	-338,556
1985	475,397	0	-475,397
1986	283,508	0	-283,508
1987	286,184	0	-286,184
1988	265,127	0	-265,127
1989	242,768	0	-242,768
1990	231,095	0	-231,095
1991	224,367	0	-224,367
1992	262,980	0	-262,981
1993	236,641	-210	-236,851
1994	134,133	-938	-135,071
1995	150,646	-386	-151,032
1996	102,955	11,574	-91,381
1997	151,403	62,550	-88,852
1998	164,627	91,456	-73,171
1999	104,110	113,507	9,397
2000	118,395	79,680	-38,714
2001	103,077	266,243	163,166
2002	113,347	437,558	324,211
2003	89,708	861,483	771,775
2004	109,430	1,080,912	971,481
2005	155,835	3,214,682	3,058,847
2006	46,846	3,559,621	3,512,775
2007	50,295	7,292,263	7,241,967
2008	101,205	12,472,681	12,371,475
2009	83,971	11,862,579	11,778,608
2010	102,879	11,211,062	11,108,183

Table A15 Cont'd

2011	120,066	23,165,389	23,045,323
2012	121,555	25,074,131	24,952,576
2013	131,958	26,045,210	25,913,251
2014	137,998	26,419,813	26,281,815
2015	140,729	26,559,993	26,419,264
2016	141,820	26,612,219	26,470,399
2017	142,234	26,631,383	26,489,149
2018	142,387	26,638,441	26,496,054
2019	142,443	26,641,186	26,498,743
2020	142,464	26,642,172	26,499,708

APPENDIX II

SURVEY

Ministère de l'Agriculture/DAPS et Dry Grain Pulses CRSP/MSU
Enquête sur l'Adoption de Variétés Améliorées de Niébé

QUESTIONNAIRE POUR L'ECHANTILLON SUPPLÉMENTAIRE DE MÉNAGES ENQUÊTÉS EN 2011 QUI ONT PRODUIT DU NIÉBÉ

L'enquêteur doit lire le suivant en langue nationale au Chef de l'Exploitation et/ou à la personne qui va répondre :

Cette enquête est menée par la DAPS du Ministère de l'Agriculture avec la participation de l'Institut Sénégalais de Recherches Agricoles et l'Université de l'Etat de Michigan aux Etats-Unis. Elle fait partie d'une étude de l'impact des programmes de recherches sur l'amélioration du niébé au Sénégal.

Je vais vous poser des questions sur votre production de niébé, surtout concernant votre utilisation ou non des variétés améliorées de niébé. Vos réponses nous permettraient de mettre en évidence l'adoption et l'impact des variétés améliorées ; d'identifier des facteurs qui contribuent à la réussite des recherches sur le niébé ; et de proposer des mesures pouvant renforcer ces programmes de recherche.

Cet entretien durera à peu près une heure. Votre participation à cette enquête est entièrement volontaire. Il n'y a pas de risque lié à votre participation, selon notre meilleure connaissance. Si vous décidez d'y prendre part, vous avez la possibilité de ne pas répondre à toutes les questions et vous pouvez suspendre votre participation à tout moment sans aucune pénalité. Vos réponses seront tenues entièrement confidentielles, autant que la loi le permet.

Au cas où vous avez des questions sur cette enquête, vous pourrez contacter Dr. Ndiaga Cissé de l'ISRA au Centre National de Recherches Agricoles, BP 53 Bambey (tél. 77 271 74 27), ou Dr. Mywish Maredia de l'Université de l'Etat de Michigan, 83 Agriculture Hall, East Lansing, MI 48824 (tél. +1-517-353-6602 ; courriel maredia@msu.edu).

En prenant part à cette enquête vous démontrez votre consentement volontaire de répondre à mes questions. Pouvons-nous commencer ?

SECTION A : IDENTIFICATION

A01. N° de la Grappe				

A02. Nom et Code de région	|___|___|
A03. Nom et Code de département	|___|
A04. Nom et code de l'arrondissement	|___|
A05. Nom et Code de la communauté rurale	|___|
A06. Numéro du DR	|___|___|___|___|

A10. Nom et N° du chef de ménage agricole	|___|
A12. Nom du village de résidence du ménage	
A13. Nombre total de personnes vivant dans le ménage	|___|___|
A14. Age du chef de ménage	|___|___|___|
A15. Niveau d'instruction du chef de ménage en français ou en arabe *(1=sans niveau ; 2=maternel ; 3=élementaire ; 4=moyen ; 5=secondaire ; 6=supérieur ; 7=autre)*	|___|___|
A16. Sexe du chef de ménage (1=masculin ; 2=féminin)	|___|
A17. Nombre total de parcelles du ménage	|___|___|

Noms et dates d'intervention du personnel

Z01. Nom et Code de l'agent enquêteur	|___|___|___|
Z02. Date d'interview	|___|___|___|___|___|___|
Z03. Nom et Code du Contrôleur	|___|___|
Z04. Date de Contrôle	|___|___|___|___|___|___|
Z05. Nom et Code de l'agent de saisie	|___|___|
Z06. Date de Saisie	|___|___|___|___|___|___|
Z07. Nom et Code de l'agent de re-saisie	|___|___|
Z08. Date de Re-Saisie	|___|___|___|___|___|___|

SECTION L : SUPERFICIE ET AUTRES CARACTERISTIQUES DE CHAQUE PARCELLE CULTIVÉE EN NIÉBÉ

L00 : Nombre total de parcelles de niébé : |___|___|

L01 : N° de cette parcelle : |___|___|
L02 : Sexe du responsable |___| (1= Masculin ; 2= Féminin)
L03 : Régime foncier de la parcelle : |___| (1= Propriété ; 2= Fermage/métayage ; 3=Prêt ; 4=Location ; 5=Autre régime)
L04 : Superficie de la parcelle (GPS) : |___|___| **,** |___|___|___|___| (hectares)

L05 : Coordonnées au centre : **Latitude** : |___|___| **,** |___|___|___|___|___| *(degrés décimales)*
de la parcelle **Longitude** : **-** |**0**|___|___| **,** |___|___|___|___|___| *(degrés décimales)*

L06 : La parcelle a-t-elle été labourée ? |___| (1= Oui ; 2= Non)
L07 : La parcelle a-t-elle reçu de la fumure organique ? |___| (1= Oui ; 2= Non)
L08 : La parcelle a-t-elle reçu de l'engrais minéral ? |___| (1= Oui ; 2= Non)
L09 : La parcelle a-t-elle été semée au semoir ? |___| (1= Oui ; 2= Non)

L10 : Croquis de la parcelle

Code de région |___||___| ; Code de dépt. |___| ; Code de l'arrond. |___| ; Code de CR |___| ; Numéro du DR |___| ; Numéro du chef de ménage agricole|___|

SECTION C : (Information supplémentaire à collecter pour chaque parcelle où le niébé a été cultivé en 2010)

N° de la parcelle	Nom de Variété	Code de Variété	Type de variété (voir code)	Origine de Semences (voir code)	Première année dans laquelle vous avez cultivé cette variété?	Récolte Graine Quantité (kg)	Part de Graine Vendu à ce jour (voir code)	Graine : Prix de vente à la récolte (FCFA/kg)	Récolte Gousses Vertes Quantité (kg)	Part de Gousses Vertes vendu à ce jour (voir code)	Gousses Vertes : Prix de vente à la récolte (FCFA/kg)	Avez-vous récolté de la fane ? (voir code)
L01	**C01**	**C02**	**C03**	**C04**	**C05**	**C06**	**C07**	**C08**	**C09**	**C10**	**C11**	**C12**

Codes :

C02 : Variété : 1=Melakh ; 2=Mouride ; 3=Yacine ; 4=Bambey 21 ; 5=Bambey 23 ; 6=Diongoma ; 7= Ndiambour ; 10=autre → ***Enquêteur***: Pour chaque cas « autre », collecter un échantillon de 20 graines de la variété cultivée, et le mettre dans un sachet avec étiquette indiquant les valeurs pour variables A06 + A10 + L01 + S01.

C03 : Type de variété : 1= Améliorée ; 2= Traditionnelles ; 3= ne sait pas répondre

C04 : Origine : 1=réserves personnelles ; 2=don d'un producteur voisin ; 3=don de l'Etat ou d'une ONG ; 4=acheté d'un producteur voisin ; 5=acheté d'un commerçant d'intrants agricoles ; 6=acheté d'un marché ; 7=autre origine

C07 : Part vendu : 0=nulle ; 1=le quart ; 2=la moitié ; 3=les 3 quarts ; 4=la totalité

C10 : comme pour C07

C12: 1=Oui, 0=Non

SECTION D: QUESTIONS AU NIVEAU DE LA VARIÉTÉ DE NIÉBÉ

Nom de Variété	Avantages de cette variété (en ordre d'importance)			Inconvénients de cette variété (en ordre d'importance)			Avez-vous l'intention de cultiver cette variété pendant la prochaine	Si non au D07, quelle variété différente comptez-vous	Vous préférez cette variété (en D08) pour quelle
	Première	Deuxième	Troisième	Première	Deuxième	Troisième			
C01	**D01**	**D02**	**D03**	**D04**	**D05**	**D06**	**D07**	**D08**	**D09**

Codes:

D01-D03: 1=rendement de graine élevé ; 2=rendement de feuilles élevé ; 3=couleur de la graine ; 4=goût de la graine ; 5=moindre temps de cuisson ; 6=résistant aux maladies ; 7=résistant aux insectes ; 8=résistant à la sécheresse ; 9=cycle court ; 10=semences disponible ; 11=prix élevé ; 12=autre avantage (à préciser)

D04-D06: 1=rendement de graine faible ; 2=rendement de feuilles faible ; 3=couleur de la graine ; 4=goût de la graine ; 5=temps de cuisson trop long ; 6=susceptible aux maladies ; 7=susceptible aux insectes ; 8=susceptible à la sécheresse ; 9=cycle trop long ; 10=semences non disponible ; 11=prix bas ; 12=autre inconvénient (à préciser)

D07: 1=Oui ; 0=Non

D08: 1=Melakh ; 2=Mouride ; 3=Yacine ; 4=Bambey 21 ; 5=Bambey 23 ; 6=Diongoma ; 7= Ndiambour ; 10=autre

D09: même codes pour D01-D03

SECTION E: INFORMATION SUPPLÉMENTAIRE DEMANDÉE AU NIVEAU DE L'EXPLOITATION

E01: Pour les besoins en eau de niébé, comment avez-vous trouvé la pluviométrie pendant la saison 2010 ? |___|

(1=très insatisfaisante ; 2=insatisfaisante ; 3=moyennement satisfaisante ; 4=satisfaisante ; 5=ne sait pas répondre)

E02: Comment avez-vous trouvé l'incidence des maladies sur le niébé cultivé en 2010 ? |___|

(1=forte incidence ; 2=moyenne incidence ; 3=faible incidence ; 4=pas d'incidence ; 5=ne sait pas répondre)

E03: Comment avez-vous trouvé l'incidence des attaques d'insectes sur le niébé cultivé en 2010 ? |___|

(1=forte incidence ; 2=moyenne incidence ; 3=faible incidence ; 4=pas d'incidence ; 5=ne sait pas répondre)

Demandez à l'individu enquêté de réfléchir aux cinq dernières années et de donner une réponse générale aux questions suivantes :

E04: Quelle partie de votre revenu monétaire est contribuée par votre production de niébé ? |___|

1 = un quart ou moins; 2 = entre un et deux) ; 3 = entre deux et trois quarts ; 4 = plus de trois quarts

E05: Quelle partie de votre consommation annuelle souhaitée de niébé en graine est satisfaite par votre production ? |___|

1 = un tiers ou moins ; 2 = entre un et deux tiers ; 3 = plus de deux tiers

E06: Quelle partie de votre consommation annuelle souhaitée de fane de niébé est satisfaite par votre production ? |___|

1 = un tiers ou moins ; 2 = entre un et deux tiers ; 3 = plus de deux tiers

E07 : Quelle est l'importance pour votre famille de la récolte de gousses vertes de niébé ?

|___| Très important comme contribution alimentaire avant la récolte des céréales
|___| Important principalement pour augmenter la diversité de la consommation alimentaire
|___| Recherche de revenus
|___| Pas d'importance ; nous ne récoltons pas de gousses vertes de niébé

SECTION F. A DEMANDER SI LE PRODUCTEUR N'A CULTIVÉ AUCUNE VARIÉTÉ AMELIORÉE EN 2010

Nom de Variété	Connaissez-vous cette variété?	Avez-vous jamais cultivé cette variété?	Si oui, pourquoi pas pendant la saison dernière?	Si non, pourquoi pas?
	F01	F02	F03	F04
Mélakh				
Mouride				
Yacine				

F01-F02: 1=Oui ; 0=Non

F03-F04: 1=rendement de graine faible ; 2=rendement de feuilles faible ; 3=couleur de la graine ; 4=goût de la graine ; 5=temps de cuisson trop long ; 6=susceptible aux maladies ; 7=susceptible aux insectes ; 8=susceptible à la sécheresse ; 9=cycle trop long ; 10=semences non disponible ; 11=prix bas ; 12=autre inconvénient (à préciser)

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