Estimation and Characterization of Bean Seed Demand in Angonia District of Mozambique

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ABSTRACT

This report highlights findings of a study that was carried out to characterize and estimate the demand for common bean seed in Angonia District of Tete Province in Mozambique. The study gathered information on the area planted to the common bean annually, engaged key informants and surveyed of 332 households in eight *Localidades* between April and May 2015. According to the study, 99.7 % heads of households depend on agriculture as the main occupation; working on average family farm size of 1.4 ha, often augmented with 0.06 ha available through leasing annually. In addition to family-owned farms, husbands and wives solely own 30% and 26% respectively. The main crops grown in Angonia District in descending order of prevalence, were maize (97%) common bean (94%), soybean (59%) and groundnut (45%). Other crops grown included Irish potato, cowpea and tobacco. The common bean has a long history of cultivation in the district; mean bean production experience of participating farmers was 16 years.

Bean production, estimated to cover 31,000 ha annually in the district by SDAE-Angonia, is dominated by local varieties such as Phalombe (red) (52%), Khaki (44%) and white (Kayera) (42%) while recently released varieties were the least cultivated (5 %). The common bean is grown in two main seasons; rainfed planting in mostly maize intercrops and irrigated cool season with 30 % sole cropping. While rain fed plots are often larger (1.2 ha) than irrigated plots (0.7 ha), interestingly, the two consume equal amounts of seed (about 20 kg). From these plots, an average bean farmer harvests 172 kg of which 26 kg is kept for seed. The study revealed that 77% of bean farmers kept their own seed; 23% bought seed and 18% of the respondents planted bean improved varieties. Also, bean production was characterized by low and inconsistent use of certified seed (17%), fertilizers (30 %) and crop protection chemicals (11%). Bean farmers procured planting material at an average price of MZN 33/kg, a priced deemed expensive by over 70% of farmers who would afford bean seed at MZN 25/kg. Most farmers sold common bean grain on local markets as individuals at an average price of MZN 30/kg compared to MZN 21/kg for maize and MZN 7/kg for pigeon pea. Due to this statistic, farmers want to adopt improved varieties and 94 % would like to increase bean production in future to improve marketable outputs. While there seemed to be a balance in participation of men and women in bean production, husbands made the decisions to grow and sell beans and controlled income from bean sales in the household. In selecting bean varieties farmers considered the following attributes in order of priority: a definite market, short time to maturity and high grain yield.

The radio remains a very important channel through which farmers learn of improved varieties of common bean (62%) and other crops (58%), hence widely viewed as a channel of choice for future awareness creation on varieties and seed availability. There was a general dearth of information on markets and visits by extension personnel which seemed to limit effective seed demand. Meanwhile, econometric analysis showed that adoption rate, household wealth, household food security status and price of improved bean seed significantly influence demand for seed. On the other hand, superior grain yield characteristics of an improved variety, a known market or demand for the variety and household size significantly influence adoption of improved been varieties in Angonia. Overall, the results of the study estimated the potential demand for bean seed in Angonia at 2069 tonnes which was slightly lower than the 2,500 t estimate from SDAE, the variance being primarily due to use of the sub optimum seed rates. The data collected in study will be critical in targeted extension services in order to enhance use of bean improved varieties and bean productivity in Angonia district.

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1.0.INTRODUCTION

1.1 Mozambique country context

Mozambique is one of the least developed countries which ranks 178 out of 186 countries on the human development index (UNDP, 2013) and has a per capita annual income of USD 360 which is among the lowest in the world. The country is making a remarkable recovery from the devastating effects of nearly two decades of civil war, posting an average annual economic growth of eight percent between 1996 and 2004, but poverty remains high, especially among the rural population which makes nearly 70 percent of the country's vulnerable households (FAO, 2013). While the number of undernourished and their prevalence in the population has been reducing, though at a slower rate in sub-Saharan Africa, estimates for Mozambique are still of concern to United Nations the (FAO, 2013) as 60 % of the population lives on less than US$1.25 per day (FAO et al, 2013).

In addition to widespread poverty, the country has high rates of; food insecurity (46 %), chronic undernutrition- stunting (46%) and underweight (12 %) in children (FAO, 2013) and wasting (over 20 %) (UNDP, 2013). Paradoxically, the country has vast agricultural potential yet cross-country analyses demonstrated double effectiveness of agro-based gross domestic product (GDP) growth in reducing poverty compared to non-agro based GDP growth (World Bank, 2007; Barrett et al, 2010) as shown through the experiences of Brazil and China. Equally, poor productivity from the agricultural sector has knock on effects on the economy and this has been the case for Mozambique where approximately 76 percent of the population is dependent on an under-performing agricultural sector for livelihoods (FAO, 2013) resulting widespread poverty. Poverty in Mozambique is multi-faceted with causes that include: i) lack of employment opportunities (FAO et al, 2013), ii) high illiteracy rates especially among women, iii) high household dependency rates, iv) low agricultural productivity stemming from non-use of suitable high yielding seed varieties and other agricultural inputs, especially in the small-holder sector and v) infrastructural constraints, particularly in rural areas.

Mozambique is therefore caught up in a vicious cycle of poor productivity, poor markets leading to low incomes, low investments in agriculture and low yields. The agricultural sector is characterized by a large number of small-scale farmers, rain-fed subsistence production, low mechanization, use of labor-based production techniques, and little use of external inputs resulting in low productivity. There is also lack of information on better crop and soil management practices.

1.2 Background on common bean production in Mozambique

Mozambique has a low protein consumption per capita of 39g per day of which only 5g per day is animal derived (FAO, 2013). Legumes such as common bean can therefore, provide a cheaper source of protein than meat and 2-3 times the amount of protein than cereals (BGMF, 2012) if produced and consumed in rural areas. The common bean is an important legume in human diets globally; providing protein, iron, zinc, fiber and complex carbohydrates (Gepts et al., 2008) and food for over 400 million people in Africa. Furthermore, common bean is also a very important source of income for small holder farmers. The production of common bean in Mozambique increased by 55 percent between 2002 and 2012 as farmers increasingly realized market potential of the crop and therefore devoted more cropping area (Table 1).

According to survey reports, between 2012 and 2014 common bean was planted on an average area of 102,000 ha per year in Mozambique, but the average yield on small holder farmers' fields is below 550 kg/ha (MASA, 2014) due to the use of local varieties and inappropriate agronomic practices. The production of common bean is highest in Niassa and Tete provinces where more than 30 percent of small scale farmers produce the crop (Table 2).

More than 80 % of the common bean grain produced in Mozambique is marketed locally, especially in the major urban centers with an estimated demand of 10,000t. The export market takes up an estimated 6 % of the common bean produced in the country (Upcoming Bean Atlas). Highlighting its importance, a recent study ranked common bean as the second most important cash crop after maize in the medium to high altitude bean producing areas of Mozambique (Rusike et al., 2013).

Table 1: Bean Production by Province between 2002 and 2012

Province	Bean Production (tons) by Year						
	2002	**2003**	**2005**	**2006**	**2007**	**2008**	**2012**
Niassa	14,888	17,849	16,255	19,857	16,339	2,2645	31,024
Cabo Delgado	18	90	50	0	132	42	153
Nampula	227	80	756	1,303	3,749	821	859
Zambezia	5,736	9,957	7,237	9,509	14,529	669	6,058
Tete	11,668	9,320	9,765	11,508	12,441	15,868	10,842
Manica	2,191	2,275	4,503	3,803	3,444	3,977	3,457
Inhambane	131	304	1,292	639	717	603	1,304
Sofala	49	18	58	30	191	10	41
Gaza	517	924	10,122	2,644	2,841	1,605	1,296
Maputo	258	172	277	335	133	421	263
NATIONAL	**35,683**	**40,989**	**50,315**	**49,628**	**54,516**	**52,661**	**55,297**

Adapted from: Trabalho de Inquérito Agrícola (TIA). 2012. Survey report of Ministry of Agriculture, Mozambique. Draft Report.

Where irrigation is available, farmers can successfully grow three bean crops per calendar year; deriving food and cash from leaves, fresh pods and the dry grain, making the common bean a reliable income source throughout the year in main growing areas. The main bean producing areas in Mozambique are medium altitude areas of Manica Province (Manica, Sussudenga and Gondola districts, Tete Province (Angonia, Tsangano, Macanga and part of Moatize districts), Zambezia Province (Gurue and Alto Molocue districts) and Niassa Province (Lichinga district) in the main rainy season, while low-lying areas also produce the crop under irrigation in the cool season.

Table 2: Bean production and yield by province in 2014

Province	Area planted (ha)	Production (t)	Yield (t/ha)	Percentage of farmers growing common
Niassa	30,400	22,028	0.72	35.6
Cabo Delgado	100	70	0.70	0.1
Nampula	1,200	467	0.39	0.8
Zambezia	13,600	7,065	0.52	6.6
Tete	34,900	15,179	0.43	31.1
Manica	8,600	4,712	0.55	13.8
Sofala	2,100	1083	0.52	6.4
Gaza	3,300	599	0.18	13.9
Maputo	2,300	381	0.17	3.3
NATIONAL	**96,500**	**51,583**	**0.53**	**9.0**

Adapted from: Anuário de Estatísticas Agrárias 2012-2014

In these locations, the bean crop is grown in combination with a number of other crops and regional preferences in grain types exist. Generally, farmers in Southern Africa (including Mozambique) prefer the large seeded cream (manteiga), red-speckled (sugar), red and red-mottled bean types. Furthermore, farmers are interested in culinary qualities such as cooking time and taste, maturity period, yield and tolerance to pests and diseases. To address these needs, CIAT in collaboration with IIAM have developed bean varieties that are highly adaptable to diverse agro-ecologies while meeting the nutrition and market needs.

1.3 History of bean technology development and dissemination in Mozambique

Bean research efforts resulted in the release of varieties by the national programme in the mid-1980s. Over the years, several other stakeholders including private seed companies have also released bean varieties. IIAM working with CIAT released bean varieties that are widely adapted to the major bean agro-ecologies of Mozambique and have resistance to multiple biotic and abiotic constraints (Table 3). These varieties also possess preferable market and nutritional traits. Among these varieties, is NUA 45, a variety that is bio-fortified with iron and zinc, targeted at contributing to addressing the prevailing high level of under-nutrition in the country. The varieties were developed and selected together with farmers through participatory evaluation and also address the culinary qualities that farmers look for in bean varieties for home consumption. Following these advances, a survey by the Ministry of Agriculture, Mozambique reported increasing use of seed of improved common bean varieties. The adoption rate of improved common bean varieties in Mozambique remains low, but was reported to be 15% in 2010 (Lopes, 2010), up from 4.9 % in 2003 and 8 % in 2008 (World Bank, 2012). Similarly, use of seed of improved varieties of other legumes also remains very low at 4.6 % for groundnut and 2.9 % for cowpea.

The low adoption rates for improved varieties in Mozambique can be attributed to the low presence of seed companies to disseminate seed in bean production areas and a generally underdeveloped seed sector, stemming from monopolistic policies. Until the year 2000, *Sementes de Moçambique* (SEMOC) was a state monopoly created in the late 1980's with the mandate to supply all commercial seed in Mozambique.

Table 3: List of bean varieties released in Mozambique

Variety	Local name	Year of release	Yield potential (kg/ha)	Characteristics
A222		2011	2,800	Matures in 85 days, Black, small seeded, niche market for *Feijoada*. Highly adapted to all major bean growing areas
AFR 703		2009	2,200	Matures in 80, days Red, large seeded, local and Malawian market. Highly adapted to all major bean growing areas
BONUS	Bonus	1995		Medium sized round sugar bean with a good regional market in southern Africa.
CAL 143	Chiata	2009	2,400	Matures in 90, days Red mottled; medium sized grain, resistant to ALS[1], Halo blight, CBB[2] and Rust. Highly adapted to all major bean growing areas
CARIOCA		1995	2,000	Matures in 85 days. Tolerant to ALS
DIACOL CALIMA		1991		Red mottled
ENCARNADO	Encarnado	1988		Red
ENSELENI		1995		
ICA PIJAO		1991		Black
IKINIMBA	Ikinimba	1986		Black
INIA 10	Manteiga	1988		Khaki / Tan
MANTEIGA	Manteiga	N/A		Cream / Tan
NUA 45		2011	2,000	Matures in 65 days, Red mottled, large seeded, rich in iron (102ppm) and zinc (35ppm), fast cooking, tasty, resistant to ALS and CBB. Highly adapted to major bean growing areas, but also adapted to short seasons
PAN 148		N/A		Sugar bean
PVA 773	PVA 773	1991		
SUG 131	Malepa	2011	2,500	Matures in 90 days, Red specked (Sugar), large seeded, resistant to ALS, CBB and rust. Highly adapted to all major bean growing areas
VTTT 923/10-3		2011	2,300	Matures in 85 days, Red specked (Sugar), large seeded, resistant to ALS, CBB and rust. Highly adapted to all major bean growing areas
VTTT 924/4-4		2011	2,500	Matures in 85 days, Red specked (Sugar), large seeded, resistant to ALS, CBB and rust. Highly adapted to all major bean growing areas
VTTT 925/9-1-2		2011	2,300	Matures in 80 days, Red. Resistant to ALS. Highly adapted to all major bean growing areas

Instead of developing a dynamic seed market, SEMOC focused on emergency programs such as the Emergency Program for Seeds and Tools (PESU) that distributed free kits of seeds and tools to about 1.2 million smallholders annually (Howard et al, 2001). In an effort to control the market

[1] Angular Leaf Spot
[2] Common Bacterial Blight

distortions, SEMOC was privatized to usher in new private seed companies, but similar to most Sub-Saharan African countries, the emerging seed companies in Mozambique tend to focus on the lucrative maize hybrid seed business (Mabaya et al, 2013) at the expense of legumes such as the common bean.

Even after liberalization, the entrenched tendency to focus on tenders for government distribution programs continued in the seed sector as production, supply and use of certified mirrored free seed distribution programs by the government. For instance, in 2007/8 following a prior government announcement for seed distribution, 218 tons of certified bean seed were produced, but the figure tumbled 98 % to only 3.9 tons only in 2009/10 (World Bank, 2012). Similarly, spatial variation in adoption of bean certified seed seems to follow government distribution patterns. Seed market development is further impeded through SDAE's use of seed fairs as platforms for farmers to acquire seed from government programmes at 50 percent of the delivered cost (World Bank, 2012) and the *Direcção Provincial de Agricultura* (DPA)'s promotion of seed production for local unimproved varieties of maize, common bean and other crops through farmers groups and cooperatives.

These government-supported market distortions and limited production scale and capacities of the emerging seed companies, access to bean seed remains limited to farmers. Although emergency programs have been the main source of seed in the past, there was no accurate documentation of quantities and quality of seed distributed (Rohrbach et al., 2001) to inform planning for future seed production. This is a huge information gap has can be attributed to lack of technical personnel on the ground.

Public extension services are very limited in Mozambique; only 6.6% of farmers had access to extension services in 2012 (TIA, 2012), a decline from an average of 12% during the period from 2002-2008 (TIA, 2008) as the government fails to replace staff. The Mozambican agricultural extension system went through several phases of transformation; from a commodity supported pro-commercial export inclination pre-independence, pro-government owned state and cooperative farms, soon after, established public agricultural extension system (Ministerial Decree 41/87, 1987), and finally adoption of pluralistic extension system (National Directorate of

Agricultural Extension (DNEA), 2007). Despite these phases of transformation, the number of extension staff remained way below optimum.

Against this background, CIAT and IIAM embarked on promotion and dissemination of bean technologies in Gurue and Angonia districts under the USAID-funded project, "Platform for Agricultural Research and Technology Innovation – PARTI" in Mozambique in 2012. PARTI centred on building capacities of partners and farmers in seed production, promotion of best agronomic practices and bean nutrition using public, private and farmer-to-farmer extension systems. These efforts were however, limited by the absence of private sector partners in seed production and supply; many small holder farmers resorted to using their own-saved seeds. This study sought to understand the nature of bean seed use in Angonia district in order to inform investment plans of the private sector and to guide future interventions to enhance access to bean seed of improved varieties.

The study had the following specific objectives:

i. To characterize common bean farmers in Angonia district in terms of household demography and the bean types they produce.
ii. To understand the socio-economic drivers of specific bean production practices and how these influence potential bean seed demand in the district.
iii. To estimate the potential demand for bean seed in the district

2.0 RESEARCH METHODS AND MATERIALS

2.1. Study sites/area description

The study was carried out in Angonia district which is situated in the northern part of Tete Province in the central region of Mozambique (Figure 1). Its administrative center is the town of Ulongué. Within Mozambique, Angonia district borders the districts of Tsangano in the south and Macanga in the west, while it borders Dedza (north and east) and Ntcheu (east) on the Malawian frontier.

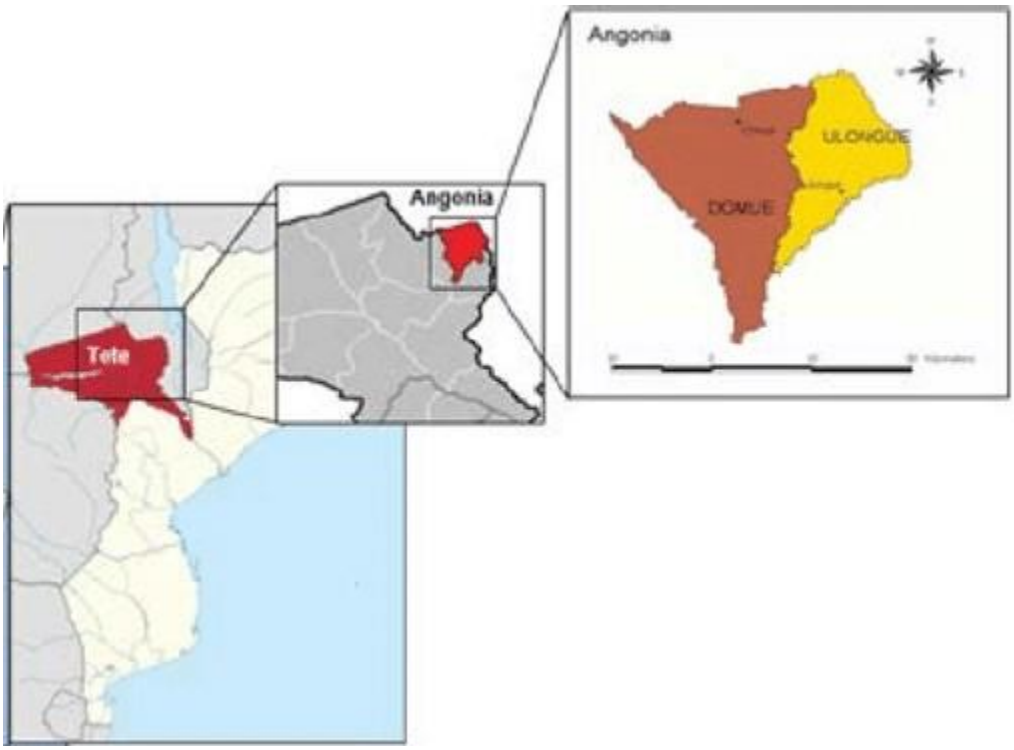

Figure 1: Map showing location of Angonia District

The district is divided into two administrative posts Ulongue and Domue. Each administrative post is made up of several *Localidades*. The population figures for the two administrative posts are given in Table 4. Angónia is a plateau of 1200-1600 metres above sea level (masl) in altitude (Ulongue, 1270 masl) (Voortman and Spiers, 1986). The climate is cool in winter and warm/mild in summer. The area receives high total annual rainfall (900-1200mm) in the rainy season from late November to early April. Rainfall is very much, seasonal and unimodal.

Table 4: Population distribution in Angonia, Mozambique

Administrative Post	Localidade	Population
Ulongue	Calomue	20,139
	Chimuala	12,211
	Dziwanga	14,756
	Mang'ane	48,323
	Monequera	36,773
	Naming'ona	25,586
	Ulongue	32,044
Sub Total		***189,831***
Domue	Binga	18,727
	Calio	24,846
	Camphessa	6,107
	Catondo	3,322
	Chifumbe	15,204
	Khombe	11,671
	Liranga	12,366
	Mpandula	17,257
	Ndaula	14,167
	Nkhame	20,599
	Seze	35,515
Sub Total		***179,781***
Grand Total		**369,612**

Source: *Serviço Distrital de Actividades Económicas* (SDAE): Angonia

Due to high rainfall, the soils have an inherent low soil fertility status primarily due to low pH and associated acidity, aluminum toxicity and phosphorus fixation. Two soil types dominate much of the region, namely the eutric leptosols in the relatively higher altitudes and the haplic lixosols (sandy clay loam to sandy loam) in the flat plains and valley bottoms. Angónia district was considered one of the granaries of Mozambique because of its production of maize and potatoes, a prestige which ended with the onset of the civil war after independence in 1975. Nonetheless, to date, the district is still within the maize belt of the Chinyanja Triangle region, where farmers plant more than three times as much area to maize as other crops (Amede et al, 2014).

Higher-value crops are grown in the valley bottoms mainly under irrigation or the dambo (wetland) system. In the dambo system, crops use residual moisture along with some supplementary irrigation to ensure adequate water supply during the growing period. Farmers also practice flood irrigation, furrow irrigation and in a few cases motorized pumps to deliver water to fields. The relatively higher-income and middle-income farmers are commonly the ones using motorized pumps while the low income farmers predominantly use furrow irrigation or manual treadle pumps to transfer water from small springs.

With the increasing market opportunities in Tete and its surroundings, due to the expanding mining sector, small-scale irrigation could help farmers to produce high-value agricultural products, access regional markets and improve their capacity to respond to emerging demands and climatic shocks. Angonia district also has a high population density, which has significantly reduced the land holding per family, hence irrigation becomes critical. Angonia district is relatively rich in agricultural and animal resources with very arable land. However, the livestock is not used for land preparation, leaving most farmers to use hand hoes for the activity.

2.2 Sampling

Data was collected from more than 300 smallholder farmers randomly sampled in the district. A lot of information was collected from the respondents in the form of a survey. The study collected data on the status of livelihoods in the study area including (education, occupations, income, food security, and nutrition), agricultural production and market access. Establishing the status of all the mentioned variables was key to understand impact of previous interventions, adoption of the promoted varieties and demand for the improved seed. Stratified random sampling was used to gather data from 332 farming households from Angonia District. The sampling procedure heavily relied on the units within the administrative structure and their respective proportional populations. Typically, a district in Mozambique has five levels of administrative units, in descending order: District, Administrative Post, *Localidade*, *Povoado* and *Povoação*. However, for this study the smallest unit considered was the *Povoado*. Angonia District has two Administrative Posts, Domue and Ulongue. The two Administrative Posts were considered the main strata. It was assumed that population characteristics could be similar within these two Administrative Posts. The District in total consists of 18 *Localidades*, 11 in Domue and 7 in Ulongue. From these, it was predetermined

that the sample would be drawn from eight *Localidades*. Proportionate to the number of localidades in the two Administrative Posts, three *Localidades* from Ulongue and five from Domue were selected. The *Localidades* selected were then treated as the second level strata. Using population proportions from the selected eight *Localidades* and the predetermined sample size of 332 farming households, 184 households from Domue and 148 households from Ulongue were randomly sampled. Using a list of *Povoados* in the selected *Localidades* obtained from the District Secretary's Office and population proportions, 32 *Povoados* were randomly selected; 14 from Ulongue and 18 from Domue. Farming households were then selected randomly from the targeted *Povoados*. The distribution of *Povoados* and number of households selected from the 8 Localidades and selected Povoados was as follows:

Table 5: Sampling strategy and outcome

Domue (184 households)		**Ulongue (148 Households)**	
Ndaula (28) Solomon (5) Catito (6) Chicolongue (5) Muende (6) Nancuaze(6)	**Seze(55)** Seze-Sede (19) Dzimeza (18) Nehata (18)	**Namingona (42)** Gorethi (21) Mphulu (21)	**Mangane (80)** Kankhani (8) Mazunga (8) Mandota (8) Chiphole (8) Yotamo (8) Ndachepa (8) Massoco-Bena (8) Hombele (8) Macuanguala (8) Ngawa (8)
Chifumbe(31) Mbuca (8) Kungulo(7) Mandala (8) Lonsa (8)	**Binga (30)** Gassiteni (10) Chinkhuamba (10) Cavumbwe (10)	**Dziwanga (26)** Malhaudzo (13) Manhanguli (13)	
Kalio (40) Kalio-Sede (14) Mthanzi (13) Mathemba (13)			

All households at *Povoado* level had an equal chance of being selected as we applied strict random sampling with the help of local community leaders. The survey was carried out in eight

Localidades of Angonia District. It was carried out in 10 days as follows; two days of training enumerators, one day of pre-testing and seven days of data collection.

2.3 Survey materials, data collection and pretesting

The study was conducted in the form of survey. The main tool for data collection was a structured questionnaire. The questionnaire collected information on household demographic characteristics, agricultural production and marketing, adoption of improved bean varieties, varietal preferences, variety characteristics and demand for seed, income, assets, decision-making, importance of beans and other crops in the household's economy, dietary diversity of the households (with children under five), and other general household specific information. The questionnaire was pre-tested, corrected for errors before administering it for final data collection. Face to face interviews with 332 smallholder farmers were done to collect the data. We collected information on beans and other crops so as to establish the general current agricultural crop production trends and interrelationships between the various crop enterprises. The survey was correctly timed as it was conducted soon after harvesting of the summer crop. Participation of farmers in selected areas was voluntary. The research team explained the purpose of the survey in each and every data collection point. Where possible respondents were gathered at selected points by the local leadership, but in other locations, enumerators had to go household after household.

2.4 Enumerator selection

Enumerators were recruited based on their proficiency in both Chichewa and Portuguese languages and previous similar experience with Beira Corridor. Both *Serviço Distrital de Actividades Económicas* (SDAE) and the Beira Agricultural Growth Corridor Lda assisted in identifying the candidates for the survey. Individual interviews we done to assess capability of the candidates; with focus on general understanding of agriculture and proficiency in Chichewa and Portuguese.

The questionnaire was prepared in English, translated to Portuguese but Chichewa language was used during the training and farmer interviews. The enumerators were taken through all the

questions discussing how to phrase them and remove ambiguities. The tool was pre-tested firstly by pairing enumerators to ask each other the questions before each enumerator had field pre-testing with two farmers each from a nearby *Povoado*. Final copies were printed after incorporating the observations and comments from the training and pre-testing. Data collection was supervised by CIAT staff and SDAE extension supervisors

2.5 Overview of the data analysis strategy

Analysis of data was done using a combination of SPSS version 20, STATA version 12 and Microsoft Excel. The bulk of the analysis was however descriptive analysis. Econometric modelling was only applied to estimate factors influencing improved seed demand and adoption rate simultaneously using a system of equations in STATA. Results presentations are mainly in the form of tables.

2.6 Econometric approach

Drawing on the demand theory for consumption goods characteristics and production input attributes, this study estimated improved seed adoption and demand for seed factors simultaneously using cross-sectional data collected from 332 randomly selected smallholder farmers. The system of equations approach was used because it uses more data and produce more efficient estimates when compared to single equation estimation approaches (Langyintuo et al., 2005). The econometric model used in this study adapts a similar approach used by Edmeades et al. (2004) to determine factors that jointly influence demand of banana varieties and their potential adoption in Uganda. Application of the joint specification and estimation approach is meant to account for both production and consumption aspects of seed, which performs better than the ordinary least squares (OLS) when fitted with household level data from Angonia Mozambique. It was however, logical to take this approach since when a farmer adopts an improved variety, he/she jointly decides on how much seed he/she would require to plant a pre-determined area. In support of using system estimation, Zepada (1994) pointed out that single equation estimation in such a case (our case) is more likely to bring simultaneity bias as demand and adoption are

endogenously determined. Smallholder bean farmers in Mozambique plant both local and improved bean varieties obtained from different sources; the market, recycled from previous harvest, and some from input support programs (World Bank, 2012). Every growing season, farmers must decide what source of seed to use in growing beans. They might purchase seed in the market or use a portion of their own grain production as "seed." Adoption of commercial seed technologies may lead to costly changes in the mix of other productive inputs such as land and labour, thus making any investment in seed technologies more costly and riskier than is often perceived. Facing nontrivial costs and risks, bean producers must choose between buying or not buying seed in a manner that maximizes their utility given both market and non-market factors. Using improved bean varieties as the target commodity, our model estimates improved variety adoption and seed demand (seed purchase) decision factors jointly in Angonia Mozambique. The main reason for using joint estimation is that more information can be used and as a result, more precise parameter estimates are obtained compared to single equation estimation i.e. OLS regression estimates. Like in other developing economies, some farmers did not plant any improved bean variety and therefore we defined the dependent variable as the proportion of area under improved bean varieties censored at zero. This implies a censored regression specified by a Tobit model of the form:

$Y_i = N_i\alpha + B\psi$ if $i = N_i\alpha + B\psi + \mu_i > T$ (Adoption)=0. If

$i^* = N_i\alpha + B\psi + \mu_i \leq T$(Non-Adoption) (1)

Where: Y_i = proportion of area planted to and improved bean variety, i*= non-observed latent variable and T= non-observed threshold level. Once a household has agreed to plant an improved variety, it simultaneously decides on the quantity of seed required to plant per given area. Assuming that the improved variety is made available, the household seed purchase decision is conditioned by the traditional input market factors, as well as other household specific attributes that may form part of the adoption decision model. The demand model may be specified as follows:

$$D_i = \Phi_k Z_{ik} + \gamma_j E_{ij} + \varepsilon_i \quad (2)$$

Where: D= the quantity of seed demanded by the i^{th} household (taken to mean strictly seed purchased from the bean seed market),

Z= a matrix of household socioeconomic factors influencing seed demand,

E= a matrix of exogenous input market factors, and

Φ and γ are parameters to be estimated while

ε = stochastic error term. It is important to note that variables contained in B and Z could overlap. The correlation coefficient between the errors of the two models measures the extent of correlation between the two equations. To account for any cross-equation correlation, the two models were estimated simultaneously. List of independent variables selected for the adoption model were chosen based on adoption literature. Basically we use; household socioeconomic attributes, crop production characteristics, crop management style, improved bean variety attributes and improved variety characteristics to explain variability in improved seed adoption and demand. Only smallholder farmers adopting the improved bean varieties were included in the demand model.

3.0 STUDY RESULTS AND DISCUSSION

3.1 DESCRIPTIVE RESULTS

3.1.1 Household Profiles (Demographic Information)

3.1.1.1 Gender and Marital status of the household head

The results for the sampled households showed active participation of both men (57.8%) and women (42.2%) in agricultural activities in Angonia. The results also show that bean farming in Angonia is done by both men and women which imply both gender groups are interested in the crop. Interest for the crop by both men and women is a good thing as it can impact positively on productivity and production of the crop.

Table 6: Gender of household head

Sex of household head	Frequency	Percentage (%)
Male	192	57.8
Female	140	42.2
Total	332	100

In addition, results showed that most (79%) most of the smallholder farmers were married, and only 21% of the sampled smallholder farmers were not married. Most of those who were not married were found to be; single never married (16%), divorced (3%), and widowed (2%). Marital status is a reflection of the strength and stability of the family system and it has knock-on effects on farm productivity. Literature shows that high proportions of divorced or widowed often returns a high dependency ratio as there will be more dependents compared to the active workforce which negatively affects productivity.

3.1.1.2 Literacy

Literacy is important as it a good proxy for education (both formal and informal); it determines a household's level of awareness to new ideas and technologies which might better the household's living conditions. Generally a greater percentage of the households were found to be literate as

55% of the household heads could read or write. The other portion (45%) were reported to be illiterate, they indicated that they could neither read nor write at the time of the survey. Illiteracy was found to be higher amongst women than men; 57% of the illiterate farmers were women.The result on literacy came as a surprise since Angonia is one of the rural districts with the highest number of schools. Table 7 below indicates statistics on literacy levels.

Table 7: Literacy of the household heads

The household head literacy	Freq.	Percent
Read only	13	3.92
Read and write	171	51.51
neither read nor write	148	44.58
Total	332	100

3.1.1.3 Age, labor and farming experience

Results show that smallholder farmers in Angonia are generally young. An average age of 40 years imply that most of the farmers are still economically active and productive. In literature, young farmers are considered to be more productive when compared to their aged counterparts. Averages for age of household head, labor and experience are shown in table 8.

Table 8: Age, farming experience and availability of household labour

Variable	Mean
Age of Household head	40.20183
Years of farming experience	16.31212
Household labour	2.6

Results also show that most of the farmers are experienced in farming in the district. Average number of years of experience of farming in the district was found to be 16 years. The common bean has a long history of cultivation in the district; one farmer indicated growing the crop consistently for 56 years. On average, each household had about 3 members who could provide

labor in the field. This could imply labour was not a challenge that could significantly constrain productivity in the study area.

3.1.1.4 Household Occupation

The study showed that 99.7% of household heads are occupied in agriculture as their main livelihood activity to which they allocate most of their resources (land, financial and human). Households that prioritize farming as a main occupation ahead of other livelihood activities are more likely to take up agricultural technological innovations (including seed of improved varieties) compared to their counterparts who prioritize other livelihood activities. Table 9 shows the proportion of farmers into fulltime farming.

Table 9: Household head occupation

Main Occupation	**Percentage**
Farming	99.7
Other	0.3
Total	**100**

3.1.2 Household Assets, equipment and livestock

3.1.2.1 Assets and equipment

Ownership of household agricultural equipment reflects the ability of a household to timely execute agronomic operations, for instance tap into moisture opportunities. Households that do not own the basic agricultural equipment such as hoes or ploughs have to delay the execution of agronomic activities such as land preparation and in some cases planting and weeding since they have to either hire or borrow. As such, they fail to compete with the rainfall regime and this negatively affects the potential yield.

Table 10: Ownership of household assets and farm implements

Equipment and assets		
Item	**% ownership**	**Mean number owned**
Plough	2	0.01
Sprayer	8	0.08
Motorcycle	9	0.09
Wheelbarrow	2	0.02
Cellphone	39	0.58
Radio	77	1
Hoe	96	3.24
Ox-cart	11	0.12
Car	3	0.04
Bicycle	70	0.95

Results in table 10 shows that, most of the households owned hoes (96%), bicycles (70) and radios (77%). For other equipment, results show that very few farmers owned them. For example, only 8% of the farmers owned a sprayer, 2% owned a moldboard plough, 2% owned a wheelbarrow, 11% owned an ox-cart, and only 39% owned a cellphone. The results show that ownership of basic agricultural equipment and assets is very poor. Assets are important in raising total farm productivity in smallholder farming, ownership of sprayers, moldboard ploughs and wheelbarrows for example is expected to improve total farm productivity. Traditionally, the farmers in Angonia do not use ploughs; they instead use hoes to make ridges and plant on the ridges. The low ownership of assets could imply serious scarcity of some vital assets a phenomenon that can constrain adoption of improved bean seed and other technologies in Angonia, Mozambique.

3.1.2.2 Livestock

In Mozambique's smallholder farming systems, livestock forms a key component of a household's overall economic well-being. On the other hand, livestock is seen as the accumulation of wealth which the household can fall back to during time of need. The proportion of households who own livestock in the form of cattle, donkeys, sheep, goats and chickens is tabulated in Table 11.

Table 11: Ownership of livestock

Livestock ownership		
Livestock type	**% ownership**	**Mean number owned**
Cattle	42	0.85
Draft donkeys	1	0.02
Sheep	1	0.02
Goats	48	1.95
Chicken	72	5.71

Chickens are the most popular livestock owned by least 72% of the households while sheep and draft donkeys are the least popular forms of livestock (at most 1% of the households own donkeys and sheep). On the other hand, livestock such as cattle and goats were owned by more than 40% of the households. Ownership of livestock is important in smallholder farming for various reasons; livestock can serve as sources of income (when need arises households can sell to get income), livestock waste can also be used as farmyard manure, and cattle and donkeys can be used to supply draught power. In rare cases, households can also slaughter their animals to supply the family with food, implying that they can be a source of the much needed protein in rural settings. This therefore implies that livestock ownership can influence positively adoption of improved crop varieties.

3.1.2.3 Household Land Holdings

Land holdings represent a key factor of production for agricultural enterprises in smallholder farming systems. The amount of land which a household allocates to a particular crop depends largely on the land holding which a household owns. In Table 12 we show land access to the household in two season 2013/14 season and 2014/15 season. Results show that land area accessed by the household in 2014/15 (3.8 Ha) was slightly higher than that of the previous season 2013/14 (3.67 Ha), suggesting farmers are still expanding their farming enterprises. Land area cultivated in the two seasons was the same as shown by an average of 3.45 Ha in both seasons. Households were found to allocate a larger portion of land accessed to cereal crops as shown by higher average

land allocated to cereals in both seasons. Access in this study is defined as a combination of owned, borrowed or leased land. In Mozambique, land is the property of the state. National and foreign investors can obtain concessions (effectively leases, known as Dereito de Uso e Aproveitamento da Terra (Land Use and Benefit Right) – DUAT in short), for unused land for 100 years, subject to community consultations (The Oakland Institute 2011). Local communities and individuals have permanent occupation rights. The Land Law recognizes customary rights and gives them formal legal rights, whilst also encouraging the growth of private sector in the regions (De wit and Norfolk 2010). The Land Law policy is aimed at allowing local communities and the private sector investors to negotiate agreements around land use rights, while the State's role is limited to ensuring that certain minimum standards are applied in these negotiations, that rights' registration complies with technical standards and that the taxation system functions effectively.

Table 12: Mean land holding for the households in 2013/14 and 2014/15 season

Access to land per household	2013/14 season	2014/15 season
Total land area accessed	3.67	3.80
Total land Area cultivated	3.45	3.45
Land allocated to cereals	3.21	3.21
Total land allocated to Legumes	3.15	3.15

3.1.3 Bean production, crop management and marketing

3.1.3.1 Production of major crops

Results show that in Angonia District, the main crops grown are maize (97% of respondents) common bean (94%) and soybean (59%) and groundnut (45%). Other crops grown in the district include Irish potato, cowpea and tobacco. Table 13 show the statistics for the major crops grown in the district. In the table we report number of farmers who indicated to have grown the crop in the 2013/14 season, the average seed rate per hectare and mean output per hectare.

Table 13: Production of major crops including beans in Angonia

Crop	% of growers	Mean seed quantity used (kg/ha)	Mean output (kg/ha)
Maize	97	30	1926
Common bean	94	21	172
Soybean	59	22	231
Sesame	0.3	-	-
Groundnut	45	12	89
Cowpeas	5	3.5	28
Pigeon pea	5	5.4	72
Irish potato	22	176	1127
Cassava	0.3	3	243
Tobacco	21	8	895

Mean seed rate for maize per hectare was found to be 30 kg implying the farmers are slightly exceeding the recommended rate for maize which is supposed to be 25 kg, due to two possible reasons. First over seeding to primarily to cater for unreliable seed germination of poor quality seed. Second, the use of old open pollinated varieties that typically have large kernels. Maize plant population management could have implications on common bean production since most of the farmers grew common bean in intercrops with maize. Overpopulation of the maize crop could reduce productivity of the intercrop due to competition for resources (moisture nutrients in the soil).

Meanwhile, mean seed rates for all the other crops including the common bean were below the recommended rates. For the common bean, the low seed rate was due to the wide row spacing used in maize-based intercrops. In terms of output, results show that average maize output was 1926 kg/ha. For the other common legumes such as common bean and soybean the yield per hectare was found to 172 and 231 kilograms respectively. Generally, productivity for most of the crops except maize was low. This highlights the impact of lack of productive resources as highlighted earlier such as low ownership of productive assets and livestock. Nonetheless, a further inquiry will be required to establish the constraints productivity in the other crops. Otherwise the results suggests that more allocation of scarce resources to the main staple, maize at the expense of all other crops such as the common bean and soybean despite their importance as sources of food and income for the households.

3.1.4 Common bean cropping systems

Cropping systems are very important as they can have implication on crop and total farm productivity. Results show that most farmers grew beans as an intercrop. Data collected for four cropping seasons show that at least 90% of farmers grew beans in intercrops in the summer season. The main component crop in the intercrops was found to be maize. However, in winter it was found that sole cropping was a slightly high as farmers indicated that at least 29% of beans were grown as a single crop. Intercropping was still the dominant cropping system as more than 70% used the practice regardless of the season (Figure 2). Respondents also highlighted that the winter cropping is mostly used to bulk seed for the summer season, suggesting a complementarity between the two systems. Table 14 shows statistics on the proportion of farmers and the cropping systems they applied to beans in the past four seasons.

Table 14: Bean cropping systems

Season	**Bean Cropping system**		
	Sole cropping (%)	**Intercropping (%)**	**Strip cropping (%)**
2014/15	9	90	1
2014	31.5	68	0.5
2013/14	8	91	1
2013	29	70	1
2012/13	7	93	0

Figure 2: Common cropping systems for the common bean in Angonia:

top row – simultaneous same row planting (left) and simultaneous strip cropping (right) in summer maize-bean intercrops; **middle row** – relay intercropping in 'maize first' summer intercrops and **bottom row** – winter bean production in sole cropping (left) and onion intercrops (right)

3.1.5 Bean production and harvesting

Bean production is one common practice in Angonia. Farmers grow beans for their household dietary needs and also for the market. Results show that on average, households in the area have been growing the crop for 16 years. Table 15 show bean production trends in the past five seasons.

Table 15: Bean production and harvesting

Season	% growers	Mean amount of seed planted (kg /ha)	Mean amount harvested (kg /ha)
2014/15 (summer)	94	25	169
2014 (winter)	62	21	124
2013/14 (summer)	91	24	179
2013 (winter)	52	18	89
2012/13 (summer)	76	24	165

Results for the past five seasons show that common bean production is common in the summer season; at least 76% of farmers grew common beans in summer, but the proportion dropped to at least 50% in the winter season. The percentage drops in winter probably because of resource constraints faced by farmers, especially access to *dambos* with consistent water supply. Results also show that farmers on average, used a minimum seed rate of 18kg/ha and a maximum of 25kg/ha rate in the past between 2010 and 2014. This seed came from farmers' own farm-saved seed (76.9%), free distribution from government/ NGO (0.3 %) or purchase from the local market (22.7 %). Despite, being slightly higher than for winter, seed rates for the rain-fed bean crop were still below the recommended seed rates. This shows that farmers are using only 25 % of the recommended seed rate of 100kg per hectare for the large seeded varieties that they grow. This could also be attributed to lack of resources such as irrigation facilities, seed, chemicals and fertilizers as farmers choose to cover larger areas with less seed and other resources. Consequently, the results also show that harvested yields were low with a maximum of 179 kg per ha and a minimum of only 89 kg per hectare, representing only 7% and 3 % of yield potential (2,500kg / ha) of released bean varieties. After harvesting, farmers kept an average of 69.02 kg for household consumption and 26.45 kg for seed.

3.1.6 Common bean marketing

The study revealed that common bean in Angonia was grown both for household consumption and for the market. Results from the survey showed that 64 % of the farmers participated in common bean markets. For market participants average participation intensity was 117 kg. Average price received for a kilogram of common bean was found to be 30 Mozambican Meticals (US$0.86)[3]. Market participation enables smallholder farmers to contribute to commodity trade and distribution to other areas within Mozambique, more over it brings income to the farmer. According to the trade theory, households participating in markets by selling surplus produce on a comparative advantage, are set to benefit not only from the direct welfare gains but also from the opportunities that emerge from economies of large scale production (Barrett, 2008). Table 16 presents the market participation statistics, mean participation intensity and the average price received on the market.

Table 16: Common bean marketing

Crop	**Market participation (%)**	**Mean amount sold (kg)**	**Mean price per kg (MZN)[4]**
Common beans	64	117	30

3.1.7 Common bean production, management and constraints

3.1.7.1 Use of productivity enhancing inputs,

An assessment of used inputs in bean production revealed that farmers generally lack resources to acquire and use productivity enhancing inputs. Analysis of data for 2013/14 season revealed that 94% of farmers grew common beans in that season. Of those who grew common beans only 25% of farmers used improved bean varieties. The use of certified seed by farmers is key in improving household food security through high yields. Recycling of seeds leads to massive reductions in yield as farm-saved seed may act as inoculum for seed-borne pests and diseases. Table 17 shows

[3] During the time of the study, the exchange rate was US$1:MZN34.8
[4] MZN = Mozambican Meticals

the rate of use of some important productivity enhancing inputs in 2013/14 season including use seed of improved varieties, use of fertilizers and inoculants.

Table 17: Use of productivity enhancing inputs

Crop	% of growers	% Used improved varieties	% used inoculants	% used basal fertilisers	% used top dressing	% used organic manure
Common bean	94	25	2	32	30	21

Results show that only 2% of the farmers in the 2013/14 season used inoculants in their bean production. Legume inoculants are used in attempts to ensure sufficient rhizobia for maximum nodulation and nitrogen fixation. Our results imply that level of inoculation was very low which can be attributed to lack of access to the inoculants for the common bean. Moreover, only 32% of the farmers used basal fertilizers, 30% used top dressing and only 21% used organic manure. Level of fertilizer use for both organic and in organic was generally low.

3.1.8 Gender perspectives in bean production decision making

In smallholder farming households, members also practice division of labor as they share responsibilities in the family for efficiency purposes. Results from our study showed that men dominated most decision making roles within the households. Results reveal that about 69% of decision makers on whether to grow common bean or not within the households were men. In other cases decisions to grow beans were made by women (13.6%), or by both husband and wife (17%) and rarely by the whole family including children (0.6%). Moreover, a more similar trend was found for control over bean production processes. Men were found to dominate control in production processes (49.2%), with wife controlling production less (25.1%). Joint decision making in controlling production was found to be at 24.1%. Joint decision making involving whole family was rare in all circumstances. Table 18 shows the proportions on decision making.

Table 18: Decision making in bean production and marketing

Item	Decision making			
	Husband	**Wife**	**Both**	**Whole family**
Decision to grow beans	68.7	13.6	17	0.6
Control over bean production activities	49.2	25.1	24.1	1.6
Decision to sale beans	71	12	17	0
Spending income from sale of beans	55	15	29	1

Moreover, men also dominated in deciding whether to sale beans or not (71%) and on control of income from bean sales (55%). Women's role in marketing and control over income was very low at less than 16% in both occasions. Joint decision making involving the husband and wife increased slightly on control over income from bean sales to (29%). Overall, results show that men had significantly higher control than women over bean production and marketing activities in the study area. Results are however inconsistent with the general notion that common bean is a women's crop, men in Angonia were shown to have a bigger role to play in production and marketing of common bean in the district. The main reason for this observation is that, common bean is a major cash crop with high returns in the area. According to some respondents, especially women, men get more involved in controlling the crop when scale of production increases. It therefore implies that an increase in adoption of improved bean seed by the farmers in the district can raise percentage involvement of men in common bean production and marketing.

3.1.9 Bean varieties grown, diversity and geographical spread

3.1.9.1 Varieties grown

The study also collected data on the different varieties grown by households in the past two seasons, particularly to take note of the dominant bean varieties and also to assess the levels of use

of some of the improved bean varieties. Variety names were captured using both local and official names. Results show that the most commonly planted variety for the past two years was Phalombe (52%) and the least were the improved varieties known by name; A222, AFR703, CAL143, NUA 45, SUG 131, VTTT 924/4-4, and VTT925/9-1-2 planted by only 0.3% of the farmers in the previous two years (Table 19). On the contrary, 20 % of the farmers reported knowledge of the existence of these improved varieties. Some modestly common varieties were found to be Namalaga (42%), Khaki (Woyanga) (44%), Demeter (29%), Khaki (Mkhalatsonga) (34%), Domuewawilira (23%), Mgogodo (21%) And Kayera (42%). Other names of local that were reported by farmers were Nazirombe (Calima / red mottled type) in Domue Mtengo umodzi area and Kaburungire (sugar type) in Macanga

The names of some varieties are mostly based on colour of other known/popular varieties. There is a general overlap in names as farmers use their own non-official naming system; for instance, the names CAL 143, Kachiyata and Napilira describe all red mottled varieties, Mgogodo and Khaki describing khaki varieties and Domue and Domue wawilira for cream varieties. Similarly, Demeter, Katalina, Charachankono, Kamphesa and Nkhawayatha, are all sugar type beans. Domue is popular with farmers because it is very high yield. This small seeded variety, however does not have a good market due to poor taste, hence its production is waning. Nkhawayatha is a sugar type of variety, rounded, but smaller than Kamphesa. This variety is popular around the areas of Seze and Domue. Phalombe is a red kidney local landrace, which has been passed down the generations. It was first popular in a district called Phalombe in Malawi. Farmers in Angonia grow this variety in response to its ready market in Malawi. The farmers emphasized that whenever they grow the varieties Domue and Chakuda (black bean), it will be for home consumption mostly due to lack of a defined market. For instance, during the time of the survey (mid marketing season), the following prices were prevailing at the Domue market: MK 450[5] (US$1.02) per kg for the Khaki type, MK 400[6] (US$0.91) for Kamphesa whereas there were no prices at all for the varieties Domue and Chakuda

[5] At the time of the study the exchange rate between the United States Dollar (US$) and the Malawian Kwacha (MK) was US$1:MK440.

[6] The prices were pegged in Malawian Kwacha, due to proximity to Malawi and the perceived dominance of other Malawian merchandise in the area.

Table 19: Varieties grown by farmers in Angonia district

Variety[7]	% Who planted in past 2 seasons	Variety	% Who planted in past 2 seasons
NUA45*	0.6	Charachankono	1.5
SUGAR 131*	3.3	Domuewawilira	23
AFR703*	0.3	Khakhi (Mkhalatsonga)	34.3
CAL143*	0.3	Khaki (Woyanga) - climber	44
VTT 925/9-1-2*	0.3	Domue	19.3
A222*	0.3	Kayera	42
Kachiyata	32.5	Thyolo	17
Katalina	31.3	Chiuzu	5.4
Phalombe	52.4	Napilira	16
Namalaga	41	Mgogodo	21
Sapatsika	8	Nkhawayata	9
Demeter	29	Nanyati	2
Chakuda	4.5		

3.1.9.2 Attributes influencing varieties choice and adoption

Characteristics that influence variety selection and adoption by farmers was another area of focus of the study. Paying attention to the attributes farmers consider most when selecting bean varieties is key as it can improve on adoption of improved varieties. Table 20 shows the proportions of farmers who consider the given variety characteristics as very important in selecting bean varieties.

Farmers were found to consider a lot of attributes when selecting varieties to adopt and grow. Results show that the most common characteristic considered by farmers in the study was known market for the variety (70%) while grain color was considered the least important characteristic (40%). Known markets for a variety are very important as farmer will have specific targets upon

[7] Varieties marked with an asterisk (*) are improved varieties recently released in Mozambique

harvesting their produce. This result confirms the earlier finding that farmers in the area grow beans not only for consumption but also for sale.

Table 20: Characteristics that influence bean variety choice

Characteristics	Yes (%)	Characteristics	Yes (%)
Grain colour	40	Disease tolerance	52
Grain size	50	Pest resistance	43
Grain yield	67	Drought resistance	48
Grain taste	58	Growth habit	42
Time to maturity	68	Plant vigour	41
Known market	70	Cooking time	65
Nutrition	54	Edible leaves	65
Performance in mixed cropping	42		

In addition, farmers also revealed that time taken by variety to maturity and grain yield for the variety are also very important. Results indicate 68% of farmers considers time to maturity to be very important and 67% indicated that grain yield of the variety is important. Another two important characteristics farmers indicated were whether a variety has edible leaves and whether the variety took less time to cook. Results from the survey indicated that 65% of the farmers listed the two characteristics as very important. If a variety has edible leaves, it means that the farmer will benefit from consuming the leaves as relish and then later as grain as well. Cooking time is important also as it saves energy and resources of the farmer by taking less time during cooking. Other characteristics that were indicated by farmers to influence their choice of variety were; drought tolerance (52%), pest resistance (43%), drought resistance of variety (48%), plant vigor (41%), grain size (50%), grain taste (58%), nutrition (54%) and performance in mixed cropping (42%). It is very important to take note of the characteristics farmers pay attention to in future interventions aimed to improve adoption of improved bean varieties. One more thing will be to improve on awareness of the attributes of improved varieties so as to influence adoption significantly.

3.1.10 Awareness, adoption and dis adoption of improved varieties

3.1.10.1 Awareness, uptake and use of improved varieties

The study also assessed the farmers' awareness on some of the bean improved varieties that were being promoted in the study area. Results show that awareness of availability of improved bean varieties was high (80%). However, use of improved varieties was very low (25%) at the time of the survey. A positive result from the survey was that most (91%) of the farmers expressed willing to plant improved varieties in future (Table 21). Furthermore, the high rate of awareness can have direct influence on adoption levels of bean improved varieties

Table 21: Awareness and use of improved bean varieties

Status	Percentage of respondents
Awareness (%)	80%
Ever planted a bean improved variety	25%
Wish to adopt in future (%)	91%

3.1.11 Bean markets and market information systems

Market information is important as it reduces transaction costs for farmers in search of markets. It improves decision making of the farmer especially when choosing whether to participate in the market or not to and also when deciding on the choice of marketing channel to use. Market information access for the improved bean varieties is also important as it can jeopardize adoption of improved varieties by the farmers as well. Lack of market information for available improved varieties on the market can reduce adoption of the varieties.

3.1.12 Sources of Market information

The survey captured sources of various market information and information sharing. This information was captured so as to have an improved understanding of the various sources of information for the smallholder farmers in the study area and if information sharing is a common

practice in the area. Information collected covered output and input prices, quantities demanded and supplied in different markets, marketing opportunities, quality standards, availability of transport and input support. Level of access to the various information and the level of sharing is shown in Table 22.

Table 22: Access to market information and sharing

Type of Information	Farmers accessing (%)	Farmers sharing the information (%)
Input/output prices	64	94
Quantities demanded	55	89
Marketing opportunities	57	88
Supplies in different markets	31	81
Information on quality standards	36	86
Availability of transport services	31	81
Input support / credit	36	80

Results revealed that most of the farmers access input and output prices information (64%). Moreover, information on input and out prices information is shared the most as 94% of farmers who had access indicated that they share the information with others. Other common types of information were found to be marketing opportunities information access (57%) and quantities demanded information access (55%). However, supplies in different markets (31%), information on quality standards (36%), transport services information (31%) and input support (36%) were less common. The interesting part of the result is that those farmers who had access to information shared with other farmers. Results found that at least 80% of farmers with access to information shared it with other farmers.

3.1.13 Main Sources of Information

Sources of information are also important as they reveal level of accuracy and reliability of information. The study gathered data on the main sources of information and ranked sources using individual farmer scores. Results revealed that the main source of information for all the listed

sources except transport information is farmer groups and associations (51%). Farmer group associations are making significant contributions in bean farming in the study district though improving farmer cooperation and as reliable sources of information. Main source of transport information was found to be other individual farmers. Results of the sources of the different types of information are shown in table 23.

Table 23: Main sources of information

Type of Information	**Main sources of information (%)**					
	Private company	**Government institution**	**Farmer group/association**	**Traders association**	**Other individual farmers**	**NGO**
Input/output prices	9.8	0.9	50.7	6.5	32	0
Quantities demanded	12.4	0	44	5.9	37	0.5
Marketing opportunities	10	1	47	5	36	1
Supplies in different markets	8	1	57	4	30	0
Information on quality standards	14	1	49	12	23	2
Availability of transport services	16	2	22	6	53	0
Input support	13	2	50	9	27	0

3.2 ECONOMETRIC RESULTS

3.2.1 Demand for improved bean seed

Estimation of seed demand is necessary and important as it provides important information for decision making by stakeholders in seed supply chains such as seed companies, agro-dealers and other development practitioners. Estimation of seed demand in Angonia was important for common bean farmers as results can be used to regulate future supplies and therefore avoid shortages and unnecessary surplus supplies that could be costly. Results in this study show that adoption rate of bean seed is about 25% and that on average each household requires about 21.78

kg of bean seed (see table 25). Given that we have approximately 95,000 households in Angonia district, we can calculate bean seed demand in the study area as follows:

$$ED = \sum_{i=1}^{N}(Adoption\ rate \times seed\ purchase) \quad (3)$$

Where N=Total number of farming households in Angonia district, ED= effective demand, Adoption rate = the rate of adoption of bean seed in the district, and seed purchase is the household's individual demand for improved seed. Substituting figures mentioned above into equation (3), the effective demand for bean seed in Angonia at is 518 tons (0.25*21.78*95,000) against a potential demand of 2,069 tons based on the current household seed requirement (with current seed rate). While, potential demand is 17 % lower than the estimate from SDAE, it is worth noting that the even effective demand is only 22 % of the ideal demand calculated on area put under the crop and based on recommended seed rate. Most farmers cited high seed cost as one of the major deterrent to adoption bean of improved varieties.

3.2.2 Determinants of demand for improved bean seed

Results from the econometric analysis in table 25 revealed that adoption rate, food consumption score, wealth index and price of bean per kilogram significantly influenced demand for seed (seed purchase).

Adoption rate of improved bean seed variety was found to influence improve seed demand significantly which implies that working to improve adoption of improved bean seed varieties directly improves quantity of seed purchased. The result is an important indicator of the utmost importance of working to improve adoption of improved varieties in Angonia Mozambique if we are to raise demand significantly.

The food security status of the household as proxied by the food consumption score (FCS) was found to have a positive significant influence on improved seed demand. This implies that households that are food secure are more likely to demand improved seed than their counterparts. This could be explained by the fact that, households may have their prime objective of feeding their families before anything else. They are only moved to attend to other resource demanding

activities when their families are in a reasonable food secure state. This again gives an important lesson on interventions meant to improve seed demand and adoption as failure to consider the food security situation in target areas can jeopardize expected impact.

Wealth index was also a significant variable found to influence seed improved seed demand positively. Household's wealth index is a measure of level of liquidity within the household. In developing countries, including Mozambique, smallholder agriculture where households are usually found to be resource poor and have limited access to credit, their wealth is usually equivalent to their productive assets (Freeman et al., 2004). The wealth status of the household significantly influences quantities of seed purchased (demanded). It therefore means that if a household improves from a lower wealth status to a higher level demand for improved seed demanded increases.

In addition price of a kilogram of improved bean seed was also found to have a negative significant influence on improved seed demanded. Precisely model results reveal that a unit increase (decrease) in price (1 metical) will reduce (increase) demand by 0.22% ceteris paribus. The classical demand theory dictates that the quantity of demanded for a normal good decreases with increasing price. It is only for luxury goods we see an opposite trend. The result therefore imply that we should consider price set for improved seed in order to influence demand in a positive way, hiking improved bean seed prices may lower seed purchase significantly.

3.2.3 Determinants of improved seed adoption

Results from the econometric analysis in table 25 revealed that grain yield characteristics, known market, seed purchase and household size significantly influenced adoption of improved bean seed.

Grain yield characteristics of improved seed were found to have a positive significant influence on improved bean seed adoption. This implied that if farmers perceived the improved bean seed variety to have superior grain yield characteristics than the local varieties chances of adopting the improved variety increased by 15%.

In addition, known market as a characteristic for the improved variety was also found to have a positive significant influence on adoption. Results reveal that if the farmer knows the market for a certain improved variety say for example NUA45 probability of adoption for that farmer will increase by 26%. It therefore shows the importance of improving awareness and education to farmers on the specific superior characteristics of promoted improved varieties. Researchers and technology disseminators should intensify on farmer education on the improved varieties so as to have a significant influence on adoption.

Moreover, it was found that household size had a negative significant influence on adoption of improved been seed varieties. An increase in the household size by a single member was found to decrease odds of adopting improved bean seed varieties by 4%. This could be because household size represents size a financial burden the household faces, hence competition with seed purchase. Big household sizes, especially those with a high number of dependents, are therefore less likely to have additional resources to adopt improved bean varieties. Similarly, it has generally been observed that poor households are less likely to adopt new technologies especially when acquiring them requires some resources (Gebre, 2012).

4.0 SUMMARY AND CONCLUSIONS

From the study results descriptive statistics and econometric estimation we can a number of conclusions.

First, agriculture is the mainstay of Angonia district; engaging more than 99 % of the farmers on a full-time basis, both experienced and economically active men and women. Men seem to control the land and cropping choices. The common bean is traditional crop in the district; farmers had a mean experience of 16 years and reports of transgenerational knowledge transfer abound. However, low literacy, especially among women could be limiting use of technologies and negatively affecting demand for seed of improved varieties.

Second, farmers in the district are slightly resource-constrained shown by the low average wealth index of 0.55 and low ownership of assets, household farming equipment and big livestock. Most of the farmers owned hoes and chickens as shown by the high percentages. Despite the resorce constraints, the households in the district were close to food secure with an average food consumption score (FCS)[8] of 36.

Third, farmers have access sizeable pieces of land where various crops are grown, and the common bean comes second after maize, grown by 94% of the farmers for household income and, food and nutrition security. Despite its high ranking in importance, the common bean faces low yields due to suboptimal seed rates in both sole and mixed cropping systems and low use of productivity enhancing inputs such as fertilizers, pesticides and quality seed of improved varieties. Bean production is therefore characterized by production of traditional varieties using farm-saved 'seed', high awareness (80%), but unreasonably low (25%) use of improved varieties.

[8] $FCS=\Sigma a_i X_i$ Where, a_i is the weight assigned to one of the eight broad food groups, based on its nutritional importance and X_i is the frequency for a seven-day recall period with which the food group is consumed. The eight food groups and their relative weights are cereals and fibres (2), pulses (3), vegetables (1), meat and fish (4), milk (4), sugar (0.5) and oils (0.5). Households with an FCS of less than 21 are deemed food insecure, those with an FCS between 21 and 35 are considered to be borderline and those with an FCS above 35 have an acceptable food security status.

Fourth, choice of bean varieties is driven by complex combination set of traits ranging from field / agronomic characteristics to food-related attributes. For farmers in Angonia, with a market participation of 64 % and selling 40 % of their produce, the market had a huge influence of varieties grown, mostly determined by the grain colour or market class. Control of the crop, from land allocation to use of income from bean sales is dominated by men, who are often the registered members of farmers' groups or associations, which in turn are pivotal in disseminating information on bean production and markets. Information sharing amongst members was also found to be very high.

Fifth, based on the econometric estimation of factors influencing demand for seed, results show that annual effective bean seed demand in the district is about 518 t, against a current potential demand of 2,069 t. Both figures are way below the ideal potential demand of 9,500 t based on the recommended seed rate. Reaching these seed demand figures would require streamlining the bean improved varieties to specific markets; a known market was cited as a major driver for bean variety choice. The current proportion of farmers (22.7 %) that purchasing grain for planting offers a starting point to ramping up effective demand for seed of improved bean varieties.

5.0 LIST OF REFERENCES

Amede, T.; Desta, L. T.; Harris, D.; Kizito, F.; Cai, X. 2014. *The Chinyanja triangle in the Zambezi River Basin, southern Africa: status of, and prospects for, agriculture, natural resources management and rural development.* Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE). 32p. (WLE Research for Development (R4D) Learning Series 1). doi: 10.5337/2014.205

Barrett CB (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy,* 33,pp. 299-317.

Birachi, E.A., Ochieng, J., Wozemba, D., Ruraduma, C., Niyuhire, M.C., and Ochieng, D (2011) Factors Influencing Smallholder Farmers' Bean Production And Supply To Market In Burundi. African Crop Science Journal, Vol. 19, No. 4, pp. 335 – 342

CIAT, ICRISAT and IITA. 2013. Bulletin of Tropical Legumes: A Bulletin of the Tropical Legumes Project. CIAT, ICRISAT and IITA.

Crawford, I.M. (1997). "Agricultural and Food Marketing Management". FAO, available on www.fao.org.

Directorate of Agricultural Extension (DNEA). 2007. Extension Master Plan 2007-2016. Ministry of Agriculture. Government of Mozambique, Ministry of Agriculture. Maputo.

Edmeades, S., Smale, M., Renkow, M., Phaneuf, D., 2004. Variety demand within the framework of an agricultural of household model with attributes: The case of banana in Uganda. International Food Policy Research Institute (IFPRI). EPTD Discussion Paper No. 125. Washington DC, USA.

Freeman, H.A., Ellis, F., Allison, E., 2004. Livelihoods and rural poverty reduction in Kenya. Development Policy Review, 22 (2): 147-171.

Gebre, GG, 2012. Determinants of food security among households in Addis Ababa, Ethiopia. Interdisciplinary Description of Complex Systems 10(2), 151 –73.

Gepts, P., F.J.L. Aragão, E. de Barros, M.W. Blair, R. Brondani, W. Broughton, I. Galasso, G. Hernández, J. Kami, P. Lariguet, P. McClean, M. Melotto, P. Miklas, P. Pauls, A. Pedrosa-Harand, T. Porch, F. Sánchez, F. Sparvoli and K. Yu. 2008. Genomics of *Phaseolus* Beans, a Major Source of Dietary Protein and Micronutrients in the Tropics. *In*; P.H. Moore, R. Ming (eds.), *Genomics of Tropical Crop Plants.* Springer. 2008. Pp 113-143.

Langyintuo, A.S., Mekuria, M., 2005. Accounting for neighborhood influence in estimating factors determining the adoption of improved agricultural technologies. Selected Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, RI, USA, July 24-27. http://agecon.lib.umn.edu/cgi-bin/pdf_view.pl? paperid=16150&ftype=.pdf.

Lopes, H. 2010. Adoption of maize and bean varieties in Mozambique. MSc Thesis. Michigan State University. USA.

Howard, J., J. Low, J.J. Jeje, D. Boughton, J.J. Massingue, and M. Meredia. 2001. Crop and Strategies for Development of the Seed sector in Mozambique. Ministry of Agriculture and Rural Development, Research Report No 43E.

Mabaya E., P. Omanga and J. DeVries. 2013. Status of Seed System Development in Sub Saharan Africa. Africa Agriculture Status Report: Focus on Staple Crops 2013. Alliance for Green Revolution in Africa (AGRA). Nairobi, Kenya. Pp 54-68

Ministério da Agricultura e Segurança Alimentar (MASA). 2014. Anuário de Estatísticas Agrárias 2012-2014. Direcção de Planificação e Cooperação Internacional (DPCI)

Mustafa, N., Abdelwhab, Abdel Azim Nour A.M. and Mohamed Fageer Aisha Sheikh, (2009). The Nutritive and Functional Properties of Dry Bean (Phaseolus vulgaris) as Affected by Gamma Irradiation. Pakistan Journal of Nutrition 8 (11): 1739-1742. ISSN 1680-5194

Pachico, D., (1993). The demands for bean technology. Trends in CIAT commodities. Working Document No. 128. pp: 60-74. Henry, G., Ed. Centro International de Agricultura Tropical (CIAT), Cali,Colombia.

Rusike, J., G. van den Brand, S. Boahen, K. Dashiell, S. Kantengwa, J. Ongoma, D. M. Mongane, G. Kasongo, Z. B. Jamagani, R. Aidoo and R. Abaidoo. 2013. Value chain analyses of grain legumes in N2Africa: Kenya, Rwanda, eastern DRC, Ghana, Nigeria, Mozambique, Malawi and Zimbabwe, www.N2Africa.org, 96 pp

Trabalho de Inquérito Agrícola (TIA). 2012. Survey report of Ministry of Agriculture, Mozambique. Draft Report.

Trabalho de Inquérito Agrícola (TIA). 2008. Survey report of Ministry of Agriculture, Mozambique. Draft Report.

World Bank. 2012. Economic and Sector Work. Agribusiness Indicators: Mozambique. Report No. 68241-MZ. World Bank, Washington DC, USA

Zepada, L., 1994. Simultaneity between technology adoption and productivity. Journal of Agricultural and Resource Economics (19) 46-57.

6.0 APPENDICES

6.1 APENDIX 1

Table 24: Descriptive statistics of variables used in estimating factors of adoption and demand for improved bean seed

Variable	Variable description and measurement	Mean	Std. Dev.
SeedPurchs	Quantity of improved bean seed purchased in kg	21.78	15.14
AdoptionRate15	Proportion of cropped area under improved bean varieties	0.26	0.19
FCScore	Household food consumption score	36.06	35.9
WealthIndex	Household's wealth index	1.22	0.55
Beans2014_15_PriceKg_7_8	Price per kilogram of improved bean seed	26.07	26.92
Bean_distmkt_12_11	Distance to the nearest bean market	10.08	7.48
BeansArea_7_5	Area grown improved bean varieties	4.24	20.05
Landarea	Total land owned by the household	3.80	3.01
GrainYield_9_5	A dummy variable with 1 if the farmer perceives the improved variety yield more grain than the local varieties and 0 otherwise.	0.67	0.47
GrainSize_9_3	A dummy variable with 1 if the farmer perceives the improved variety produces larger grain than the local varieties and 0 otherwise.	0.5	0.50
DroughtResistance_9_12	A dummy variable with 1 if the farmer perceives the improved variety is more drought resistant than the local varieties and 0 otherwise.	0.48	0.5
Market_9_7	A dummy variable with 1 if the farmer perceives the improved variety to have a known market and 0 otherwise.	0.70	0.46
PestResistance_9_8	A dummy variable with 1 if the farmer perceives the improved variety is more resistant to pests than the local varieties and 0 otherwise.	0.43	0.50
DependencyRatio	Household age dependency ratio	1.02	0.85
Hsize	Size of the household	4.82	1.99

6.2. APPENDIX 2: Factors influencing demand and adoption of improved bean seed in Angonia, Mozambique

Table 25: Econometric Results

	Coef.	Std. Err.	z	P-Value
SeedPurchs				
AdptionRate15	37.00623	13.013	2.84	0.004***
FCScore	1.261862	0.4762417	2.65	0.008***
WealthIndex	6.370105	3.322609	1.92	0.055*
Beans2014_15_PriceKg_7_8	-0.2159689	0.1079687	-2.00	0.045**
Bean_distmkt_12_11	-0.1871484	0.4235212	-0.44	0.659
BeansArea_7_5	0.6919781	1.522122	0.45	0.649
_cons	45.14397	9.437689	4.78	0.000
AdptionRate15				
Landarea	0.008721	0.0178444	0.49	0.625
GrainYield_9_5	0.1522404	0.0736394	2.07	0.039**
GrainSize_9_3	0.0770696	0.0776388	0.99	0.321
DroughtResistance_9_12	0.137388	0.109243	1.26	0.209
Market_9_7	0.2606056	0.0814079	3.20	0.001***
PestResistance_9_8	0.0997107	0.1038535	0.96	0.337
SeedPurchs	0.006295	0.0031918	1.97	0.049**
DependencyRatio	-0.0322062	0.0340048	-0.95	0.344
Hsize	-0.0389993	0.0190088	-2.05	0.040**
Beans2014_15_PriceKg_7_8	-0.0006553	0.001624	-0.40	0.687
_cons	0.5916575	0.1139187	5.19	0.000

***Variable significant at 10%; **Variable significant at 5%; *Variable significant at 1%