

# Farm types and adoption of proven innovative practices in smallholder bean farming in Angonia district of Mozambique

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Received 1 December 2016  
Revised 30 March 2017  
Accepted 31 March 2017

## Abstract

**Purpose** – Improving the adoption rates of proven innovative practices in bean farming and their impacts on livelihoods requires persistent promotion of practices, complemented by rigorous socioeconomic analysis that recognises the diversity of smallholder farmers. The purpose of this paper is to typify farm households in Angonia district of Mozambique, based on their socioeconomic characteristics prompting the adoption of proven innovative practices in bean production, management, and marketing.

**Design/methodology/approach** – The authors use a multivariate statistical analysis approach that combines principal component analysis, and cluster analysis to clearly identify five distinctive farm household types with respect to the adoption of proven innovative practices in smallholder bean farming using socio-economic factors.

**Findings** – The study findings show that various socioeconomic factors define clusters and can be associated with the adoption and use of innovative practices in smallholder bean farming. The five farm types identified are: female landowners with small farm sizes (29.52 per cent); educated farmers with access to credit (6.63 per cent); relatively rich male land owners with large farm sizes and low education (8.73 per cent); youthful, inexperienced and poor male farmers (6.33 per cent); and experienced female farmers with high labour endowments (8.43 per cent). The respective farm types seemed to have different patterns in the adoption of proven innovative practices in bean farming.

**Originality/value** – The authors recommend that policy makers promote strategies meant to raise adoption of innovative practices in bean production, management and marketing in Mozambique that takes into account household diversity. The farm types identified by this study can be a good starting point for guiding such future efforts.

**Keywords** Typology, Mozambique, Smallholder farmers, Multivariate analysis, Bean production, Management and marketing

**Paper type** Research paper

## 1. Introduction

Improved crop production requires the development and dissemination of an array of proven technologies tailored to farm-specific conditions, rather than blanket recommendations across diverse farms (Chikowo *et al.*, 2014; Zingore *et al.*, 2011). Previous research for Sub-Saharan Africa (SSA) suggests a high degree of variability among smallholder farmers in terms of both socio-economic and bio-physical conditions (Chamberlin, 2007; Chikowo *et al.*, 2014; Tittone *et al.*, 2010). Chikowo *et al.* (2014) even reiterated that, household wealth, priorities, and crop production objectives, determine to a greater extent the availability and allocation of resources to different activities. It therefore implies that adoption and rates of adoption of technologies will vary between farms of dissimilar resource endowment and production orientation, leading to variation in crop productivity at the farm level. More so, it implies that,



technological interventions expected to yield better results in fighting poor productivity in smallholder farming systems must be designed to target these diverse and heterogeneous farms and farming systems (Tittonell *et al.*, 2010). Failure to recognise this heterogeneity is often linked to projects yielding lower than expected impacts in SSA (Chikowo *et al.*, 2014; Giller *et al.*, 2011).

Carrying out a farm typology study can be a useful strategy to classify smallholder farmers using their salient socioeconomic variability. Farm typology studies that classify farmers using their socio-economic characteristics might uncover important information that may be linked to the adoption of agricultural technologies. Precisely, developing a farm typology constitutes an important step in evaluating the constraints and opportunities that exist within the household (Bidogeza *et al.*, 2009; Williams, 1994). Multivariate statistical analysis has been proven to work effectively in creating such typologies, particularly when in-depth farm household survey data are available (Bidogeza *et al.*, 2009; Williams, 1994). The two widely employed techniques to identify a typical farm typology are, principal component analysis (PCA) and cluster analysis (CA).

In this paper, we identify several farm types in Angonia district in Tete province of Mozambique that might explain different behaviour in the adoption and use of proven innovative practices (technology and methods) in bean farming (production, management and marketing). These farm clusters are based on many socio-economic factors such as education level, gender and occupation to name just a few. The identified farm types should yield essential information needed to diagnose and understand the problems as well as opportunities for improvement in the adoption rates of bean technologies in Angonia which are low (Lopes, 2010). In addition, revealed farm types can help to foster further research within the district. As noted in the previous literature, such farm types have been cited to be important in building representative farm models (see Köbrich *et al.* (2003).

## 2. Agriculture and socioeconomic development in Mozambique

The agricultural sector plays a crucial role in the socioeconomic development of Mozambique. The majority of the population living in rural areas heavily depend on agriculture for their livelihood (Lopes, 2010; Lukanu *et al.*, 2004). The sector accounts for an estimated 28 per cent of the country's gross domestic product (Tomo, 2009) and employs over 75 per cent of the population (Lopes, 2010; Tomo, 2009). Subsistence agriculture is the dominant employer of the workforce though agricultural productivity is weak (Cunguara *et al.*, 2011). The agricultural sector in Mozambique is dualistic, comprising of commercial and smallholder sub-sectors. The smallholder sub-sector cultivates a large share of the land and produces most of the food crops (Mango *et al.*, 2015).

Despite the crucial contribution of agriculture to livelihoods in Mozambique, poverty remains high amongst the rural population (Mucavele, 2013). The country remains one of the world's poorest countries, with a low GDP per capita and a significant proportion of the people living below the poverty line (Central Intelligence Agency, 2013; Silva, 2013). Even though a recent report by the World Bank alludes to potential inconsistencies in the poverty estimates computed by the Mozambican Government (World Bank, 2012b), poverty is still a chief concern in the country, especially amongst the rural populace.

The underlying causes of poverty in the country are diverse and include, but are not limited to: high illiteracy rates especially amongst women; high household dependency rates; low agricultural productivity particularly in the smallholder sector aggravated by lack of high yielding seed varieties and a constant supply of inputs; infrastructural constraints, particularly in rural areas; lack of employment opportunities; and insecurity (due to on and off clashes between the government and opposition forces). Low agricultural productivity in the smallholder sector is more likely to be causing significant harm

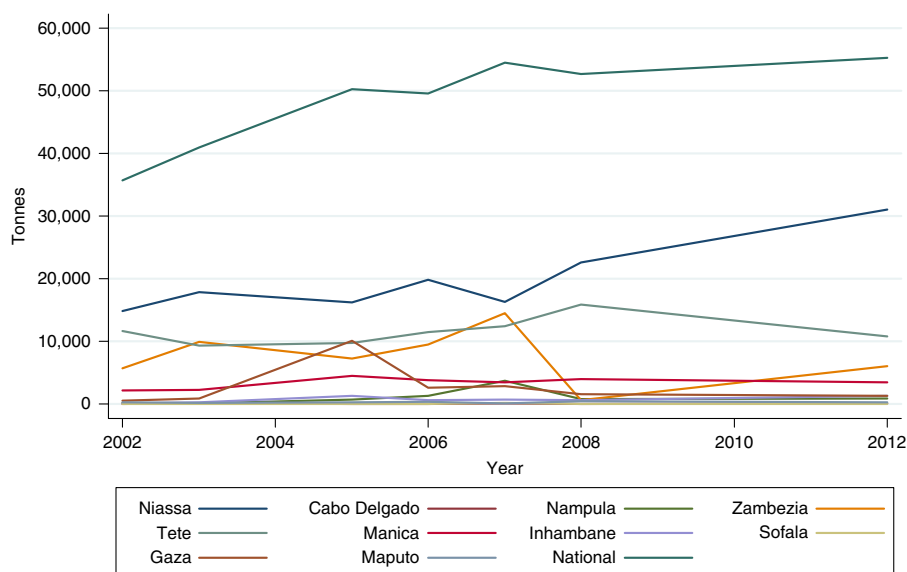
considering that the majority of the population depends on agriculture (Lopes, 2010; Tomo, 2009). Several researchers have since documented the multiplier effects from agriculture to non-agriculture activities, especially in SSA and Asia (Christiaensen *et al.*, 2011; Haggblade *et al.*, 2007; World Bank, 2007). It therefore implies that the majority of the poor in the developing world including Mozambicans stand to benefit more from the GDP originating from agriculture than from an equal amount of GDP generated outside the sector (Haggblade *et al.*, 2007). Achieving pro-poor growth with maximum pay-off in terms of poverty reduction would call for policies and investments that support the development of agriculture (Kraay, 2006; Ravallion and Datt, 2002).

It is evident that the Mozambican government is following the same path of curbing poverty via development policies that promote growth in agriculture (Government of Mozambique, 2006, 2011). Rural development policies have amongst other objectives, the objective of assisting smallholder farmers in starting or increasing agricultural production for self-sustenance and for the international market to raise rural incomes and GDP. Partnerships of the government with research organisations and development partners in agriculture are other good examples of showing commitment by the government to curb poverty. For instance, the ministry of agriculture through the Institute of Agricultural Research of Mozambique (IIAM) is collaborating with international research organisations including the International Centre for Tropical Agriculture (CIAT), in strengthening partnerships for innovation in legumes' (beans, groundnuts and sesame) research and technology transfer in the country. In this project CIAT is undertaking all activities on beans. The section that follows is a brief history of a collaborative effort of CIAT and IIAM in developing and disseminating y bean technology in Mozambique.

### **3. Bean production, technology development and dissemination in Mozambique**

Common bean is an important legume in human diets globally; providing protein, iron, zinc, fibre and complex carbohydrates (Gepts *et al.*, 2008) and food for over 400 million people in Africa. In Eastern and Southern Africa, beans are recognised as the second most important source of human dietary protein and third most important source of calories (Buruchara, 2007). As food pulses, beans are a cheap but important source of high-quality proteins, and are consumed throughout the year since they are easy to store. They are, thus, one of the best means of mitigating food nutrition problems experienced in countries like Mozambique. Furthermore, common bean is also a very important source of income for smallholder farmers. The production of common bean in Mozambique is on the increase, with an increase of about 55 per cent evident between 2002 and 2012 (Trabalho de Inquérito Agrícola (TIA), 2012). In Figure 1, we show the trends in bean production by province from 2002 to 2012.

Bean research efforts in Mozambique resulted in the release of varieties by the government 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 (Buruchara *et al.*, 2011). These varieties also possess preferable market and nutritional traits. The varieties were developed and selected with farmers through participatory evaluation and also address the culinary qualities that farmers look for in bean varieties for home consumption (Buruchara *et al.*, 2011). Despite these advances, a survey by the Ministry of Agriculture, showed that the adoption rate of improved common bean varieties in Mozambique remains low (Lopes, 2010). The low adoption of improved varieties in Mozambique can be traced back to historic paradigms. Until the year 2000, Mozambique Seeds (SEMOC) was a state monopoly created in the late 1980s with the mandate to supply all commercial seed in Mozambique. Instead of fulfilling smallholders' demand for seed, SEMOC became



**Figure 1.** Bean production trends in Mozambique from 2002 to 2012

**Notes:** National is a summation of production from the given ten provinces

exclusively involved in emergency programs with 90 per cent of SEMOC’s sales directed to emergency programs through a multi-million dollar ten-year Emergency Programme for Seeds and Tools (PESU) that distributed free kits of seeds and tools to about 1.2 million smallholders annually (Howard *et al.*, 2001). Thus production, supply and use of certified seed have therefore been highly determined by free seed distribution by the government (Howard *et al.*, 2001). For instance, in 2007/2008, 218 tons of certified bean seed was produced, but the figure plummeted to 3.9 tons only in 2009/2010 (World Bank, 2012a). Thus the adoption of certified bean seed has been somewhat fluctuating and generally varying according to the targeted government distribution zones.

The privatisation of SEMOC opened opportunities for new private seed companies to emerge, but similar to most SSA countries, the emerging seed companies in Mozambique tend to focus on the lucrative maize hybrid seed business at the expense of legumes (Mabaya *et al.*, 2013). These new companies are quite small and not well established and thus limiting their ability to produce and supply the required quantities of improved seeds. Thus many smallholder farmers resort to using their own-saved seeds (Mabaya *et al.*, 2013). In addition, public extension services are very limited in Mozambique (TIA, 2012).

Against this background, CIAT and IIAM embarked on the 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. Much of the work 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. This study aims to improve future efforts in promoting widespread uptake of innovative practices in bean farming in Mozambique by defining characteristic farm households that can be targeted. Deliberate targeting of the specific farm household types with strategies tailored to their inherent socioeconomic variability can improve adoption rates and livelihood impacts of bean value chains.

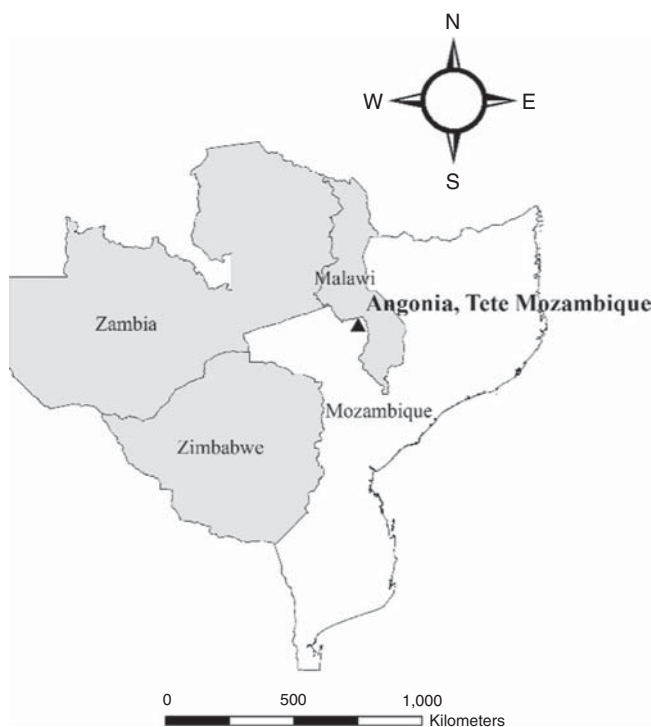
## 4. Materials and methods

### 4.1 Description of study area

The study was carried out in Angonia district which is situated in the northern part of Tete Province, central region of Mozambique (Figure 2). The district is divided into two administrative posts, Ulongue and Domue. The climate is cool in winter and warm/mild in the summer. The area receives relatively high total annual rainfall (900-1,200 mm) in the rainy season from late November to early April. The district falls within what is mostly considered as 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.

### 4.2 Sampling and data collection

The overall approach to the study was quantitative using structured questionnaire survey. The questionnaire collected information on household socio-economic and demographic characteristics, agricultural production, crop management, marketing, adoption of bean technologies (i.e. use of improved bean varieties, certified seed, inoculants, etc.), access to credit, extension services, participation in bean demonstrations, access to bean training services, and access to information. Face-to-face interviews with 332 smallholder farmers were conducted to gather the data. The survey was done in May 2015. Stratified random sampling was used to select respondents. 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 a descending order. We have the



**Figure 2.**  
Map showing the location of Angonia district in Tete province of Mozambique

District, below it is the Administrative Post, then the Location (Localidade), followed by town (Povoado) and then the parish (Povoação) as the smallest unit. However, for this study the smallest unit considered was the Povoado. The two Administrative Posts (Domue and Ulongue) were considered the main strata. The Localidades randomly selected were treated as the second level strata. Treating povoados as the third level strata, 332 households were interviewed. Information on the total populations in the respective levels of administrative units used was obtained from district secretary's office.

#### 4.3 Multivariate statistical analysis

In this study, we examine household-level data from smallholder bean farmers in Angonia district in Tete province of Mozambique to construct farm household typologies. We employ a multivariate analysis approach that combines a PCA, a technique which is necessary for data reduction (i.e. to summarise the data sets into smaller and non-correlated dimensions or components) (Kuivanen *et al.*, 2016; Vyas and Kumaranayake, 2006) and a two-stage CA technique to characterize the smallholder farmers in the district. As noted in Lewis-Beck (1994) and Bidogeza *et al.* (2009), summarizing the data through PCA is an important step before undertaking the CA to the data set.

Prior to proceeding with the PCA approach, we performed the Bartlett's test (Bartlett, 1950) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy to evaluate the appropriateness of the variables to be used as inputs to the PCA approach (Field, 2009). The Bartlett's test of sphericity checks the null hypothesis that the inter-correlation matrix came from a population in which the variables to be used in the PCA are all non-collinear (i.e. an identity matrix (Field, 2009)). The results from this test using the survey data revealed a significant test ( $\chi^2 = 1938.33$ ;  $p$ -value = 0.000) suggesting that the variables are uncorrelated hence suitable for a PCA. On the other hand, the KMO test compares the correlations and the partial correlations between the variables with a small KMO suggestive of highly correlated data. Using the Kaiser (1974) characterisation of the KMO values revealed that our KMO statistic of 0.575 is in the lower threshold and suggestive of less correlated data. The results support the appropriateness of our data for the multivariate analysis procedures.

The PCA approach followed the Kaiser criterion of retaining all the components with eigenvalues greater than one. Also, to simplify the interpretability of the PCA results we rotated the components using the Kaiser's normalisation applicable when the number of variables does not exceed 30 (Field, 2009), which is the case with our data. This approach has also been applied in recent and related studies (Bidogeza *et al.*, 2009; Nainggolan *et al.*, 2013). The resulting PCA components are then used as inputs to the CA to characterize the different clusters of smallholder bean farmers in the data set. To better understand the farm household typologies of the smallholder bean farmers in Angonia district, we employed a commonly used hierarchical clustering technique called the Ward's procedure to define the number of groups  $G_i$  (Ward, 1963). We then employed a non-hierarchical, apportioning procedure to refine the created  $G_i$  groups (Hair, 2010). The Ward's clustering criterion combines all the objects that result in an increase in overall within-cluster variation to the smallest degree (Mooi and Sarstedt, 2010). Since there is no single procedure applicable to select the minimum number of clusters, we follow the approaches adopted in Köbrich *et al.* (2003) and requested a total of five clusters from the CA. To ensure we generate the optimal number of clusters, we also utilised a dendrogram created from Ward's approach together with an expert knowledge of the study area. The dendrogram is a pictorial depiction of the hierarchy of the nested cluster solutions (Schonlau, 2002). Additionally, we conducted a one-way analysis of variance (ANOVA) to identify the differences in variability between the generated clusters. This approach allows us to identify specific variables that contribute the biggest differences between the clusters. We conducted all the analysis in STATA version 13.0 with the relevant cluster commands (StataCorp, 2013).

#### 4.4 Choice of variables and descriptive statistics

Descriptive statistics of variables used to construct a typology of farmers in Angonia district are shown in Table I:

- (1) Farm size: farm size is an important factor that can influence adoption of technologies (Bidogeza *et al.*, 2009; Nkonya *et al.*, 1997) and even other decisions on the farm like collective action in marketing (Fischer and Qaim, 2012). Households with large farm sizes may have a greater capacity to test and adopt bean technologies. Jamison and Moock (1984) and Nkonya *et al.* (1997) demonstrated that farm size positively influence adoption of fertilizers and improve maize seed, respectively. Mean farm size in our sample is 3.80 hectares.
- (2) Education: empirical evidence link education with technology (Asfaw and Admassie, 2004; Onu, 2006) and marketing (Fischer and Qaim, 2014). Education improves the farmer's capacity to evaluate technologies and other practices that may be beneficial to adopt on the farm. In this study; mean number of years in formal education is about 4.00 and each household had about 1.34 literate household members. Only 4.20 per cent of the farmers had received training in bean production, marketing and or post-harvest management whilst only 9.60 per cent had visited a demonstration plot on beans at the time of the survey.

	Definition of the variables	Mean	SD
farmsize	Farm size in hectares (ha)	3.803	3.006
educ_num	Number of years in formal education	3.992	2.628
Literate	Number of literate (can read and write) household members	1.337	1.533
training_pdMkt	= 1 if household received training related to bean production, marketing or post-harvesting; 0 otherwise	0.042	0.201
demonstration_visit	= 1 if the farmer visited a bean demonstration event; 0 otherwise	0.096	0.296
landOwnership	= 1 if wife owns land; 0 otherwise	0.262	0.440
sex_female	= 1 If farmer is female; 0 otherwise	0.422	0.495
age	Age of farmer in years	40.202	13.724
farm_exper	Experience in bean farming in years	16.340	11.927
familysize	Size of family (number of household members)	4.810	1.983
farm_wkrs	Number of farm workers	2.557	1.564
Extension_legume	= 1 if farmer has access to extension in Legume farming; 0 otherwise	0.066	0.249
Info_access	= 1 if farmer has access to information on beans marketing; 0 otherwise	0.642	0.480
Info_sosRadio	= 1 if farmer main source of information is Radio; 0 otherwise	0.386	0.487
Credit	= 1 if farmer accessed agricultural credit; 0 otherwise	0.117	0.322
Distance_mkt	Distance to the nearest bean market	11.806	7.767
wealth_low	= 1 if farmer is in low asset wealth category; 0 otherwise	0.410	0.493
wealth_high	= 1 if farmer is in high asset wealth category; 0 otherwise	0.395	0.489
bean_income	Income from Bean crop in Mozambican Metical	5,502.365	34,788.960
certified_seed	= 1 if farmer used certified been seed; 0 otherwise	0.148	0.355
crop_syst_intrcp	= 1 if farmer grow beans as an intercrop; 0 otherwise	0.855	0.352
bean_improvd	= 1 if farmer planted improved bean seed varieties; 0 otherwise	0.169	0.375
bean_innocu	= 1 if farmer used inoculants; 0 otherwise	0.018	0.133
basalfert	= 1 if farmer used basal fertilizers in bean production; 0 otherwise	0.301	0.459
Organic_Manure	= 1 if farmer used organic manure in bean production; 0 otherwise	0.193	0.395
Topdressing	= 1 if farmer used topdressing fertilisers in bean production; 0 otherwise	0.280	0.450
weeding	Bean weeding frequency (frequency of weeding the crop up to maturity)	2.079	0.568
sale_collectiv	= 1 if farmer sell beans collectively; 0 otherwise	0.120	0.326
Sale_beans	= 1 if farmer sell beans; 0 otherwise	0.690	0.463

**Table I.**  
Descriptive statistics  
for the variables used  
in the analysis of  
Angonia district  
Mozambique

**Note:** Data were collected from selected smallholder farmers in Angonia district in Tete province Mozambique

- (3) Gender: gender is another determinant of several farming decisions in smallholder farming (Murray *et al.*, 2016; Quisumbing and Pandolfelli, 2010). As stated in Murray *et al.* (2016) women farmers in particular may not have the same power and resources to make crucial decisions relating to changing agricultural practices. In this study we include two dummy variables land ownership (= 1 if wife owns land; 0 otherwise) and sex (= 1 if household head is female; 0 otherwise) to represent gender. About 26.20 per cent of women (wives) owned land and 42.20 per cent of the farmers in our sample are female.
- (4) Experience in bean farming: experience is another important factor that can influence farming decisions within the household (Fischer and Qaim, 2012; Makate *et al.*, 2016). Experience works positively in influencing farming decisions by reducing perceptions of risk associated with change. Farmer's attitudes towards risk and perception of risk associated with new technologies/practices change with time and influence adoption decisions (Ghadim and Pannell, 1999). We however, take note of the fact that the influence of experience on adoption can be equivocal. In this study, we include farmer's age and his/her farming experience in bean production as measures of experience. Mean age of household head in our sample is 40.20 years whilst mean bean farming experience is 16.34 years.
- (5) Labour: availability of labour is another important factor that can influence adoption of innovation decisions on the farm. Some technologies/practices require more labour as opposed to others (Murray *et al.*, 2016). When markets for labour are not available which is common in smallholder farming, households supply their own labour for farm activities. This however, can be a constraint in innovative decisions adoption on the farm as they may tend to adopt technologies/practices that require less labour (Bidogeza *et al.*, 2009). Households with bigger sizes and particularly many active farm workers are therefore expected to have higher propensities to adopt innovative practices on the farm. In our sample, mean family size is 4.81 and mean number of farm workers per household is 2.56.
- (6) Access to extension services, information, credit and distance to market: agriculture extension access is an important source of information for farming communities. Agricultural extension officers link farmers with research. They decode information from researchers into a language and format that farmers can understand. It, therefore, implies that extension access is an important factor to influence farming decisions on the farm. Access to extension specifically in legume farming is 6.60 per cent in our sample. Access to information on bean marketing in our sample is 64.2 per cent. Access to market information on beans can drive bean technology adoption as access to markets is a big motivator for production in smallholder farming (Fischer and Qaim, 2012). Credit may also influence farming decisions as some technologies require initial capital investments (Doss, 2006). Access to credit in our sample is at 11.70 per cent. Mean distance to the nearest main bean market is at 11.81 kilometres. Distance to market is a determinant of farming innovation adoption as it has an influence on transactions costs associated with accessing input and output markets (Fischer and Qaim, 2012; Fischer and Qaim, 2014).
- (7) Asset wealth: farmers' decisions to adopt innovative practices are highly influenced by access to resources (Cunguara *et al.*, 2011; Makate *et al.*, 2017; Onu, 2006). We include two categories of asset wealth (low and high wealth) obtained from PCA of household assets (Filmer and Pritchett, 2001). Low wealth is a dummy variable indicating the poorly resourced whilst high wealth indicates the better resourced. In our sample, 41.00 per cent of farmers are in the low wealth category whilst 39.50 per cent are in the high wealth category.



- (8) Innovative practices in bean production and marketing; we include several variables to represent use of innovative practices in bean production and marketing in the study area. These include; use of certified bean seed, improved seed, use of inoculants, fertilizers (basal and top dressing fertilisers), use of organic manure, intercropping (maize-bean intercropping), weeding practices, market participation and collective market participation.

It has been determined that use of improved varieties and certified seeds increase productivity in crop production (Katungi *et al.*, 2010; Lopes, 2010; Zavale *et al.*, 2005). Inoculants improve nitrogen fixation and hence are necessary for improving bean productivity (Buruchara, 2007; Buruchara *et al.*, 2011). In our sample, 14.80 per cent of farmers use certified seed, 16.90 per cent use improved seed and only 1.80 per cent use inoculants.

Intercropping also has numerous benefits to bean production that include; weed suppression and reduced susceptibility to insects and diseases among other benefits. About 85.50 per cent of the farmers grow beans as an intercrop.

Fertilizers and organic manure are necessary complementary inputs for ensuring positive outcomes from technology adoption (Islam *et al.*, 2016). In our sample, 30.10 per cent of the farmers use basal fertilisers, 28.00 per cent use topdressing fertilisers and 19.30 per cent use organic matter. In addition, crop management practices such as weeding are necessary in controlling weeds (Rockström *et al.*, 2009). Mean weeding frequency in our sample is 2.08.

Market participation is necessary for fighting rural poverty and promoting rural development (Jayne *et al.*, 2010). Collective action in marketing reduces transaction costs and improves bargaining power of farmers on the market which can improve benefits they obtain from the market (Fischer and Qaim, 2014). In our sample, 69.00 per cent participate in the bean output market and 12.00 per cent participate collectively.

## 5. Results and discussions

### 5.1 PCA results

We include a total of 30 variables in PCA (Table I), of which 10 principal components with eigen values greater than one have been retained for further analysis. The variables explain about 63.45 per cent of total variance. As shown in Table II, it is possible to define components according to the variables each component is strongly associated with. For ease of identification, component loadings with a score of 0.4 and above are in bold.

The first component explains approximately 7.67 per cent variability and is positively correlated with access to extension services, training in bean production marketing and or post-harvest management and visiting bean demonstration events. Thus, the component represents farmers knowledgeable in beans. The second component is almost as important as the first component and explains about 7.62 per cent of the variance and positively correlates with basal and topdressing fertiliser usage. The component, thus, represents farmers with access to fertilisers. Component 3 explains 7.14 per cent variance in data and positively correlates with use of improved and certified seed. The component is thus for farmers using improved certified seed.

Components 4 (6.85 per cent), 5 (6.83 per cent), and 6 (6.82 per cent) are almost equal in importance in explaining variability as the first three components. Component 4 correlates positively with gender (female) and collective marketing and negatively with weeding frequency. Thus, female farmers sell bean collectively on the market but practice less weeding. Component 5 correlates positively with age and farming experience, thus can be named experience. On the other hand, component 6 correlates positively with family size, number of farm workers and number of literate members. Thus, component 6 can be named labour.

Component 7 and 8 explains nearly 6.28 and 5.38 per cent of the variance, respectively. Component 7 correlates positively with low wealth and negatively with high wealth.

Variable	Components									
	Comp 1	Comp 2	Comp 3	Comp 4	Comp 5	Comp 6	Comp 7	Comp 8	Comp 9	Comp 10
farmsize	0.021	0.084	0.176	-0.070	0.094	0.071	-0.105	0.288	-0.003	-0.298
educ_num	0.225	0.051	-0.087	0.004	-0.208	0.002	-0.179	-0.063	-0.226	0.363
Literate	-0.005	-0.094	0.038	-0.116	0.027	<i>0.484</i>	-0.143	-0.040	-0.137	0.091
training_pdMkt	<i>0.450</i>	0.121	0.082	0.120	-0.056	-0.024	-0.090	0.124	-0.018	-0.015
demonstration_visit	<i>0.547</i>	-0.081	-0.041	0.025	0.025	-0.082	0.063	-0.048	-0.044	-0.025
landOwnership	-0.116	-0.148	-0.045	0.060	0.057	-0.049	0.137	-0.081	0.334	<i>0.433</i>
bean_income	-0.001	0.020	0.032	-0.069	0.032	-0.005	-0.060	0.210	-0.026	<i>0.615</i>
Income_crops	-0.106	0.093	-0.002	0.107	0.035	-0.107	-0.094	0.017	<i>0.557</i>	0.028
sex_female	-0.084	-0.050	-0.079	<i>0.540</i>	-0.055	-0.091	0.001	0.121	0.012	-0.022
age	0.005	-0.036	-0.015	-0.021	<i>0.627</i>	0.009	-0.007	0.045	-0.041	0.004
familysize	-0.068	0.047	-0.062	-0.057	0.008	<i>0.566</i>	0.084	0.105	0.062	-0.115
farm_wkrs	0.104	-0.016	-0.107	0.188	0.095	<i>0.442</i>	0.047	-0.008	-0.010	-0.009
Distance_mkt	0.005	-0.009	-0.025	0.114	-0.008	0.032	0.074	<i>0.573</i>	0.115	0.107
farm_exper	0.014	0.026	-0.023	-0.006	<i>0.647</i>	0.025	-0.061	-0.053	0.021	0.011
Extension_legume	<i>0.546</i>	-0.014	-0.019	-0.092	0.044	0.045	0.071	-0.010	0.040	0.027
Info_access	0.081	0.041	0.227	0.231	0.026	0.196	0.043	-0.290	0.073	0.043
Info_sosRadio	-0.185	0.010	0.103	0.151	-0.196	0.322	-0.018	-0.118	-0.135	0.128
Credit	0.188	-0.029	0.064	-0.065	-0.104	0.067	-0.066	-0.012	<i>0.474</i>	-0.075
wealth_low	0.043	0.030	-0.004	-0.021	-0.063	0.050	<i>0.658</i>	0.070	-0.037	-0.016
wealth_high	-0.002	0.019	-0.006	0.007	-0.001	0.047	<i>-0.614</i>	0.072	0.039	0.014
certified_seed	0.001	-0.006	<i>0.636</i>	-0.027	-0.021	-0.038	-0.031	0.010	-0.002	-0.026
crop_syst_intcrp	-0.009	0.020	-0.051	0.019	0.022	-0.027	0.043	<i>-0.528</i>	0.157	-0.090
bean_improvd	-0.018	-0.037	<i>0.636</i>	-0.022	-0.017	-0.013	0.034	0.006	0.014	0.017
bean_innocu	0.096	0.082	0.015	-0.221	-0.013	0.172	-0.012	-0.155	0.309	0.219
basalfert	-0.013	<i>0.630</i>	-0.026	-0.002	0.012	-0.004	-0.011	0.005	0.005	0.042
Organic_Manure	0.005	0.067	0.171	0.243	0.218	-0.118	0.056	-0.173	-0.267	0.225
Topdressing	-0.003	<i>0.632</i>	-0.012	0.001	-0.018	-0.003	0.026	-0.017	0.037	-0.064
weeding	-0.115	0.244	-0.016	<i>-0.416</i>	0.012	-0.067	0.072	-0.026	-0.150	0.134
sale_collectiv	0.034	0.208	-0.024	<i>0.477</i>	0.007	0.048	-0.033	-0.050	-0.022	0.019
Sale_beans	0.018	0.081	0.124	0.061	0.097	0.089	0.200	0.198	0.127	0.145
Eigen values	2.300	2.287	2.142	2.056	2.049	2.047	1.884	1.615	1.396	1.261
Cumulative proportion of explained variance (%)	7.67	15.29	22.43	29.28	36.11	42.94	49.21	54.60	59.25	63.45

**Table II.**  
The distribution of the nine components extracted from principal components analysis including the factor loadings of the 30 variables and the cumulative proportion of the explained variance

The component is for those farmers with poor asset wealth. Component 8 correlates positively with distance to market and negatively with intercropping. Larger distances to input and output markets discourage intercropping. Component 9 explains 4.65 per cent of variance and correlates positively with total crop income and access to credit. Thus, households with access to credit obtain high incomes from crop production. Component 10 explains 4.20 per cent variability and it correlates positively with female landowners and income from beans. Thus, female landowners are more likely to earn higher returns from beans.

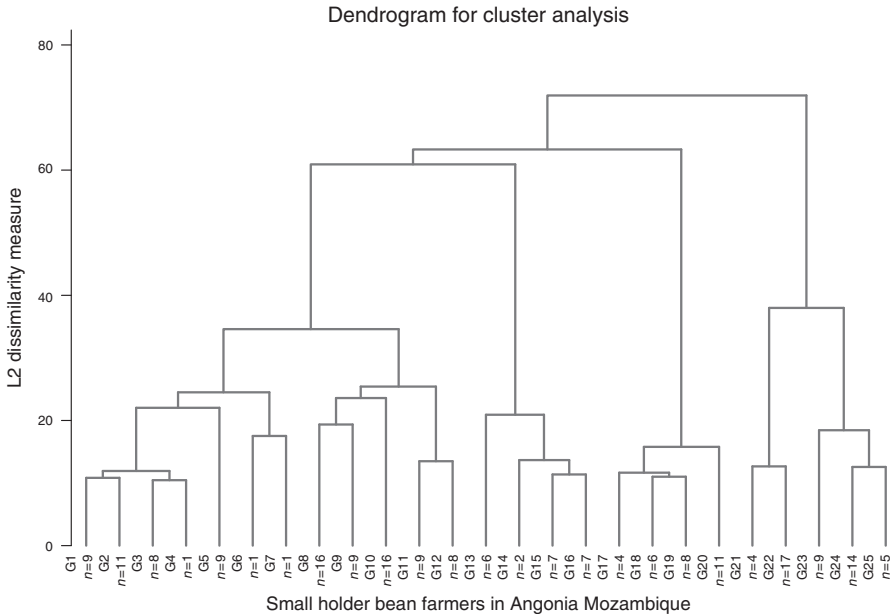
### 5.2 CA results

In order to obtain a meaningful classification, the number of retained clusters should be realistic with the empirical situation (Bidogeza *et al.*, 2009). Following the same line of reasoning, we defined five clusters representative of farm households in Angonia district,

Mozambique. In addition, and to ensure we generate an optimal number of clusters, we also utilised the dendrogram created from Ward's approach together with an expert knowledge of the study area (Figure 3).

In Table III we show the characteristics of selected clusters of farm households in Angonia district of Mozambique and *p*-values of one way ANOVA (equality of group mean). For a guide in interpretation, the more distinctive a variable value is among groups, the lower is its *p*-value. From the typology and the given *p*-values (Table III), we can clearly see that factors such as farm size, number of years in formal education, literacy, access to training in bean production, marketing and post-harvest management, visiting bean demonstration sites, women owning land, female household headship, age, experience in bean farming, availability of labour, wealth status, access to market information on beans, information source, access to credit and extension significantly distinguish clusters. This is also true for innovative practices in beans except for intercropping, use of organic manure and sale of beans, which shows good choice of variables.

Cluster 1 (female landowners with small farm sizes), constitutes 29.52 per cent of the total sample and have women (wives) owning land and small farm sizes as the two most distinctive characteristics. Thus, the cluster is that for households in which the wife owns land and average farm sizes are relatively small compared to other groups. In addition, the group have above average rates in use of basal fertilisers and of collective market participation on the bean market. Though income from beans is not significantly different amongst groups, the group has the highest returns in bean income. However, the use of improved bean seed, inoculants, certified seed, top dressing fertilisers and weeding frequency are below average in this group. Low usage rates of bean technological



**Figure 3.** Dendrogram resulting from Ward's method of cluster analysis using data from Angonia district in Mozambique

**Notes:** Note that, for brevity we have limited our view to the top 25 branches of the dendrogram with cutnumber (25). These branches are labelled G1-G25 by default with the respective sample sizes shown beside

	(1) Cluster I Cluster means	(2) Cluster II Cluster means	(3) Cluster III Cluster means	(4) Cluster IV Cluster means	(5) Cluster V Cluster means	(6) All clusters Cluster means Cluster SD		<i>p</i> - value
farmsize	3.694	3.932	5.414	3.714	4.268	3.803	3.006	0.0129
educ_num	3.631	5.454	3.275	4.283	3.568	3.992	2.628	0.0163
Literate	1.337	1.636	1.897	0.571	1.036	1.337	1.533	0.0174
training_pdMkt	0.020	0.455	0.000	0.000	0.036	0.042	0.201	0.0000
demonstration_visit	0.082	0.773	0.000	0.000	0.000	0.096	0.296	0.0000
landOwnership	0.347	0.136	0.069	0.143	0.179	0.262	0.440	0.0071
bean_income	8,112.545	4,017.795	2,634.469	3,682.048	2,873.671	5,502.365	34,788.960	0.9177
sex_female	0.500	0.136	0.207	0.048	0.714	0.422	0.945	0.0000
age	42.194	39.000	36.034	34.571	42.750	40.202	13.724	0.0457
familysize	4.776	5.000	4.966	4.095	5.107	4.810	1.983	0.3922
farm_wkrs	2.551	3.182	2.138	0.714	3.429	2.557	1.564	0.0000
Distance_mkt	13.138	12.082	10.483	12.419	10.082	11.806	7.767	0.3113
farm_exper	16.857	17.455	12.448	11.095	20.857	16.340	11.927	0.0178
Extension_legume	0.020	0.773	0.000	0.000	0.000	0.066	0.249	0.0000
Info_access	0.582	0.864	0.897	0.238	1.000	0.642	0.480	0.0000
Info_sosRadio	0.337	0.091	0.517	0.238	0.500	0.386	0.487	0.0064
Credit	0.092	0.591	0.207	0.000	0.071	0.117	0.322	0.0000
wealth_low	0.347	0.273	0.207	0.571	0.393	0.410	0.493	0.0931
wealth_high	0.439	0.636	0.552	0.286	0.321	0.395	0.489	0.0744
certified_seed	0.041	0.182	0.966	0.048	0.000	0.148	0.355	0.0000
crop_syst_intcrp	0.847	0.909	0.793	0.857	0.964	0.855	0.352	0.3772
bean_improvd	0.071	0.182	1.000	0.000	0.036	0.169	0.375	0.0000
bean_innocu	0.010	0.091	0.000	0.000	0.000	0.018	0.133	0.0427
basalfert	0.051	0.318	0.172	1.000	1.000	0.301	0.459	0.0000
Organic_Manure	0.194	0.091	0.207	0.190	0.286	0.193	0.395	0.5662
Topdressing	0.020	0.318	0.207	0.905	0.964	0.280	0.450	0.0000
weeding	1.980	1.909	2.138	2.952	2.000	2.079	0.568	0.0000
sale_collectiv	0.133	0.227	0.069	0.000	0.679	0.120	0.326	0.0000
Sale_beans	0.990	1.000	1.000	1.000	1.000	0.690	0.463	0.9087
<i>N</i> (%)	98 (29.52%)	22(6.63%)	29(8.73%)	21(6.33%)	28(8.43%)	332		

Notes: SD, standard deviation. Data were collected from selected smallholder farmers in Angonia District of Mozambique

**Table III.**  
Characteristics of  
selected clusters of  
smallholder bean  
farmers in Angonia  
district, Mozambique

attributes and fertilizers in this group seem to corroborate the findings from other studies such as Murray *et al.* (2016), Bidogeza *et al.* (2009), Doss and Morris (2000), which demonstrate that female headed households face constraints such as low levels of education and small farm sizes which prevent the adoption of costly and knowledge intensive technologies. Improving education on bean technologies through either extension training or encouraging participation in bean demonstration activities might improve the adoption of innovative practices (improved seed, inoculants, and weeding practices) in this group *ceteris paribus*.

Cluster 2 (educated farmers with access to credit) has mostly education (number of years in formal education, access to training on beans and access to bean demonstration activities) and access to credit as the main characteristics that differentiate it from other groups. It constitutes only 6.63 per cent of the total sample of farmers. In terms of innovative practices, the group has the highest rates in use of inoculants, and above average rates in; use of basal and top dressing fertilisers, use of improved certified bean seed, and collective market participation. Weeding frequency is below average. The capacity to evaluate innovative practices (because of their education) beneficial to bean farming and ability to purchase productive inputs (due to access to credit) could explain high usage rates of innovative practices in this group.

Cluster 3 (rich male landowners with low education and large farm sizes) constitutes 8.73 per cent of the sample and has low education (least number of years in education, no access to bean training and demonstration activities), high male landowners and large

farm sizes as the main distinguishing characteristics. In addition, the group relies mainly on the national radio as the main source of information. In terms of innovative practices, the group has the highest rates in use of improved certified bean seed. Moreover, the group has above average rates in weeding frequency and use of top dressing fertilisers. However, collective market participation and use of basal fertilisers is below average in this group. Not even a single farmer uses inoculants. Large farm sizes and wealth can partly explain the high adoption rates of improved bean seed and use of top dressing fertilisers. Though income from beans is not statistically significant to distinguish groups, the group receives the least returns from bean farming. The results could be bringing out the fact that wealth and access to land resources alone cannot be sufficient to prosper in bean production. Important factors such as education are also necessary as they can assist in making the best use of available resources and technologies. Low returns from the bean market could be attributed to high transactions costs incurred as the group prefer to market the product individually and not as a group. Improving access to training and bean demonstration activities can improve prospects of changing the status quo in this group.

Cluster 4 (young, inexperienced, poor male farmers) is characterised by low number of literate household members, the lowest average age, lowest average female representation, lowest average number of farm workers, no access to bean training and demonstration activities, least years of farming experience, no access to extension and credit. In addition, the group has low rates of access to information and is the poorest group. The group constitutes approximately 6.33 per cent of the total sample. In terms of innovative practices; the group does not use improved bean seed and inoculants. The group however, has high fertiliser utilisation rates and weed the bean crop more frequently when compared to other groups. The group does not practice collective market participation. Thus, the low literacy representation, lack of access to extension, training on beans and bean demonstration activities could be behind the zero adoption rates of improved seed and use of inoculants. Lack of credit access and low experience might be plausible explanations to the observed low adoption rates. The youth in the region (Chinyanja region) are often said to lack interest in agriculture (CGIAR Research Program on Water LaEW, 2014) and prefer off-farm activities such as vending at nearby border posts, e.g. Calomue. The results are also in agreement with those of Grazhdani (2013) who observed that young inexperienced farmers are usually risk averse and more liable to adopt a few technology options.

Cluster 5 (experienced female farmers with high labour endowments) includes 8.43 per cent of farm households and is characterised by high female representation, highest mean years of experience and age, highest mean number of available farm workers. In addition, the group has 100 per cent information access but no access to agricultural extension services. The group has below average rates in use of improved bean seed, does not use certified seed and inoculants. Rate of fertiliser use in bean production is relatively high and so is the rate of collective market participation. Improving access to agriculture extension services may improve the adoption of improved bean seed in this cluster. Considering the high utilisation of fertilisers, the adoption of improved bean seed varieties might improve productivity and the consequent benefits from bean farming. This is possible given that the group appears to believe in organising themselves as a collective unit when selling bean output which reduces marketing costs.

## 6. Conclusions and policy implications

We rely on a multivariate analysis approach that combines PCA, and CA to identify five distinctive farm households within Angonia district of Mozambique with respect to the adoption of proven innovative practices (technologies and methods) in smallholder bean

farming, using socio-economic factors. We analysed data on 30 variables from 322 smallholder bean farmers. PCA identified ten factors that accounted for nearly 63.45 per cent of the variance in the original 30 variables. The identified ten factors were used in CA to characterise smallholder bean farming households. Using the ward technique and an expert knowledge of the study area, CA led to the creation of five farm types. The first farm type is characterised by female landowners with small farm sizes who have low rates of adoption of improved bean seed, inoculant use, topdressing fertilisers and certified seed use. The second type represents educated farmers with access to credit. The group has the highest rates in adoption of inoculants, basal and top-dressing fertilisers, use of improved and certified bean seed and participates in the bean market as a collective unit. The third type represents rich male landowners with large farm sizes but low education levels. This group has high rates in adoption of improved and certified seed, high average weeding frequency and use of topdressing fertilisers. However, collective market participation, use of inoculants and basal fertilisers is poor in this group. The fourth type represents the young and inexperienced poor male farmers who do not use improved bean seed, inoculants in production or collective market participation. The group only has relatively higher rates in use of fertilisers and weeding frequency. The fifth type is characterised by experienced female farmers with high labour endowment who have low rates of adoption of improved bean seed and do not use inoculants. Moreover, the group has an above average rate of fertiliser use and high average rate in practising collective market participation.

Our study has highlighted the salient heterogeneities of smallholder farming households with regards to the adoption and usage of innovative practices in bean farming (both in production and marketing). Some households are more constrained to adopt practices as compared to others because of their inherent socioeconomic characteristics. The findings here call for segregated approaches in promoting the adoption and use of the various innovative practices in smallholder bean farming areas of Angonia. No single uniform approach will equally improve the adoption of proven innovative practices in bean farming in Mozambique given the heterogeneity in population.

Policies and efforts to improve the adoption of proven and released technologies in beans should be more focussed on specific groups such as the identified farm typologies explicitly defined in this study. It therefore implies that anticipations of improving productivity in beans to raise rural household incomes, reduce poverty and enhance food and nutrition security of resource poor farmers, especially women through dissemination of proven technologies will greatly improve if strategies are aligned to the different farm household types we have identified. More so, deliberate targeting of the typical farm households defined in this study with strategies tailored to suit their unique characteristics can possibly reduce socioeconomic status-related inequalities in bean farming. Extension, researchers, and development practitioners can therefore develop or modify their existing frameworks for improving uptake of innovative practices in bean farming for them to address possible drawbacks that can result from assuming homogeneity amongst smallholder farming households in Mozambique.

In conclusion, defining farm household types in Angonia is an important step towards improving the adoption of innovative practices in bean farming. Multivariate statistical techniques such as PCA and CA are essential tools suitable for identifying important socio-economic characteristics of households that underlie the adoption of proven technologies despite their statistical limitations as noted in the previous literature (Vyas and Kumaranayake, 2006). Typologies identified should help facilitate the scaling up of released innovative practices in bean farming in Angonia.

### **Acknowledgement**

The authors would like to acknowledge the financial assistance received from USAID Mozambique that was used in carrying out this study. We are grateful to the International

Center for Tropical Agriculture that commissioned and supported this study. The authors extends special gratitude to the staff of Institute of Agricultural Research of Mozambique (IIAM), District Service for Economic Activities (SDAE) and the Beira Agricultural Growth Corridor that offered immense support during the study period.

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