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# Typological characterisation of farms in a smallholder food-cash crop production system in Zimbabwe – opportunities for livelihood sustainability

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**Abstract**

The diversity of smallholder farms in space, resource endowment, production and consumption decisions are often a hindrance to the design, targeting, implementation and scaling out of agricultural development projects. Understanding farm heterogeneity is crucial in targeting interventions that can potentially contribute to improved crop productivity, food security and livelihood sustainability. The study sought to define and understand farm typology in a resettlement smallholder food-cash crop production area in Zimbabwe. Data was collected from five focus group discussions (FGDs), and 102 household interviews. Principal component analysis (PCA), multiple correspondence analysis (MCA) and cluster analysis were used to analyse quantitative and qualitative data variables and aggregate farms into clusters according to production means, socio-economics and demographics. The three identified farm types were (i) resource-endowed, commercial oriented farms, (ii) medium resourced and (iii) resource constrained farms practising subsistence and income oriented production. Labour was cited as a major challenge, with high labour cost relevant for type I farms, while household size has more bearing for type II and III farms. Ownership of tillage implements and operations varied from mechanised on resource endowed farms, to animal drawn on some medium and resource constrained farms. The farms exhibited variable livelihood strategies and all clusters exhibited market participation, albeit to varying extents. Thus strengthening of market links is imperative. Use of multivariate methods allowed for identification of the most discriminating variables for farm delineation and subsequent clustering of farms forms the basis for further exploring variability across farm types for the targeting of management interventions for livelihood sustainability.

*Keywords:* diversity, livelihood, maize-tobacco, multivariate analysis, sustainability, targeted interventions, typology

## 1 Introduction

Smallholder agriculture is a critical component of Africa's agricultural sector responsible for the bulk of food production and income for the developing countries (Muchero, 2008; Wiggins, 2009). Common constraints to productivity in smallholder agriculture include biophysical and socio-economic challenges such as poor soil fertility, rainfall variability and unreliability, and limited access to capital, labour and markets (Ncube *et al.*, 2009; Salami *et al.*, 2010). Although, most challenges faced by smallholder farms are common across spatial and temporal divides, the interaction of biophysical and socio-economic factors results in the heterogeneity of farm types or typologies within and across landscapes. In most regions of sub-Saharan Africa (SSA), soil types and fertility management have culminated in soil heterogeneity within and across farms (Masvaya *et al.*, 2010; Tittonell *et al.*, 2005), while resource endowment, land holdings, production orientation and objectives further compound the stratification of farms into com-

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plex, dynamic and diverse farm typologies (Kuivanen *et al.*, 2016; Mtambanengwe & Mapfumo, 2005; Tittonell *et al.*, 2010). Envisaged impacts of technologies are often not realised in most smallholder farming systems in the developing countries, because they repeatedly fail to match the complexity and diversity of the farming systems (Emtage & Suh, 2005).

An understanding of the diversity across the farms within farming systems is paramount to improved precision in the design of technological interventions (Hilhorst & Muchena, 2000; Tittonell *et al.*, 2010), which could improve applicability, relevance and adoptability of agronomic and technological interventions and recommendations. The concept of farm typologies identifies groups of farms on the basis of similar sets of attributes ranging from social, ownership, operational, production to structural characteristics (Kostrowicki, 1977). Participatory approaches have been used to this end (Mtambanengwe & Mapfumo, 2005; Ncube *et al.*, 2009; Zingore *et al.*, 2007). While the obvious strength of participatory approaches is the involvement of community members in the delineation, individual farm characteristics are likely traded in for general and more encompassing community classification. However, decision making and production orientation of farms is a household decision, hence there is need to aggregate farms according to household characteristics not general community characteristics. Increasingly, multivariate statistical techniques such as principal component analysis (PCA), multiple correspondence analysis (MCA) and cluster analysis have been used in farm typology studies within various farming systems (Bellini & Ramberti, 2009; Kuivanen *et al.*, 2016; Rusinamhodzi *et al.*, 2012; Tittonell *et al.*, 2010). Multivariate analysis techniques applied to household data, systematically reduce data dimensions, farm heterogeneity and give results, that are reproducible in space and time (Kostrowicki, 1977). PCA is more commonly applied to quantitative data, while MCA is adaptated to analyse categorical variables (Jolliffe, 2002; Ozden & Mendes, 2005; Savary *et al.*, 1995). Therefore, specific data types can be analysed by specific methods thus presenting a challenge when mixed data is available. Consequently, complementary application of PCA and MCA to mixed data is an attractive option whose effectiveness has been demonstrated in several studies (Ballesteros *et al.*, 2015; Mekkawy *et al.*, 2017; Smith *et al.*, 2002).

The Svosve smallholder farming area, in Zimbabwe, is predominantly a food and cash crop production area. Farms can be generally categorised as smallholder, displaying certain features such as reliance on farm production for livelihoods, limited access to capital inputs as well as dependence on household labour for farm production (Chamberlain, 2007; Ellis, 1988). Maize is grown to meet the household's subsistence, while tobacco is grown as the main cash crop, contributing significantly to smallholder farmers' income (Masvongo, 2013; Shumba & Whingwiri, 2006). Livestock is kept as a source of draft power, organic manures as well as a protein source (Mugwira & Murwira, 1997; Ouma *et al.*, 2003). Although, tobacco production by smallholder farmers is not new, increased participation by smallholder farmers in Africa's leading tobacco producing countries, Malawi, Tanzania and Zimbabwe has been reported (Masvongo, 2013; Prowse, 2013), hence making this farming system a key area of interest upon which smallholders' food and income security are hinged.

Several studies have classified smallholder farms into typologies that seek to aid targeting of interventions (Kuivanen *et al.*, 2016; Tittonell *et al.*, 2010), but maize-tobacco production systems have been largely ignored. This study, thus aims to define and understand the farm types under such systems. The objective of this study was to establish farm typologies in Svosve smallholder farming system and identify farm type-specific constraints and opportunities for the targeting of agricultural interventions and recommendations for improved food security and livelihoods.

## 2 Materials and methods

### *2.1 Site description*

The study was conducted in Svosve area, in Mashonaland East province of Zimbabwe (18° 21′ 56″ S and 31° 42′ 19″ E). The area is in the agroecological region (AER) IIb receiving an average of 750 mm of rainfall annually between October and April, and has been described as having a "favourable climate for growing crops" (Chimhowu & Woodhouse, 2008). However, seasonal and spatial variations in rainfall distribution are common. Granite-derived sandy soils (Lixisol; FAO, 1998), which are inherently infertile and highly leached, are dominant in the study area.

Smallholder farming is the typical production system mainly characterised by mixed crop-livestock production. Maize (*Zea mays* L.) is grown as the staple crop, while secondary crops include millet (*Pennisetum glaucum* L.), groundnuts (*Arachis hypogaea* L.), bambara nuts (*Vigna subterranea* L.), sweet potato (*Ipomoea batatas* L.) and sugar beans (*Phaseolus vulgaris* L.). Tobacco (*Nicotiana tabacum* L.) is grown as a summer crop in 1 or 2 year rotations with maize across plots within the farm. Horticultural crop production also contributes to both household consumption and income generation. Most horticultural production is conducted on the wetlands (gardens) during the winter season. Livestock consists of cattle, goats, donkeys as well as free ranging chickens. Cattle provide the main source of draught power and organic manure.

The characteristic settlement models consist of the colonial reserves (communal) of the 1900s, the early resettlement farms initiated in the early 1980s until 1997 and resettlement farms instituted under the fast track land reform program (FTLRP) of the 2000s (Moyo, 2006). Most of the farms are made up of individual family homesteads in nucleated villages, individual arable plots with communal grazing, woodlots and water points (Utete, 2003). A few of the farms are self-contained, where the residential, arable and grazing land were allocated in one consolidated farm unit (ibid.). Landholdings in colonial reserves can be as low as 0.5 ha, while in the early resettlement farmland holdings are of variable sizes. Under the FTLRP, the villagised farms (with homesteads concentrated in villages) range from 1 to 20 ha (Matodi, 2012). The self-contained farm types under the FTLRP, range from small, medium to large scale commercial farming with variable farm sizes.

Therefore, for purposes of this study, the villagised farm variants, from the early resettlements and the FTLRP were sampled. Most villages are made up of between 20 to 25 households under the leadership of one administrative headman (*sabhuku*) (Chimhowu & Woodhouse, 2008).

## *2.2 Data collection*

### *2.2.1 Household survey*

A structured questionnaire was administered to a total of 102 farmers in March 2016. Initially, five randomly selected villages were targeted for sampling, but due to inconsistencies of production across seasons, households from villages next to the randomly selected villages were interviewed, so as to reach the sample size. As a result, the interviews extended over a total of eight villages, and interviews per village ranged from 6 to 15. Inconsistency in tobacco production is mostly due to frustrations from low market prices in some seasons. Purposeful random sampling was used in farmer selection, and the criterion for selection was involvement in tobacco production counting back three seasons. Purposeful sampling is useful in the identification of information-rich cases so as to obtain the most knowledge about the phenomenon of interest, while granting the most effective use of limited resources (Cresswell & Clark, 2011; Patton, 2002). Random sampling within the purposefully selected population was used to identify variability within the population of interest (Palinkas *et al.*, 2015). The objective of the study was to understand the diversity of farms that are not only involved in staple crop production, but also engaged in major cash crop production. The extension officers were crucial in the identification of the farmers. Without judicious record keeping, the risk of wrong information being supplied increases, therefore to improve accuracy of data collected, data from the most recent three seasons, 2012/13, 2013/14 and 2014/15 was collected. The household questionnaire covered aspects on land holding, crops grown, inorganic and organic fertiliser use, agronomic practices, sources of labour, crop residue handling practices, production constraints and crop output. In addition, demographic details and assets ownership data were collected.

### *2.2.2 Focus groups discussions*

Focus group discussions (FGDs) were conducted in five out of eight villages sampled for the household survey. The FGDs were carried out after completion of household interviews so as to minimise public influence and bias in household data collection. The FGDs were facilitated with the assistance of the extension officers. Attendance was open to all farmers, with each FGD having an average attendance of 30 people consisting of both men and women. Farmers were asked to list the crops grown in the village as well as livestock kept and rank them according to importance to the village, with number 1 being the most important. Socio-economic and bio-physical factors limiting the productivity of farms were identified and prioritised.

## *2.3 Statistical analysis*

Qualitative and quantitative data collected from the household survey and FGDs were processed and analysed using the Statistical Package for Social Sciences (SPSS) version 21 programme, to generate general descriptive trends and frequencies. Variables selected for farm typology characterisation were classified into the following categories; socio-demographic, land holding and use, labour, livestock ownership, access to production inputs, specific capital goods, general capital goods, shelter, transport, information and communication means as used in other similar studies (Chavez *et al.*, 2010; Kuivanen *et al.*, 2016; Tittonell *et al.*, 2010). Quantitative and qualitative variables were subjected to PCA and MCA for dimension reduction. Data exploration included obtaining means, ranges and quartiles for quantitative data and frequencies for qualitative data. To avoid distortions in statistical analysis, outlier detection using boxplots was employed (Hair *et al.*, 2010; Kuivanen *et al.*, 2016).

### *2.3.1 Principal component analysis (PCA)*

PCA was used in the selection and grouping of quantitative variables that influence farm productivity into uncorrelated groups called principal components (PCs). Standardisation of the variables was performed to deal with the complexity of analysing data measured on different measurement scales (Mooi & Sarstedt, 2011). Consequently, *z* scores for the data were used to run the PCA. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett test of sphericity were first conducted to test if the data set was adequate for PCA. A KMO value of $> 0.5$ indicated adequacy of data to be analysed using PCA (SPSS, 2012). Principal components were generated based on a correlation matrix and rotated using the varimax rotation to eliminate multi-collinearity among the PCs. The variance of each PC defined as an eigenvalue is used as the basis for significant PC selection (Lattin *et al.*, 2003; Swan & Sandilands, 1995). Principal components with eigenvalues $> 1$ were selected as significantly influencing variability in farm types and were selected for further analysis. Within each PC, a variable with factor loading $> 0.5$ was retained, while those with lower loading factors were discarded. Furthermore, correlated variables within a PC were represented by the variable with the highest loading coefficient (Jagadamma *et al.*, 2008).

#### 2.3.2 *Multiple correspondence analysis (MCA)*

MCA was used to reduce data dimensions through exploration of relationships among the categorical variables. This analysis uses cross tabulations and gives graphical presentation of the relationships in a low dimensional plane. Correspondence analysis is based on the computation of a data matrix of frequencies (Savary *et al.*, 1995). Two dimensions of data presentation are commonly considered as adequately facilitating data visualisation and interpretation (Gifi, 1996; Savary *et al.*, 1995). Similar, to PCA, eigenvalues are used to determine the significance of a dimension in accounting for variability. The sum of eigenvalues is called inertia and represents the chi-square statistic divided by the total number of observations (Greenacre, 1984). An inertia value $> 0.2$ and a Cronbach's alpha score, were used as basis for dimension selection and retention (Hair *et al.*, 1998; Johnson & Wichern, 2007).

Discrimination measures plots and joint plots of category points were used to identify category relationships (Costa *et al.*, 2013). Further, correlations transformed variables were explored so as to identify significant ($r < 0.3$) correlations among MCA selected variables with meaningful practical significance (ibid.).

#### 2.3.3 *Cluster analysis*

Cluster analysis was used to identify homogenous groups of farms based on the PCA and MCA selected variables. The selected variables were subjected to a 2-step cluster analysis. The 2-step clustering procedure combines the principles of hierarchical and non-hierarchical (*K* means) methods (Mooi & Sarstedt, 2011). Hierarchical cluster analysis uses an agglomerative clustering algorithm which utilises multi-dimensional distances between entries as the basis for separation and selection of number of clusters. In *K* means clustering, cluster solutions are optimised until maximum homogeneity within clusters is achieved through reassigning of cases to clusters (Hair *et al.*, 2010). Two-step cluster analysis has the advantage of allowing grouping of cases using a mixture of continuous and categorical variables in a single pass.

## 3 Results

### 3.1 *General village characterisation*

Focus group discussions were used to gain insight into general production trends, constraints and opportunities in the area. The main crops cultivated and listed according to importance included maize, which is cultivated to ensure household food security and occasionally for income, tobacco is the main cash crop, vegetables are cultivated as both household food source and income generation, groundnuts and sweet potatoes are cultivated as secondary crops to lesser extents. Production constraints included limited access to fertiliser inputs due to high prices and transport costs, availability of land preparation implements, variable and unreliable rainfall, labour and poor market prices for produce. Limited access to extension services due to high extension officer: farmer ratio was also cited as a limiting factor. However, farmers said they had access to important information through radio and television media, while some also utilised their cell phones for farming information gathering.

Sources of fertilisers for maize and tobacco production included personal, contracts with private companies and government hand-outs to a lesser extent. Furthermore, use of organic nutrient sources such as cattle manure, composts and leaf litter was constrained by small livestock numbers, bulkiness, lack of transport, diseases associated with use of animal manures as well as lack of information on composting techniques. Cattle manure was the most commonly used organic nutrient resource.

### 3.2 *Household data exploration*

Out of the 102 households interviewed, three households were cropping on borrowed land, hence only 99 households who owned land were considered for further analysis. From the data exploration, large variability was obtained on land holdings, which had a large standard deviation. Further exploration of land holding data using box plots indicated positive skeweness, due to outliers in the 90th percentile, from land holdings greater than 40 ha. The outliers were discarded so as to improve the multivariate analysis and its

**Table 1:** *Quantitative variables used in principal component analysis ($n = 95$).*

| *Variable* | *Minimum* | *Maximum* | *Mean* | *Standard Deviation* |
|---|---|---|---|---|
| Total area of land owned (ha) | 1 | 40 | 12.27 | 10.763 |
| Maize area (ha) cultivated across 3 seasons | 0.00 | 7.00 | 1.32 | 1.105 |
| Tobacco area cultivated (ha) across 3 seasons | 0.00 | 12.00 | 1.71 | 1.964 |
| Number of oxcarts owned | 0.00 | 3.00 | 0.79 | 0.634 |
| Number of tractors owned | 0.00 | 3.00 | 0.15 | 0.525 |
| Number of ploughs owned | 0.00 | 3.00 | 1.03 | 0.721 |
| Number of cattle owned | 0.00 | 60.00 | 5.65 | 8.352 |
| Number of goats owned | 0.00 | 12.00 | 2.44 | 3.228 |

generalisation to the population. Ninety five farms were thus retained for statistical analysis. Data descriptives and frequencies for the retained farms are given in Table 1 and 2.

### 3.3 Quantitative variables selection

A KMO value of 0.8 and a significant ($P = 0.000$) Bartlett's test of sphericity indicated that the variables were related, therefore could be analysed using PCA. Out of the 12 PCs generated, 3 PCs with eigenvalues > 1 which accounted for 72.2 % variability were selected (Fig. 1). The first PC, explained 46.3 % variability in the data set, while the 2nd and 3rd PC explained 16.9 % and 9 % respectively.

The PCs were characterised according to the loading factors within each PC. The variables with significant (> 0.5) factor loading in PC 1 were area planted to maize and tobacco in all 3 seasons under consideration and cattle ownership. Area planted to tobacco during the third season, 2014/15 was the highest loading variable within this PC. The significantly (> 0.5) loading variable in PC 2 was small livestock ownership (goats), while total land holding significantly loaded into PC 3 (Table 3).

### 3.4 Qualitative variables selection

A two dimensional depiction of the data was achieved through MCA. The two dimensions represented, respectively, Cronbach's alpha 0.74 and 0.63, eigenvalues 3.1 and 2.4 and inertia 0.24 and 0.19. Cumulatively, the two dimensions accounted for 42.5 % variability. Education level of the household head was the clearly discriminating variable in dimension 1, with a discriminating value > 0.5. In addition, age of household head, television and car ownership also contributed to dimension 1. This dimension was a mixture of social, economic and demographic variables. The second dimension was termed the labour dimension, with the significantly discriminating variables being source of labour for maize and tobacco production (Fig. 2). Percentage of land under utilisation had similar and significant loading on both dimensions, but was considered on dimension 2 due to the slightly higher discriminating measure on this

**Table 2:** *Percentages of categorical variables used in multiple correspondence analysis.*

| *Variable* | *Classes* | % ($n = 95$) |
|---|---|---|
| Sex of household head | Male | 82.1 |
| | Female | 17.9 |
| Age of household head (years) | 20–29 | 3.2 |
| | 30–39 | 30.5 |
| | 40–49 | 24.2 |
| | 50–59 | 24.2 |
| | 60+ | 17.9 |
| Highest level of education attained by household head | None | 1.1 |
| | Primary school | 25.3 |
| | Junior secondary school | 16.8 |
| | Senior secondary school | 42.1 |
| | Post senior secondary training | 14.7 |
| Proportion of land being cultivated (%) | 0–10 | 13.7 |
| | 11–30 | 35.8 |
| | 31–50 | 29.5 |
| | 51–80 | 12.6 |
| | 81–100 | 8.4 |
| Source of labour for maize production | Household males | 15.8 |
| | Household females | 10.5 |
| | All household members | 57.9 |
| | Hired | 11.6 |
| | N/A | 4.2 |
| Source of labour for tobacco production | Household males | 10.5 |
| | Household females | 9.5 |
| | All household members | 52.6 |
| | Hired | 17.9 |
| | N/A | 9.5 |
| Access to mineral fertiliser | No | 7.4 |
| | Yes | 92.6 |
| Access to cattle manure | No | 18.9 |
| | Yes | 81.1 |
| Main house roof type | Asbestos | 94.7 |
| | Thatch | 5.3 |
| Main transport mode | Private car | 32.6 |
| | Motorbike | 3.2 |
| | Public transport | 64.2 |
| Ownership of information and communication gadgets | Radio | 74.7 |
| | Television | 53.7 |
| | Cell phone | 95.8 |

dimension. Sex of household head, access to mineral fertilisers and cattle manure, cell phone and radio ownership, housing type were weakly correlated to the two dimensions with discriminating measures < 0.3, therefore they were of no practical significance and were discarded.

**Table 3:** *Loading variables in the selected principal components.*

| | *Principal Component* | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Total area of land owned | 0.148 | 0.012 | 0.910 |
| Maize area cultivated 2014/15 | 0.864 | 0.158 | 0.094 |
| Tobacco area cultivated 2014/15 | 0.905 | −0.161 | 0.068 |
| Maize area cultivated 2013/14 | 0.711 | 0.353 | 0.265 |
| Tobacco area cultivated 2013/14 | 0.890 | −0.120 | 0.128 |
| Maize area cultivated 2012/13 | 0.719 | 0.280 | 0.365 |
| Tobacco area cultivated 2012/13 | 0.861 | −0.120 | 0.155 |
| Total number of cattle | 0.620 | 0.456 | −0.219 |
| Total number of goats | −0.073 | 0.658 | −0.125 |

Extraction method: Principal Component Analysis.
Rotation method: Varimax with Kaiser normalisation. Rotation converged in 4 iterations.

### 3.5 *Cluster profiles*

The silhouette measure of cohesion and separation of clusters was scored as fair. Three farm type clusters were generated from the 2-step cluster analysis of PCA and MCA derived variables.

#### 3.5.1 *Type I: Resource-endowed farms with a commercial oriented farming system.*

This cluster is the smallest cluster, representing only 6 % of the surveyed farms. The cluster was classified as the resource-endowed commercial oriented farm types. Land holding on these farms is the largest, with an average of 18 ha, of which a significant proportion is utilised for crop production (Table 4). The farms produce maize and tobacco on the largest plots, relative to other clusters. Maize is produced on average on 4 ha, while tobacco is allocated twice this area. Both crops are produced using hired labour (Table 4). A high level of mechanisation is exhibited by possession of high capital assets that include a tractor. In addition, the farms own a car. The highest number of cattle ownership is also found within this cluster. Household heads within typeI farms are aged between 40–59 years and possess college level training.

#### 3.5.2 *Type II: Medium resourced farms practising mixed subsistence and cash crop production.*

Type II farms were classified as the medium resourced farms and represented the largest group (73 %) of the total

**Table 4:** *Cluster characteristics derived from 2-step clustering.*

| *Variable* | *Cluster* 1 (% $n = 73.7$) *Type II* | 2 (% $n = 6.3$) *Type I* | 3 (% $n = 20.0$) *Type III* |
|---|---|---|---|
| Total land holding (ha) | 13.5 | 18.0 | 6.5 |
| Mean maize area (ha) | 1.3 | 4.0 | 0.3 |
| Mean tobacco area (ha) | 1.5 | 8.9 | 0.6 |
| Total number of cattle | 6.0 | 29.0 | 1.0 |
| Total number of goats | 3.0 | 0.0 | 0.0 |
| *Categorical variables* | % of N | | |
| Age of household head | | | |
| 20–29 | 1.4 | 0.0 | 10.0 |
| 30–39 | 22.2 | 0.0 | 65.0 |
| 40–49 | 25.0 | 50.0 | 15.0 |
| 50–59 | 27.8 | 50.0 | 5.0 |
| 60+ | 23.6 | 0.0 | 0.0 |
| Highest education level reached by household head | | | |
| None | 2.8 | 0.0 | 0.0 |
| Primary school | 31.9 | 0.0 | 10.0 |
| Junior secondary school | 16.7 | 0.0 | 15.0 |
| Senior secondary school | 34.7 | 0.0 | 75.0 |
| College training | 13.9 | 100.0 | 0.0 |
| Proportion of land being cultivated (%) | | | |
| 0–10 | 12.5 | 0.0 | 21.1 |
| 11–30 | 36.0 | 0.0 | 42.1 |
| 31–50 | 32.0 | 15.0 | 21.1 |
| 51–80 | 16.7 | 20.0 | 0.0 |
| 81–100 | 2.7 | 65.0 | 15.7 |
| Source of labour for maize production | | | |
| Household males | 19.5 | 0.0 | 5.0 |
| Household females | 12.5 | 0.0 | 5.0 |
| All household members | 58.3 | 25.0 | 55.0 |
| Hired | 9.7 | 75.0 | 10.0 |
| N/A | 0.0 | 0.0 | 25.0 |
| Source of labour for tobacco production | | | |
| Household males | 13.9 | 0.0 | 0.0 |
| Household females | 11.1 | 0.0 | 5.0 |
| All household members | 51.4 | 25.0 | 65.0 |
| Hired | 16.6 | 75.0 | 10.0 |
| N/A | 6.9 | 0.0 | 15.0 |
| Plough ownership | | | |
| Yes | 99.0 | 100.0 | 25.0 |
| No | 1.0 | 0.0 | 75.0 |
| Tractor ownership | | | |
| Yes | 6.9 | 100.0 | 0.0 |
| No | 93.1 | 0.0 | 100.0 |
| Car ownership | | | |
| Yes | 36.1 | 100.0 | 0.0 |
| No | 63.9 | 0.0 | 100.0 |
| Television ownership | | | |
| Yes | 58.3 | 100.0 | 25.0 |
| No | 41.7 | 0.0 | 100.0 |

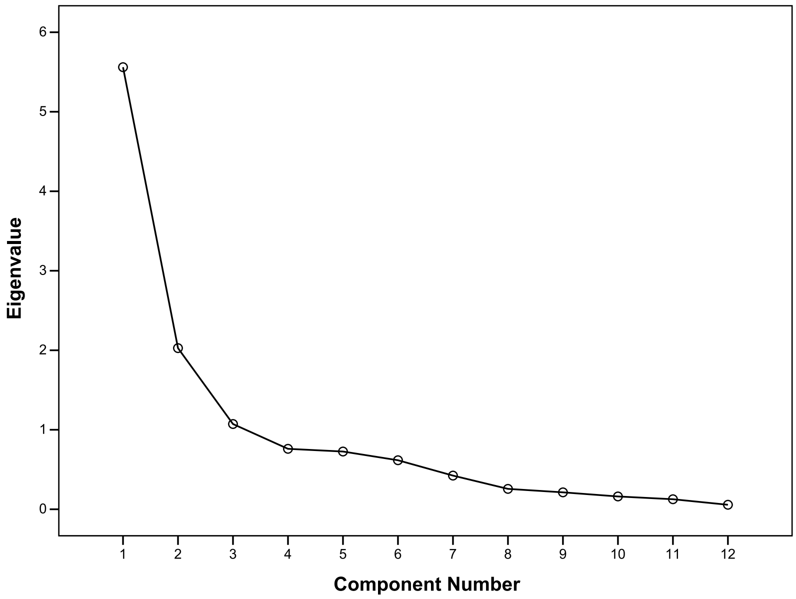


**Fig. 1:** *Scree plot showing eigenvalues of principal components.*

number of surveyed farms. Mean land holding is 13.5 ha, which is intermediate between the resource endowed and resource constrained farms. A significant number of farms (68 %) cropped between 11 to 50 % of total land holding against 81–100 % cropped under type I farms (Table 4). Approximately equal land area (ca. 1 ha) is allocated to maize and tobacco production. Labour is mainly provided by household members for both maize and tobacco production, which is sometimes complemented with hired labour. Tobacco was not produced on 6.9 % of the farms during 2014/15 season. Average number of cattle owned is 6 and 99 % own a plough. About 7 % own a tractor, 36 % own a car and more than half own a television set. This cluster is characterised by almost equal numbers of household heads per age group, except the 20–29 age group which was significantly lower (Table 4).

### 3.5.3 *Type III: Resource constrained farms practising mixed subsistence and cash crop production.*

This forms the second largest group and is classified as the resource constrained cluster. This cluster represents 20 % of the surveyed farms. The farms are typically the smallest with a mean size of 6.5 ha. Both maize and tobacco are planted on relatively smaller plots, 0.3 and 0.6 ha respectively. Eighty percent of the farms within this cluster cultivate on less than 50 % of land owned (Table 4). Although, maize and tobacco production are typical, during 2014/15 season, 25 % and 15 % of the farms did not produce maize and tobacco, respectively. Family labour is the main source for crop production. Only 5 % own a plough, while average cattle ownership is 1. No high capital assets

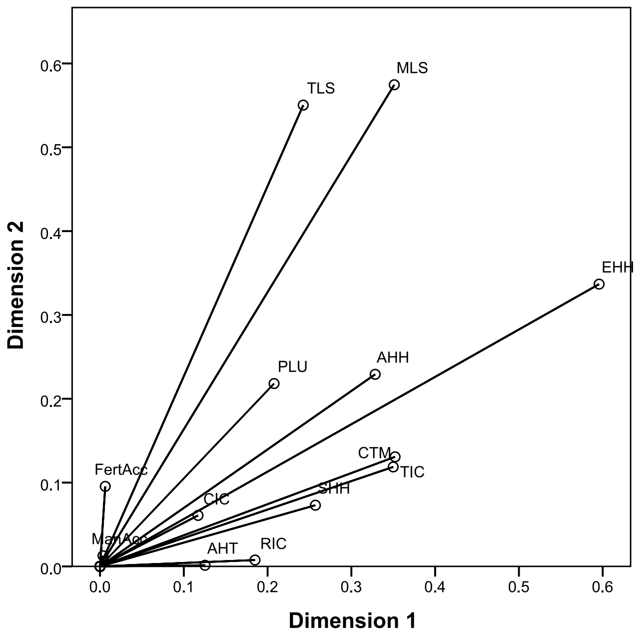


**Fig. 2:** *Discriminating measures plot of categorical data variables.*
*FertAcc, access to fertiliser; ManAcc, access to manure; AHT, main housing type; CIC, Cell phone ownership; RIC, radio ownership; CTM, car ownership; SHH, sex of household head, TIC, television ownership; EHH, household head education level; PLU, percentage of land cultivated; TLS, tobacco labour source and MLS, maize labour source.*

are owned by this group. The household heads on these are farms are mostly aged between 30–39, and attained senior secondary education (Table 4).

## 4 Discussion

Findings from FGDs indicated that Svosve smallholder area consists predominantly of a food-cash crop smallholder farming community. Farmers attested to higher market participation as opposed to typical smallholder subsistence farming. This was attributed to the production of tobacco as a cash crop. However, constraints including limited access to fertiliser inputs due to high prices and transport costs, land preparation implements, variable and unreliable rainfall, labour shortage and poor market prices for produce were cited. These constraints are not unique to the Svosve area and have been cited across SSA (Chamberlain, 2007; Ncube *et al.*, 2009; Salami *et al.*, 2010). Limited access to extension services due to a low ratio of extension officer to farms was also cited as a limiting factor. However, alternative sources of information including radio, television and cell phones are being utilised by farmers to access to important information thus indicating a shift towards advanced information and communication technology (ICT) based information systems in the area. This is corroborated by findings from Masuka *et al.* (2016).

Although farmers collectively cited general challenges in production, it is important to note that the extent to which groups of diverse farms are impacted by the challenges are variable. Therefore, an understanding of farm diversity will allow for identification of specific constraints and impacts across heterogeneous farms. This is important in the tailoring and targeting of interventions for agricultural development. This approach has been adopted by several studies (Kraaijvanger *et al.*, 2016; Mądry *et al.*, 2016; Tittonell *et al.*, 2010). Consequently, household interviews and multivariate analysis methods were used to group farms according to shared salient features that impact farm production orientation so as to facilitate matching of constraints and opportunities accordingly, for maximum impact. The identification of farm types in this study forms a basis for subsequent discussion on constraints and opportunities for agricultural development in the farming system.

The resource endowed type I farms exhibited a high level of commercialisation distinguished from the other farming households by the large areas on which both maize and tobacco are planted. The proportion of land utilisation within this group was higher than for the two other farm types. This was facilitated by the ownership of high mechanisation implements, such as tractors which are utilised for tillage operations thus ensuring optimal utilisation of land. Within this group, the large maize areas are indicative of the commercial orientation of the farms, as the production exceeds average for household consumption. Although, tobacco has higher tillage and labour demand than maize, it is allocated twice the area for maize possibly because it is commercially more profitable. Timeliness of operations, given the large scale of production is, thus ensured through use of hired labour. Large cattle numbers point to diversification of enterprises, which is a key indicator of well-resourced farms where livestock act as a buffer to shocks, thus decreasing household vulnerability (Kuivanen *et al.*, 2016). Therefore, in terms of constraints, with hired labour being the main source of labour, these farms may be vulnerable to seasonal changes in labour availability and costs which could impact their productivity. On the other hand, mechanisation, draft power and tillage related challenges have little impact on this group. However, intensive crop production and use of highly mechanised systems may exacerbate soil fragility through soil organic matter loss and increase bulk densities due to soil compaction (Chavez *et al.*, 2010); hence adoption of practices such as crop residue retention and reduced tillage practices that result in soil organic matter build-up is imperative. This cluster is characterised by household heads that have attained college training, therefore are generally regarded as educated.

The medium resourced, type II farms, practice food security and income generation oriented production as signified by maize and tobacco production. However, these farms exhibit a low level of mechanisation, relative to the type I farms, mostly relying on manual power for farm operations, as evidenced by 99 % plough ownership and on average 6 head of cattle. Land utilisation is less than that of type I farms, despite these farms being smaller in size. This is indicative of constrained production. Although the farms have access to basic tillage assets, a cattle herd of 6 and a plough are likely inadequate to meet the tillage operation needs of the farms. This challenge was echoed during the FGDs as a major limitation to production. This on the other hand, may present opportunities for soil fertility regeneration through fallowing. There is need for investment towards more mechanised systems, if land is to be fully utilised. In addition, reliance on family labour for production of both maize and tobacco is a major constraint, because its availability is dependent on household size, the age and fitness of household members. Furthermore, both maize and tobacco are summer crops, hence they compete for resources, thus in the absence of hired labour to complement household labour, production and productivity is reduced. Therefore, in the absence of additional resources, staggering of farm operations may offer some relief. This cluster is the most variable in terms of household demographics, where education level and age of household head are almost evenly spread out across the spectrum. Sustainability of livelihoods in a rural setup is related to biophysical conditions, as such management practices that reduce soil degradation and promote soil regeneration (Dunjana *et al.*, 2012; Kuivanen *et al.*, 2016) which should be tailored to efficiently utilise cluster available resources.

Type III farms were characterised as low resource endowment farms, that exhibit typical salient characteristics of resource constrained farms, including least land holdings as reported in other studies, locally and within the SSA region (Kuivanen *et al.*, 2016; Rusinamhodzi *et al.*, 2012; Zingore *et al.*, 2007). Similarly, the relative landholding of this group is the lowest, while the highest percentage of uncropped land (21 % against 0 % and 12.5 % on type I and II farms, respectively) is exhibited by this group of farms. Similar, observations were made by Mtambanengwe & Mapfumo (2005), where in cases where land is not a limiting factor, but other production factors as farm equipment or labour are, uncropped land is common. Maize is planted for subsistence as indicated by the small plots on which it is produced. Although, tobacco is allocated twice the area, cultivated area is relatively lower than that of the medium resourced and resource endowed farms. This could be attributed to limitations on production resources such as inputs and labour for tillage operations. During the 2014/15 season, maize was not cultivated on 25 % of the farms, while 15 % did not cultivate tobacco. This could have been due to a number of reasons and among them, production related constraints, thus forcing the farms to choose only one main crop over the other. This is indicative of households' divergent production orientations. It is common for resource constrained farms to practice subsistence production, however, in this case some farms are clearly prioritising income oriented production over subsistence. Therefore, with regards to food security, such farms are susceptible to both biophysical and market shocks thus making them extremely vulnerable. In this regard, it is vital to provide these farmers with adequate technical back up via extension, improve linkages with contractors to ensure that productivity is improved and livelihoods are sustained.

Dorward (2009) postulated three main livelihood strategies in rural setups, namely, "hanging in" where farmers engage in activities to maintain current livelihood, "stepping up" indicated by expansion of current production activities leading to semi-commercial farming and "stepping out", when farming activities are used to accumulate assets that allow engagement in non-farm activities. In the study area, type I farms fit the criteria of "stepping out". The farms have accumulated capital assets and continue to prosper in crop production as evidenced by high land utilisation. True to the postulate, these farms have stepped out as evidenced for example, by ownership of passenger vehicles which are used as a form of off-farm income source. Type II farms also closely match the "stepping up" hypothesis as evidenced by consistent 1 ha/year tobacco production, a purely commercial crop. Interventions that seek to address biophysical, economic challenges as well as sustainability in that regard will likely further facilitate "stepping up" for these farms and possibly "stepping out" for others. The "hanging in" farms are described as those that maintain their current livelihood by practising subsistence production. Interestingly, because of the uniqueness of the study area being predominantly tobacco production area, these farms exhibit a propensity for semi-commercial production as well, as indicated by tobacco production on twice the size of plots allocated to maize.

In targeting interventions for improved livelihoods in farming systems, agroecological potential and market opportunities are two dimensions that have been identified as determining opportunities and constraints (IFPRI, 2007). Such is the case within the study area. Due to market availability, all three identified farm types display market participation, albeit to varying extents due to the readily available tobacco market. Consequently, strengthening of market links for inputs and produce within the study area, will likely result in the progression of some farms from one livelihood strategy to the next. Furthermore, within the agroecological potential context, tailored biophysical interventions for sustainable soil use and management will have to be addressed per cluster.

## 5 Conclusion

Three farm types were identified in the study area, namely resource endowed commercial oriented farms, medium resourced and low resource endowed farms practising subsistence and semi-commercial production. The use of multivariate analysis allowed understanding of farm diversity within the study area and highlighted the varying extents to which the FGD cited constraints affected each farm cluster. For example, while labour constraints are common across the three farm types, issues around the cost and seasonal availability are relevant for type I farms as they depend on hired labour for production, while for types II and III farms, labour is provided by household members hence household size will have a greater bearing. Similarly, draft power challenges are variable across the clusters resulting in varying extents of land utilisation, production and soil degradation, which has a bearing on livelihood sustainability. Consequently, in order to improve livelihoods for each cluster, the challenges and opportunities should be made within the context of the cluster and interventions be recommended accordingly.

*Competing interests*

The authors declare that they have no conflict of interest.

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## References

Ballesteros, P. W., Lagos, B. T. C. & Ferney, L. H. (2015). Morphological characterization of elite cacao trees (*Theobroma cacao* L.) in Tumaco, Nariño, Colombia. *Revista Colombiana Ciencias Hortícolas*, 9 (2), 313–328. doi:10.17584/rcch.2015v9i2.4187.

Bellini, G. & Ramberti, S. (2009). Is the Italian organic farming model inside rural development? A farm structure survey data analysis. Wye city group on statistics on rural development and agriculture household income, Second Meeting, Italy, Rome, 11–12 June 2009, FAO Head-Quarters. Available at: http://www.fao.org/fileadmin/templates/ess/pages/rural/wye_city_group/2009/Paper_2_b2_Bellini_Ramberti_Organicfarming_RD.doc (accessed on: 24 January 2018).

Chamberlain, J. (2007). Defining smallholder agriculture in Ghana: Who are smallholders, what do they do and how are they linked with markets? GSSP Background Paper No. 6. Washington, DC.

Chavez, M. D., Berentsen, P. B. M. & Oude-Lansink, A. G. J. M. (2010). Creating a typology of tobacco farms according to determinants of diversification in Valle de Lerma (Salta-Argentina). *Spanish Journal of Agricultural Research*, 8 (2), 460–471.

Chimhowu, A. & Woodhouse, P. (2008). Communal Tenure and Rural Poverty: reflections on land transactions in Svosve Communal Area. BWPI Working Paper No. 35. Manchester, U.

Costa, P. S., Santos, N. C., Cunha, P., Cotter, J. & Sousa, N. (2013). The Use of Multiple Correspondence Analysis to Explore Associations between Categories of Qualitative Variables in Healthy Ageing. *Journal of Aging Research*, #302163. doi:10.1155/2013/302163.

Cresswell, J. W. & Clark, V. L. P. (2011). *Designing and conducting mixed method research*. (2nd ed.). Sage Publishing Inc., Thousand Oaks, CA.

Dorward, A. (2009). Integrating contested aspirations, processes and policy: development as hanging in, stepping up and stepping out. *Development Policy Review*, 27, 131–146.

Dunjana, N., Nyamugafata, P., Shumba, A., Nyamangara, J. & Zingore, S. (2012). Effects of cattle manure on selected soil physical properties of smallholder farms on two soils of Murewa, Zimbabwe. *Soil Use and Management*, 28, 221–228.

Ellis, F. (1988). *Peasant Economics: Farm Households and Agrarian Development*. Cambridge University Press, Cambridge.

Emtage, N. & Suh, J. (2005). Variations in socioeconomic characteristics, farming assets and livelihood systems of Leyte rural households. *Annals of Tropical Research*, 27, 35–54.

FAO, ISS & ISRC (1998). *World reference base for soil resources*. World Soil Resource Report. Rome, Italy.

Gifi, A. (1996). *Non-Linear Multivariate Analysis*. John Wiley and Sons, Chichester, UK.

Greenacre, M. J. (1984). *Theory and Applications of Correspondence Analysis*. Academic Press, London.

Hair, J., Black, W., Babin, B. & Anderson, R. (2010). *Multivariate Data Analysis*. Pearson Prentice Hall, New Jersey, USA.

Hair, J. F., Tatham, R. L., Anderson, R. E. & Black, W. (1998). *Multivariate Data Analysis*. (5th ed.). Prentice-Hall, Upper Saddle River, New Jersey, USA.

Hilhorst, T. & Muchena, F. (eds.) (2000). *Nutrients on the move-Soil fertility dynamics in African Farming Systems*. International Institute for Environment and Development, London.

IFPRI (2007). *IFPRI's Africa Strategy: Toward food nutrition security in Africa*. Research and Capacity Building. Washington, DC.

Jagadamma, S., Lal, R., Hoeft, R. G., Nafziger, E. D. & Adee, E. A. (2008). Nitrogen fertilization and cropping system impacts on soil properties and their relationship to crop yield in the central Corn Belt, USA. *Soil Tillage and Research*, 98, 120–129.

Johnson, R. A. & Wichern, D. W. (2007). *Applied Multivariate Correspondence Analysis*. (6th ed.). Prentice-Hall, Upper Saddle River, New Jersey, USA.

Jolliffe, I. T. (2002). *Principal Component Analysis*. (2nd ed.). Springer-Verlag New York Inc., New York, USA.

Kostrowicki, J. (1977). Agricultural typology concept and method. *Agricultural Systems*, 2, 33–45.

Kraaijvanger, R., Almekinders, C. J. M. & Veldkamp, A. (2016). Identifying crop productivity constraints and opportunities using focus group discussions: A case study with farmers from Tigray. *NJAS - Wageningen Journal of Life Sciences*, 78, 139–151. doi: 10.1016/j.njas.2016.05.007.

Kuivanen, K., Alvarez, S., Michalscheck, M., Adjei-Nsiah, S. & Descheemaeker, K. (2016). Characterising the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. *NJAS - Wageningen Journal of Life Sciences*, 78, 153–166. doi: 10.1016/j.njas.2016.04.003.

Lattin, J., Carroll, J. & Green, P. (2003). *Analyzing multivariate data (Duxbury Applied Series)*. Brooks/Cole, CA, USA.

Mądry, W., Roszkowska-Mądra, B., Gozdowski, D. & Hryniewski, R. (2016). Some aspects of the concept, methodology and application of farming system typology. *Electronic Journal of Polish Agricultural Universities*, 19 (1), #12.

Masuka, B. P., Matenda, T., Chipomho, J., Mapope, N., Mupeti, S., Tatsvarei, S. & Ngezimana, W. (2016). Mobile phone use by small-scale farmers: a potential to transform production and marketing in Zimbabwe. *South Africa Journal of Agricultural Extension*, 44, 121–135.

Masvaya, E. N., Nyamangara, J., Nyawasha, R. W., Zingore, S., Delve, R. J. & Giller, K. E. (2010). Effect of farmer management strategies on spatial variability of soil fertility and crop nutrient uptake in contrasting agro-ecological zones in Zimbabwe. *Nutrient Cycling in Agroecosystems*, 88, 111–120.

Masvongo, J. (2013). Viability of tobacco production under smallholder farming sector in Mount Darwin District, Zimbabwe. *Journal of Development and Agricultural Economics*, 5, 295–301.

Matodi, P. B. (2012). *Zimbabwe's fast track land reform*. ZED Books, London and New York.

Mekkawy, W., Barman, B. K., Kohinoor, A. H. M. & Benzie, J. A. H. (2017). Characterization of Mono-sex Nile tilapia (*Oreochromis niloticus*) hatcheries in Bangladesh. *Journal of Aquaculture Research and Development*, 8 (7), #1000498. doi:10.4172/2155-9546.1000498.

Mooi, E. & Sarstedt, M. (2011). *A concise guide to market research: the process, data, and methods using IBM SPSS Statistics*. Springer, Heilderberg, Germany.

Moyo, S. (2006). The evolution of Zimbabwe's land acquisition. *In:* Rukuni, M., Tawonezvi, P., Eicher, C., Munyuki-Hungwe, M. & Matondi, P. (eds.), *Zimbabwe's Agricultural Revolution Revisited*. pp. 148–163, University of Zimbabwe Publications, Harare, Zimbabwe.

Mtambanengwe, F. & Mapfumo, P. (2005). Organic matter management as an underlying cause for soil fertility gradients on smallholder farms in Zimbabwe. *Nutrient Cycling in Agroecosystems*, 73, 227–243.

Muchero, M. (2008). The Development of a SADC Regional Agricultural Policy (RAP). *In:* Agriculture-Led Development for Southern Africa: Strategic Investment Priorities for Halving Hunger and Poverty by 2015. Palm Beach, Gaborone, Botswana.

Mugwira, L. M. & Murwira, H. K. (1997). Use of cattle manure to improve soil fertility in Zimbabwe: Past and current research and future research needs. Networking paper No. 2. Soil fertility for maize based cropping systems in Zimbabwe and Malawi. CIMMYT, Harare, Zimbabwe.

Ncube, B., Twomlow, S. J., Dimes, J. P., Van Wijk, M. T. & Giller, K. E. (2009). Resource flows, crops and soil fertility management in smallholder farming systems in semi-arid Zimbabwe. *Soil Use and Management*, 25, 78–90.

Ouma, E. A., Obare, G. A. & Staal, S. J. (2003). Cattle as assets: Assessment of non-market benefits from cattle in smallholder Kenyan crop-livestock systems. *In:* Proceedings of the 25th International Conference of Agricultural Economists (IAAE). 16–22 August, Durban, South Africa. pp. 328–334, International Association of Agricultural Economists.

Ozden, S. & Mendes, M. (2005). The usage of Multiple Correspondence Analysis in rural migration analysis. *NEW MEDIT - A Mediterranean Journal of Economics, Agriculture and Environment*, 4 (4), 36–41.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N. & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Adminstration and Policy in Mental Health*, 42 (5), 533–544. doi: 10.1007/s10488-013-0528-y.

Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods*. (3rd ed.). Sage Publishing Inc., Thousand Oaks, CA.

Prowse, M. (2013). A history of tobacco production and marketing in Malawi, 1890–2010. *Journal of Eastern African Studies*, 7 (4), 691–712. doi: 10.1080/17531055.2013.805077.

Rusinamhodzi, L., Corbeels, M., Nyamangara, J. & Giller, K. E. (2012). Maize-grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crops Research*, 136, 12–22. doi: 10.1016/j.fcr.2012.07.014.

Salami, A., Kamara, A. B. & Brixiova, Z. (2010). Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities. Working Paper Series No. 105. African Development Bank, Tunis, Tunisia.

Savary, S., Madden, L. V., Zadocks, J. C. & Klein-Gebbinck, H. W. (1995). Use of Categorical Information and Correspondence Analysis in Plant Disease Epidemiology. *Advances in Botanical Research*, 21, 213–240.

Shumba, E. M. & Whingwiri, E. E. (2006). Commercialisation of smallholder agriculture. *In:* Rukuni, M., Tawonezvi, P., Eicher, C., Munyuki-Hungwe, M. & Matodi, P. (eds.), *Zimbabwe's Agricultural Revolution Revisited*. pp. 577–591, University of Zimbabwe Publications, Harare, Zimbabwe.

Smith, R. R., Moreira, V. L. & Latrille, L. L. (2002). Characterization of dairy productive systems in the Tenth Region of Chile using multivariate analysis. *Agricultura Técnica*, 62 (3), 375–395.

SPSS Inc (2012). *SPSS Statistics 21*. IBM, Chicago IL.

Swan, A. & Sandilands, M. (1995). *Introduction to geological data analysis*. Blackwell, London.

Tittonell, P., Muriuki, A., Shepherd, K. D., Mugendi, D., Kaizzi, K. C., Okeyo, J., Verchot, L., Coe, R. & Vanlauwe, B. (2010). The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa – A typology of smallholder farms. *Agricultural Systems*, 103 (2), 83–97. doi: 10.1016/j.agsy.2009.10.001.

Tittonell, P., Vanlauwe, B., Leffelaar, P. A., Shepherd, K. & Giller, K. E. (2005). Exploring diversity in soil fertility management of smallholder farms in western Kenya: II. Within-farm variability in resource allocation, nutrient flows and soil fertility status. *Agriculture, Ecosystems and Environment*, 110, 166–184. doi: 10.1016/j.agee.2005.04.003.

Utete, C. (2003). Report of the Presidential Land Review Committee, Volume 1 and 2. Main report to His Excellency, The President of the Republic of Zimbabwe. Harare, Zimbabwe.

Wiggins, S. (2009). Can the smallholder model deliver poverty reduction and food security for a rapidly growing population in Africa? *In:* Proceedings of the FAO Expert Meeting on How to Feed the World in 2050. Food and Agriculture Organization, Rome.

Zingore, S., Murwira, H. K., Delve, R. J. & Giller, K. E. (2007). Soil type, management history and current resource allocation: Three dimensions regulating variability in crop productivity on African smallholder farms. *Field Crops Research*, 101 (3), 296–305. doi: 10.1016/j.fcr.2006.12.006.