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Typology of Smallholder Farming in South Africa's Former Homelands: Towards an Appropriate Classification System

By

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Thesis presented in partial fulfilment of the requirements for the degree of Master of Science in Agriculture (Agricultural Economics) in the Faculty of AgriSciences at Stellenbosch University

Supervisor: Lulama Traub

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Dedication

I dedicate this master's thesis to my Heavenly Father for giving me both the opportunity and desire to complete this research. To Him belong all the glory and honour in Christ Jesus. He has transformed my life and has given me a hope and a future. Without Him, I am nothing.

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Then I would also like to express my gratitude to my supervisor, Ms Lulama Traub, for the time and effort she put into this thesis. You have been an inspiration and a source of motivation. To my family and friends, thank you all for the support and the love I have received from you.

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Abstract

Typology of Smallholder Farming in South Africa's Former Homeland: Towards an Appropriate Classification System

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The agriculture sector continues to be viewed as a vehicle through which economic growth and development can be achieved; particularly for developing economies. This view is incorporated in South Africa's rural development framework in the National Development Plan, which indicated that this sector will be the main driver in developing the country's rural economies. However, the South African agricultural sector is known to be dualistic; consisting of a large-scale commercial and a small-scale subsistence sector. This study is particularly focused on smallholder farming in South Africa, which have developed as a result of the decades of government intervention that have guided reform driven by the general political and economic philosophy of white domination. The most notable interventions, which drew the line between white and black landholding, were the Natives' Land Acts of 1913 and 1936, followed by various policy interventions to support White, large-scale agriculture.

The question remains whether or not an expanded smallholder sector can significantly contribute to rural development, employment creation and poverty reduction in the former homeland areas of South Africa. In order to answer this question, the need arises for reliable data on smallholder farming, conceptual clarification on definitions of "smallholder" or "small-scale" farmers and diversity among farming systems needs to be taken into account. These considerations are crucial in order to design and implement effective rural development policies.

One way of addressing this question is the use of farm typologies. Given the diversity that exists within agricultural systems, various schemes of classification have been developed and evolved over time. The objective of this study is to provide an empirical framework that would classify smallholder farmers in the former homeland areas of South Africa according to their livelihood strategies. This study seeks to achieve the objective in three distinct ways. Firstly, by giving a broad overview of the smallholder sector in South Africa. Secondly, by utilizing Geographic Information Systems (GIS) techniques to identify farming households situated in the former homeland areas, using the General Household Survey (GHS) and the Income and Expenditure Survey (IES). Thirdly, apply multivariate statistical techniques, specifically Principle Component Analysis (PCA) and Cluster Analysis (CA), to develop the ultimate classification system.

The results from both typologies suggested eight distinct types or groups of farming households in the former homeland areas. Important findings suggest that higher salary incomes are crucial for the enablement of households to market their produce. Social grants were found to be key in determining livelihood strategies among faming households, most notably old age and child support grants. One of the groups that were identified was typically food insecure, with their agricultural production not sufficiently feeding the household. Lastly, direct agricultural support from the government was clearly focused on livestock services which placed a minority of households at a distinct advantage to sell produce to the market.

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Uittreksel

'n Tipologie van Kleinskaalse Boerdery in Suid-Afrika se Voormalige Tuislande: Die Ontwikkeling van 'n Toepaslike Klassifikasiesisteem

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Die landbousektor word algemeen gesien as een van die moontlike drywers vir ekonomiese groei en landelike ontwikkeling, spesifiek in ontwikkelende lande. Hierdie siening word ook uitgesonder deur die Suid-Afrikaanse ontwikkelingsraamwerk, en by name in die Nasionale Ontwikkelingsplan wat aandui dat die landbousektor die hoofrol behoort te vervul om landelike gebiede te ontwikkel. Die vermoë om hierdie mandaat uit te voer moet in die konteks van die kenmerkende dualisme raakgesien word. Suid-Afrika het hoofsaaklik twee tipes boere; grootskaalse kommersiële boere en kleinskaalse, meestal bestaansboere, wat meestal in die voormalige tuislande opereer. Hierdie dualisme is die resultaat van verskeie regeringsinmengings, hoofsaaklik gedryf deur die algemene politieke bestel, ideologie en beleid wat op rasseklassifikasie gegrond was gedurende die vorige eeu. Sekerlik een van die mees bekende was die Naturellegrond Wet van 1913 en 1936, wat die skeidingslyn tussen swart en wit grondbesit ingestel het. Verder is verskeie wetgewings implimenteer om die kommersiële landbousektor te bevoordeel gedurende hierdie tydperk..

In hierdie konteks is dit belangrik om te vra of die uitbreiding van die kleinskaalse landbousektor werklik kan bydra tot landelike ontwikkeling, werkskepping en armoedeverligting in die voormalige tuislande van Suid-Afrika. Om hierdie vraag te beantwoord word betroubare inligting benodig, moet die konsep van "kleinskaalse boere" uitgeklaar word en laastens moet diversiteit tussen verskillende boerderystelsels in ag geneem

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word. Die antwoorde op hierdie vrae is noodsaaklik vir die ontwikkeling en implimentering van effektiewe landelike ontwikkelingsbeleid.

Die gebruik van boerderytipologieë is 'n oplossing om hierdie kwessies aan te spreek. Verskeie klassifikasiesisteme is in die verlede ontwikkel om die diversiteit in boerderystelsels te ondersoek. Die hoof doel van hierdie studie is om 'n empiriese raamwerk te ontwikkel om kleinskaalse boerderye, wat in die voormalige tuislande voorkom, volgens hul lewensbestaanstrategieë te klassifiseer. Om hierdie doelwit te bereik, sal die studie eerstens 'n oorsig gee van die kleinskaalse landbousektor in Suid-Afrika. Tweedens sal Geografiese Inligtingstelsels (GIS) tegnieke gebruik word om spesifiek huishoudings in die voormalige tuislande te indentifiseer in die Algemene Huishoudings Opname (AHO) en die Inkomste en Uitgawes Opname (IUO). Derdens sal meerveranderlike statistieke gebruik word, spesifiek Hoofkomponentanalise (HKA) en Bondelontleding (BO), om die klassifikasiesisteem te ontwikkel.

Die resultate van die tipologieë wat in hierdie studie ontwikkel is gee agt spesifieke groepe van boerderyhuishoudings. Hierdie groepe was beduidend verskillend van mekaar en elkeen se lewenbestaanstrategieë word uitgewys. Die hoofbevindings dui aan dat addisionele salarisinkomste 'n belangrike rol speel in die vermoë van kleinskaalse boere om hul produkte te verkoop. Verder is dit opmerklik dat maatskaplike toelaes 'n aansienlike rol gespeel het in die vorming van die groepe, spesifiek wat betref ouderdomspensioene en kindertoelae. Daar is ook 'n spesifieke groep huishoudings in beide tipologieë wat probleme ondervind om voedselsekuriteit op huishoudelike vlak te handhaaf. Laastens wys die studie dat direkte landbou-ondersteuning teenoor kleinskaalse boere 'n kenmerkende fokus op lewendehaweboerderye plaas wat sulke boerderye bevoordeel het om vir die mark te produseer.

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Chapter

1 Introduction

The debate on the role of agriculture in development was initiated by the classical theorists, led by Arthur Lewis (1954), who viewed economic development as a growth process of relocating productive factors away from agriculture towards a modern industrial sector (Byerlee, et al., 2009). Beginning in the 1960's, Johnston and Mellor (1961) with their seminal work, argued that agriculture was essential for growth especially in the early stages of industrialization. Following the Green Revolution in Asia, where the positive impact of agricultural growth on rural development was found to be the strongest in countries with agriculture sectors dominated by smallholder farmers, a renewed emphasis was placed on broad-based agricultural growth and productivity increases in rural economies (Mellor, 1976; Rosegrant & Hazell, 2001; Lipton, 2005; Byerlee et al., 2009; Diao et al., 2010). To date, the agriculture sector continues to be viewed as a vehicle through which economic growth and development can be achieved, particularly for developing economies where the agricultural sector is dominated by largely informal, small-scale producers (Machethe, 2004; Dercon, 2009; Christiaensen et al., 2010; De Janvry, 2010; De Janvry & Sadoulet, 2010).

In contrast, the agricultural sector in South Africa is dualistic; consisting of a large-scale commercial and small-scale subsistence sector. The commercial sector includes approximately 40 000 large-scale farming enterprises whereas the small-scale sector consists of approximately 2 million, largely subsistence, farming households (Aliber & Hart, 2009; Aliber & Cousins, 2013). Prior to 1994, policy emphasis was placed on the development and support of the formal commercial agricultural sector to the exclusion of a much larger number of smallholder, black farms located in the homeland areas (Modiselle, 2001). The historical development of the dualistic agricultural system reveals a long history of biased and distortionary policy interventions, spesifically in the colonial era (Thirtle, et al., 2000). The most notable intervention, which the drew the line between white and black landholding, was the Natives' Land Act of 1913 and 1936. These legislative measures effectively destroyed a once thriving African farming sector which was able to compete with white settler farms during the mid-19th century (Vink & van Zyl, 1998). Furthermore, various policy instruments were introduced from 1910 onwards to support the white commercial

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farming sector. These measures broadened the dualistic gap between smallholder and large-scale farming in South Africa, which are still present today.

In 1994, with the transition to democracy, agricultural policies were aimed at supporting smallholder agriculture in South Africa in the form of infrastructure grants, production inputs support, access to loans and extension services. Through such support programs, the goal of the new administration was to create a new unified economy where both large and small farm enterprises could compete in both domestic and international markets (Van Averbeke & Mohamed, 2006). However, evidence suggests that these programs have been ineffective in stimulating rural growth and poverty alleviation and the dualistic nature of the agricultural sector continues to persist; with smallholder farmers in South Africa facing challenges of limited access to markets, inputs and credit as well as constrained property rights and relatively high transaction costs (Perret et al., 2005; Ortmann & King, 2006; Hall & Aliber, 2010).

To date, the National Development Plan (2011) recognizes the importance of the agricultural sector in developing the county's rural economies and generating employment through the creation of at least one million new jobs. The NDP also makes specific reference to the former homeland areas:

> *"Underdevelopment in the former homelands must be confronted through agricultural development, improved land management, infrastructure and targeted support to rural women."* (NPC, 2011).

However, the question remains as to whether or not an expanded smallholder sector can make a significant contribution to rural development, employment creation and poverty reduction in South Africa's rural areas (Cousins, 2013). To address this question, two key problems hindering policy formulation towards smallholder farming in South Africa need to be tackled. The first is the lack of reliable and detailed empirical data on small-scale farmers. The number of survey instruments seeking detailed information regarding smallholder agriculture in South Africa has been limited and outdated (Aliber & Hart, 2009; Aliber & Hall, 2010). This apparent lack of detailed information on smallholder agriculture makes it almost impossible to understand the diversity within these agricultural production systems, each having a unique set of distinctive limitations and constraints and faces a heterogeneous decision-making environment (Van der Ploeg et al., 2009).

The second is conceptual; in other words, what exactly is meant by the term "smallholder" and "small-scale farmer"? The definition of smallholder farmers has been ambiguous and different terminology has been used to classify them (Ortmann & King, 2006). Diversity in farming systems occur within a diverse biophysical and socio-economic environment and using terms such as "smallholder" tends to obscure inequalities and class-based differences within a large group of heterogeneous farmers (Cousins, 2010; Tittonell, et al., 2010). These considerations are crucial and needs to be addressed if a farmer-focussed and farming-systems research approaches are utilized in order to designing and implement effective rural development policies (Laurent et al., 1999; Cousins, 2013).

One way of addressing the abovementioned challenges to support policy formulation is the use of farm typologies (Capillon, 1993). Typologies have a long lineage in sociology with the primary aim of distinguishing the social and economic characteristics of rural households (Whatmore, 1994; Emtage, 2004). Within the framework of rural development, a typology is a procedure (qualitative and/or quantitative) for developing and describing relatively homogenous groups of households with similar constraints and objectives, which are expected to respond to external influences in a similar fashion (Perret & Kirsten, 2000; Tefera, et al., 2004).

1.1 Objectives of this study

The goal of this study is to develop a typology of the smallholder farming sector within South Africa; particularly within the former homeland areas. This typology will provide a valuable understanding of the factors affecting farming systems in these areas and would indicate how this sector could possibly contribute to the mandate of development to create employment and reduce poverty within South Africa's rural economies.

To achieve this goal the study objective is to provide an empirical framework that would classify smallholder farmers in the former homeland areas of South Africa by making use of sound statistical procedures. The study draws on the work done by Perret and Kirsten (2000), Anseeuw et al. (2001) and Perret et al. (2005) in using a livelihood approach to study diversity and livelihood strategies of rural households. To address this objective this study will;

1. Provide an overview of the smallholder farming sector in South Africa from the late 19th to the early 21st century.

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2. Utilize Geographic Information Systems (GIS) techniques to identify farming households situated in the former homeland areas. Applying GIS techniques to sample farming households in the former homeland areas, will give a much needed description of the sector.
3. Develop a classification system of smallholder farmers utilizing Principle Component Analysis (PCA) and Cluster Analysis (CA). Using these multivariate statistical techniques will enable the development of an adequate classification system based on a range of household indicators, rather than one indicator, such as farm size. The analysis will be done by treating the household as the primary economic unit and a sustainable livelihood approach will be used to create typologies of smallholder farming households utilizing data from both the General Household Survey (GHS) and the Income and Expenditure Survey (IES). To test the robustness and validity of the proposed typologies, empirical testing in the form of an Analysis of Variance (ANOVA) is conducted to see if there are significant differences between the groups and whether the proposed typological groupings are valid and stable.

1.2 Study Outline

The first chapter gives an overview of the South African smallholder farming sector with specific reference to the history, agrarian structure and the definition of smallholder farmers. It contextualises the current environment of the sector and provides important emphasis on past policies.

Chapter Three will follow with a literature review on typology development. This will be done by introducing classification of agricultural systems and by looking at the rationale, theoretical background and approaches used to develop typologies. The different methods used to create classification systems will then be discussed, explaining the differences between qualitative and quantitative classification systems and will seek to introduce the various instruments to be used in the next chapter. Chapter Four is the chapter on the methodology used in the study and therefore explains all the steps used in the analysis to create the proposed typology of farming households in the former homeland areas of South Africa.

Chapter Five gives the results and will explain the findings on the specific group classifications. Chapter Six contains a summary of the results of the study, provides a synthesis of those results and gives some policy recommendations.

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Chapter

2 An Overview of the South African Smallholder Sector

2.1 Introduction

This chapter describes the smallholder agricultural sector in South Africa within its specific environment. The elements in this chapter are important for understanding the dynamics of smallholder livelihoods in the South African agricultural economy. The chapter will start with an overview of the dualism within the sector, highlighting the important policy interventions that have caused it. This will be followed by the evaluation of the current agrarian structure in South Africa, indicating where the smallholder sector fits into the national economy. Then emphasis will turn to the definition of smallholder farmers both internationally and domestically. Finally, the rural livelihoods in South Africa will be reviewed with emphasis on farming as a livelihood strategy.

2.2 The Dualistic Agricultural System in South Africa

The current South African agriculture sector is a result of many factors in the past. The sector has played a prominent role in the economic development of South Africa, but is also well known for its lack in making full use of the available resources at its disposal. The development of the agricultural sector during the last century is characterized by structural change and the effect of political, economic, social, and historical factors that have caused the duality within the sector (Essa & Nieuwoudt, 2003). It is dualistic in the sense that it consists of a well-integrated, highly capitalized commercial sector on the one hand and a fluctuating subsistence or smallholder sector on the other (Vink & Kirsten, 2003; Aliber & Hart, 2009; May & Carter, 2009). This implies, therefore, that the South African agriculture sector has mainly two types of farmers; subsistence farmers in the former homeland areas and large-scale commercial farmers on privately owned land (Kirsten & van Zyl, 1998). Also in between these two main categories are farmers moving from subsistence agricultural production towards commercialization mostly with the help of government programmes aimed at establishing more black commercial farmers in South Africa.

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The dualistic nature and division between the commercial, large-scale farming sector and the comparatively low productive, struggling smallholder sector is not merely a result of economies of scale. This distinctive, dualistic structure in the farming sector has been created as a result of the interplay between public policies and the functioning of land, labour, and capital markets over time (Vink & van Zyl, 1998). Arguably, the most detrimental discriminatory legislation towards the marginalisation of black farmers was the Natives' Land Acts of 1913 and 1936. These legislative measures of discrimination against black farmers were instrumental in creating the dualism that currently persists within the agricultural sector (Kirsten et al., 1998).

The history of smallholder farming in South Africa is well documented in the literature (Bundy, 1979; Kirsten, et al., 1998; Thompson, 2000; Hamilton, et al., 2012). African farming societies existed many years before the arrival of white European settlers in the 17th century (Thompson, 2000; Parkington & Hall, 2009). These indigenous African societies in Southern Africa consisted of hunter-gatherers (San), pastoralists (Koikoi), and the Bantu-speaking mixed farmers (Africans) (Thompson, 2000). The arrival of European settlers, particularly those interested in farming, resulted in a long history of conflict on land acquisition between white settlers and the indigenous African tribes in South Africa (Thompson, 1995; Terreblanche, 1998; Tihanyi & Robinson, 2011). The story of disempowerment of these African farmers continued throughout the centuries leading up to the establishment of the Union in 1910. European settlers influenced the government in applying restrictive measures on black African land rights in the period leading to the establishment of the Union (Binswanger & Deininger, 1993). These policies was ushered in to suppress and isolate African farmers from mainstream agriculture, and aimed at transforming them into wage labourers (Vink & van Zyl, 1998).

Before the establishment of the Union, African farming was relatively viable during the second half of the 19th century. African farmers at the time, whether farming on private land or as tenants, proved to be as efficient as large-scale settler farmers. According to Bundy (1979) these African farmers supplied the major towns of the colony with grain and exported surplus to the Cape between 1850 and 1870. Compared to large-scale farming, these African family farming units were efficient and viable to produce agricultural products with simple technologies and plentiful land. Labour was said to be the most important success factor of farming at the time and white settlers with low profitability could not offer wages that would attract indigenous labourers, who had no need to work for wages (Mbongwa et al., 2000).

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In the early part of the 20^{th} century at the time of the establishment of the Union in 1910, the existing racial discrimination in access to land was consolidated (Vink & van Zyl, 1998). The Natives' Land Act of 1913 drew the line between white and black landholding and prohibited any transactions for the purchase, hire or acquisition of land to black people (Mbongwa et al., 2000). Under the terms of the Land Act of 1913, 7% of the land and later 13% under the 1936 Land Act was reserved exclusively to Africans. This Act attempted to outlaw access to land such as tenancy and sharecropping, and caused much disruption to black farming production (Vink & van Zyl, 1998). The combined effects of the Land Acts and several other interventions stripped the African household farming sector of its independence and these farmers were condemned to agricultural production inside the reserves on small areas of communal land. These famers were choked of opportunities outside of the labour market and gradually capital, wealth, farming skills and information build up by centuries was being destroyed (Mbongwa et al., 2000). It is estimated that 13 million of the 40 million South Africans lived in the homeland areas at the time of transition and that 80% of the rural people were living in poverty (Lyne & Darroch, 2003).

The settler state did not only introduce the above mentioned discriminatory policies that crippled the African farming sector, but also introduced a wide range of instruments to support white commercial farming (Vink & van Zyl, 1998). The main objective was to use factors of production optimally with respect to development and the state supported white farmers through legislation such as the Cooperative Societies Acts and the Marketing Acts, through investment in research and development, infrastructure and extension services (Vink, 2009). Subsequent measures of protection that followed to achieve these objectives for "white Agriculture" were administered prices, input subsidization, import controls, compulsory single-channel marketing and export subsidies and generous disaster assistance towards agriculture (Oettle et al., 1998; Makhura & Mokoena, 2003).

2.2.1 Post-Apartheid: 1994 - 2013

The transition from Apartheid to a new democratically elected government in 1994 brought about various policy changes to transform the agricultural sector to an open economy. Policy changes in the agricultural sector included the deregulation of the marketing system, abolition of certain tax concessions, reduction in expenditure from the national budget, land reform, trade reform and new labour legislation (Groenewald & Nieuwoudt, 2003). With these changes in policy many African farmers expected positive changes to the agricultural sector.

The African National Congress (ANC) stipulated that the improvement of small-scale agricultural production and increased participation of emerging farmers in the economy were the pillars of the Reconstruction and Development Programme (RDP) (Makhura & Mokoena, 2003). The general aim of the new agricultural policy was to create a new unified economy where both large and small farm enterprises could compete in harmony in the domestic and international markets (Van Averbeke & Mohamed, 2006). The ruling party indicated that a larger and more vibrant small-scale farming sector had the potential to address key issues such as rural poverty, unemployment and food insecurity (Aliber & Hall, 2010).

Towards undoing the effects of decades of policies that affected black South Africans, the new government initiated a series of land reform programmes from 1994 with the intent to redistribute 30% of the white owned land to previously disadvantaged people. The intention was to make land accessible, to enable security of tenure for these rural people, and to improve small-scale production capacity. Three main land reform instruments were used: Land restitution, Land tenure reform and Land redistribution (Lyne & Darroch, 2003).

2.3 The Agrarian Structure in the 21 century

The agricultural sector continues to be characterized by inequality in terms of the distribution of economic assets, support services, market access, infrastructure and income (Oettle et al., 1998). The total land area in South Africa is approximately 122.3 million hectares of which farmland consists of 100.6 million. Among the 100.6 million hectares of farmland, 83.3% is grazing land and only 16.7 million hectares are considered potential arable land (DBSA, 2000). Furthermore, only 1.35 million hectares of the potential arable land in South Africa is available for irrigation and accounts for more than one third of the total output in the agriculture sector (Vink & Kirsten, 2003). Commercial agriculture takes up 86.2 million hectares of the available farmland, while the smallholder sector only utilizes 14.5 million hectares (Fenyes & Meyer, 2003; DAFF, 2012a).

Commercial agriculture in South Africa is made up of a relatively small number of commercial farmers who occupy 87% of total agricultural land and are responsible for over 95% of agricultural production in South Africa (Vink & Kirsten, 2003). The number of farmers have been declining over time from 60 000 in 1996 to approximately 45 000 by 2002. More recently, this number was estimated to be even lower at 35 000 large-scale, mostly white, farmers (Aliber & Cousins, 2013). As a result, there has been an increase in the concentration of farming units within the commercial agricultural sector with landholdings

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being consolidated into larger farming units of ownership and production while smaller and less efficient farmers were forced out of farming (Vink, 2009). The average farm size of these commercial farms in South Africa was estimated to be 1349 hectares in 1996 and would have increased slightly over the past few years (Fenyes & Meyer, 2003). These farmers, who are mostly white, are able to compete globally in agricultural markets and earn income comparable to the highest income groups in the country (Pauw, 2007). The contribution of commercial agriculture to the national economy has decreased over time (Vink & Kirsten, 2003) with agriculture's current share in GDP less than 3% since 2005 (Greyling, 2012).

The smallholder sector in South Africa is mostly found in the former homeland areas on very small landholdings (Groenewald & Nieuwoudt, 2003) and is found in a wide range of locations in South Africa from deep rural areas to townships, cities and on commercial farms (Lahiff & Cousins, 2005). Production tends to be mostly on a subsistence basis for household consumption (Aliber & Hart, 2009) from gardens, demarcated fields or open rangelands. Fenyes and Meyer (2003) suggest that the majority of these rural households consist of women, children and aged people. There is considerable variation in the sizes of land for smallholder cultivation but is generally extremely small and in the range of 0 - 1.5 hectares per household. Of these, a substantial proportion of households farm on less than 0.5 hectares and only a small percentage of households farm on plots larger than 5 hectares (Lahiff, 2000).

Smallholder farmers in South Africa face various challenges when it comes to agricultural production. Limited access to markets, production factors and credit combined with property right constraints and high transaction costs make life very difficult for these producers farming on small pieces of land (Ortmann & King, 2006). Smallholders are faced with a range of technical and institutional factors which influences access to markets. Smallholder farmers that do market their produce will mainly deliver to one of three destinations, namely fresh produce markets, informal markets and less frequently, supermarket chains (Baiphethi & Jacobs, 2009).

2.4 Defining Smallholder Farming Systems

The definition of smallholders varies between countries and agro-ecological zones and the notion of "small" varies in different contexts (Narayanan & Gulati, 2002; Dixon et al., 2003; Nagayets, 2005; Machingura, 2007). This explains the freqeunt and interchangeble usage of the term "smallholder" with "small-scale", "subsistence", "resource poor", "small", "low-income", "low-input" and the list continues (Nagayets, 2005; Machingura, 2007). There

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seems to be no universally accepted definition for smallholder farmers, but some definitions have been noted in the literature both globally and domestically.

2.4.1 Global Definition

One of the more general approaches used to define smallholder farmers would be to assess the common characteristics of these farmers such as their land and capital access, exposure to risk and input technologies and market orientation (Chamberlin, 2008). For instance, Lipton's (2005) definition of a smallholder is based on whether or not most of the labour is performed by members of the family, while Dixon, Abur & Watterbach (2003) suggest that the term smallholder relates to their limited resource endowment relative to the other farmers in the sector. The definition used by Ellis (1999) is incorporated with this which states that smallholder farmers are farm households that have access to land and rely primarily on family labour for production to produce for subsistence and/or market sale (Machingura, 2007).

The World Bank defines a smallholder as farmers with less than 2 hectares of cropland and those that have a low asset base (World Bank, 2003). Finally, according to Narayanan and Gulati (2002), a smallholder farmer is characterized as one who practises a mix of commercial and subsistence production and where the bulk of labour comes from the family. These definitions all have a similar theme and concentrate on the basic characteristics such as constraints to land and labour (Machingura, 2007).

The formal definitions listed above have often been used to define smallholder farmers around the world; however, another common approach to define smallholders is to use farm size (or livestock numbers). This is mostly justified by the availability of international empirical data that can be used for a more general classification of smallholders (Nagayets, 2005; Machingura, 2007; Thapa, 2009). Yet this definition does have limitations of its own. Important factors such as quality of resources, farming operations, managerial ability and disparities across regions are not controlled for in farm size. For example, a small farm that produces high value crops on irrigated land is not comparable to a small farm on marginal land that produces staple crops. Kirsten and Van Zyl (1998) go on to state that:

> "*Size is not a good criterion for defining small farms. For example, one hectare of irrigated peri-urban land, suitable for vegetable farming or herb gardening, has a higher profit potential than 500 hectares of low*

quality land in the Karoo. Turnover, or rather the level of net farm income, determines the farm size category, not the land size."

2.4.2 Smallholder Farming within South Africa

There are various different general definitions for smallholder farmers in South Africa and the terminology used to refer to them has been inconsistent. Various authors have used descriptive words to classify smallholders and these terms have been used interchangeably (Ortmann & Machethe, 2003). The terminology used has often also been linked to the specific number of farmers in a specific group, which makes classification difficult. Furthermore, the lack of good quality data on smallholder farmers exacerbates this problem of smallholder definitions (Cousins, 2013).

The term "small-scale" is often used in South Africa to refer to black smallholder farmers characterised by non-productive, backwards, non-commercial and subsistence agriculture (Kirsten & van Zyl, 1998). It is often used as the broader term to refer to the total number of farmers or households involved in agricultural production on a relatively small scale. According to Coetzee (2003) South Africa has approximately 2.1 million small-scale farmers, while Vink (2009) reports that there were approximately 1.3 million smallholder households involved in farming. According to the National Department of Agriculture in 2001, this amounted to approximately 3 million farmers or individuals (NDA, 2001). The more general consensus, however, suggests that the total number of small-scale farming households in South Africa is approximately 2 million farming households (Aliber, 2005; Aliber & Hall, 2010; Aliber & Cousins, 2013).

This broad group of small-scale farmers or farming households can be sub-divided into two groups as indicated in Table 1. The National Department of Agriculture, Forestry and Fisheries have sub-divided these farmers in South Africa into two distinct categories in their 2012 Integrated Growth and Development Plan (IGDP) (DAFF, 2012b). Firstly, Emerging smallholder farmers are formally defined as those that are located in the former homeland areas and are predominantly black. This group consist of approximately 140 000 black farming households who are said to be more commercially inclined by marketing their produce (Aliber & Hall, 2010; Tihanyi & Robinson, 2011). Secondly, the IGDP suggests that the second group of farmers, known as subsistence producers, are defined as those approximately 2 million households involved in agriculture which only produce agricultural goods for own household consumption (DAFF, 2012b). These estimates seem to align closely

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with the findings in the GHS of 2009 and 2010, which are given in Table 1. These are extrapolated estimates of the number of black farming households in 2009 and 2010 in the South African population using the sampling weights in the data.

Table 1: Number of black farming households in South Africa

Definition	2009		2010	
	Number[1]	**Share of Total**	**Number[1]**	**Share of Total**
Subsistence Farming Households	2324379	94.59%	2307496	93.51%
Emerging Farming Households	132843	5.41%	160043	6.49%
Total	2457222	100%	2467539	100%

Source: GHS 2009 and 2010

The latest estimate on households involved in agriculture comes from the 2011 census, reporting that 2.6 million black households were involved in farming in South Africa. The KwaZulu-Natal and Eastern Cape were the provinces with the most agricultural households with 24.9% and 20.7% of the total respectively (StatsSA, 2013). Smallholder agricultural activities are very much concentrated in the former homeland areas of South Africa and in rural areas. The results from the GHS 2010 and Census 2011 are considered to be the latest and most reliable indicators of the current number of smallholder farming households. Thus, the South African smallholder sector consists of between 2.5 and 2.6 million households, of which approximately 160 000 sell their produce to the market, while the rest produce for subsistence purposes. This is illustrated in Figure 1 below, giving the graphical representation of the terminology used to define smallholders in South Africa.

[1] Population figures are weighted by sampling weights

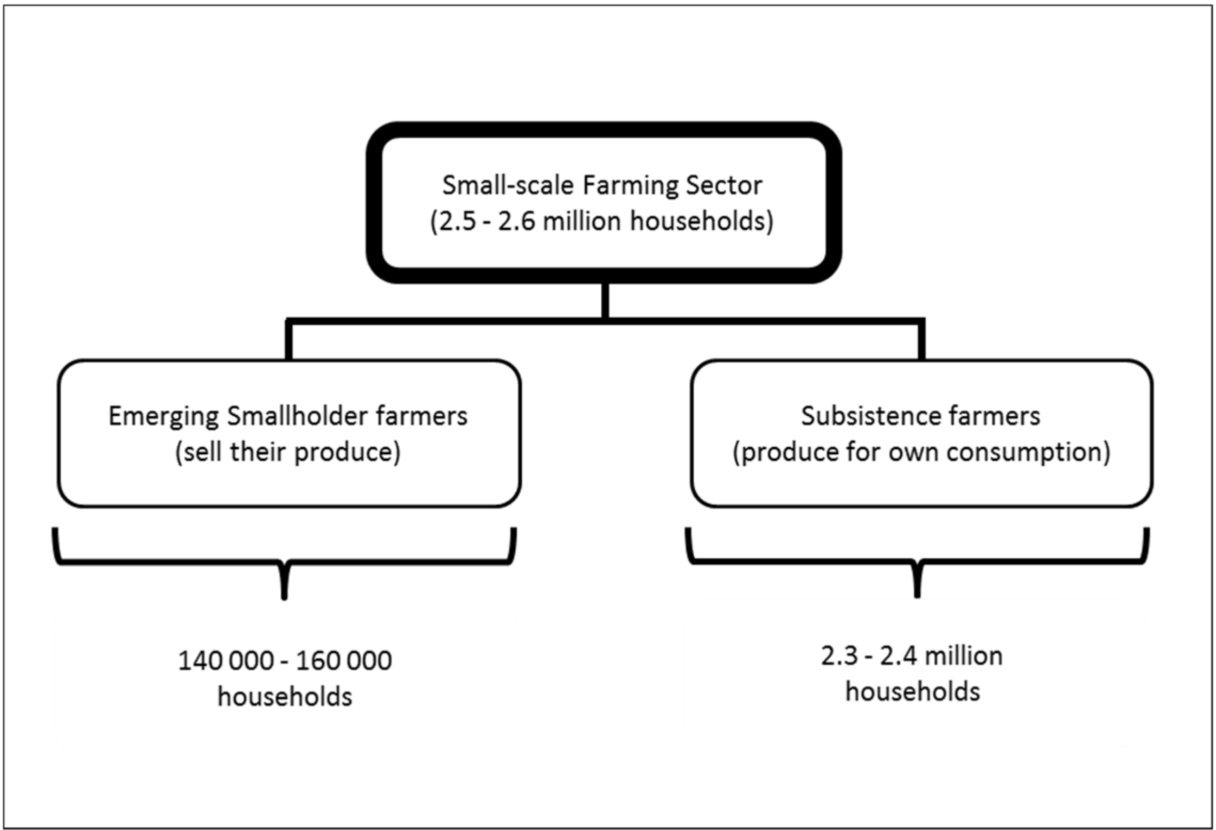

Figure 1: Graphical representation of the terminology used to define smallholder farmers in South Africa

Source: Own compilation based on GHS, 2010; DAFF, 2012b; StatsSA, 2013

2.5 Smallholder livelihoods in South Africa

It is well known that smallholder farming systems in sub-Saharan Africa occur within an environment with diverse biophysical and socio-economic conditions. Rural households develop different livelihood strategies said to be conducive to the given opportunities and constraints in their specific environment (Tittonell et al., 2010). Ellis (1998) refers to this livelihood diversification among rural households as a process by which a diverse portfolio of activities and social support capabilities are chosen for improved living standards.

Rural livelihoods in South Africa can be characterised by an environment with diverse economic activities which could be farm or non-farm related (Alemu, 2012). It is clear that rural livelihoods are today impacted by both legacies of the past and more concurrent changes presently and include factors such as the ascendancy of supermarket retail and the increased social grant assistance in the recent past (Neves & Du Toit, 2013). Many rural people are either directly or indirectly involved in agriculture (Pauw, 2007) and their livelihood options would either be farm-related (livestock and crop production), off-farm (wage employment on other farms) or non-farm (non-agricultural income sources such as wage employment and remittances) (Alemu, 2012). Thus, these households create a living from various sources such as production, labour, trading, and transfers. The latter is well known to form the backbone of South African rural families in the form of social grants and remittance payments (Perret et al., 2005).

Smallholder households, mostly in the former homelands, are typically poor, black (includes African, Coloured and Asian) agricultural households that struggle to support themselves with income earned from agricultural activities. Production is mostly aimed at providing staple foods for household consumption and can be produced on anything from gardens, demarcated fields or open rangelands. There is considerable variation in the sizes of land for smallholder cultivation and extremely small (Lahiff, 2000). According to Perret and Kirsten (2000) only 2.7% of the 70% who participates in agricultural systems relies on their farming activities for income. More recent estimates from the GHS seem to indicate that only 5.8% of all black farming households sell their produce (GHS, 2010).

2.6 Support to smallholder farming in South Africa

Support to the smallholder sector in South Africa was first introduced by the Development Bank of Southern Africa (DBSA) in the mid 1980's (Aliber & Hall, 2010). This was done by providing Farmer Support Programmes (FSP) supporting smallholder farmers in the homeland areas (from 1987 to 1993) and provided support services in the form of inputs, capital, mechanisation, marketing, training and extension. These interventions, though not perfect, were formally ended when the homelands were reintegrated into the provinces of South Africa in 1994 (Aliber & Hall, 2010).

Since the formal ending of Apartheid, the policy objectives relating to smallholder farming in South Africa have been framed in a very broad perspective; to help smallholders to become commercial and to expand (Aliber & Hall, 2012). These efforts were aimed at rectifying the dualistic gap between the smallholder and large-scale sectors and to maximise the contribution of the agricultural sector towards growth and development in the economy (NDA, 2001). The Department of Agriculture came up with various policies to support smallholder farmers as this was said to give solutions to the longstanding problems of unemployment and rural neglect. Yet, these policy interventions have done very little to support this sector; some even contributed to its decline (Lahiff & Cousins, 2005). These

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include the deregulation of commodity markets, failed land reform initiatives and the dismantling of development corporations.

In recent years, smallholder agriculture in South Africa has climbed the political agenda attracting new policy emphasis (Hall & Aliber, 2010). There could be various reasons for this, but Aliber and Hall (2012) suggest major food price inflation since 2000 and the need to secure food security within the country, were the main reasons. This message was very clearly expressed in the ANC Election Manifesto:

> "*The ANC government will: Intensify the land reform programme to ensure that more land is in the hands of the rural poor and will provide them with technical skills and financial resources to productively use the land to create sustainable livelihoods and decent work in rural areas. ... [And] expand [the] agrarian reform programme, which will focus on the systematic promotion of agricultural co-operatives throughout the value chain, including agro-processing in the agricultural areas. Government will develop support measures to ensure more access to markets and finance by small farmers, including fencing and irrigation systems.* (ANC, 2009).

Statements like these have created a general rhetoric that smallholder farming will receive more direct support from government. When looking at the amount of public expenditure on the agricultural sector over the past 5 years, both at national and provincial level, it seems that increased support has materialized. Considering the fact that large-scale white farmers receive limited direct support from government, Aliber and Hall (2012) roughly estimate that this expenditure would amount to more than R2500 per '*agriculturally active*, *black household'* using only provincial expenditure. However, in reality, the distribution of these government transfers rarely reach the hand of the farming households and are often highly skewed to favour certain farmers (Hall & Aliber, 2010). Table 2 follows the same procedure as the above mentioned paper, but shows agricultural support towards black farming households from 2009 to 2011 using the GHS survey.

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Table 2: Government agricultural support to black farming households

Type of support	2009		2010		2011	
	Number[2]	Share of Total (%)	Number[2]	Share of Total (%)	Number[2]	Share of Total (%)
Training	49425	1.91	45058	1.56	74372	2.44
Extension visits	46477	1.79	59688	2.07	73998	2.43
Grants	5228	0.2	6347	0.22	10955	0.36
Loans	3379	0.13	6101	0.21	12103	0.4
Input as part of loan	7744	0.3	26706	0.93	26990	0.89
Inputs for free	52237	2.02	132394	4.6	148324	4.87
Livestock health services	261368	10.08	228811	7.94	204426	6.71
Other	1770	0.07	4801	0.17	14034	0.46
Total	336754	12.99	388898	13.5	368249	12.07

Source: GHS 2009, 2010 and 2011

From Table 2 it is clear that only approximately 13% of black farming households received direct support. This support came mostly in the form of livestock health services and secondly input supplies. The question that needs answering is how such substantial transfers from government have resulted in so little benefit to farmers. Aliber and Hall (2012) suggest a few explanations: Firstly, the lack of resources seems to be stretched when it comes to extension personnel who need to cover such a big proportion of farmers. Secondly, many black farmers are said to be almost invisible in the sense that many departments are unaware of their existence. Thirdly, there is a preference for quality instead of quantity and other related issues with under spending from government.

2.7 Conclusion

This chapter has given a broad overview of the South African smallholder sector. The first section explained the dualistic nature of the agricultural system and the various factors that have played a prominent role its development. This review indicates that distinct policy interventions, specifically the Natives' Land Acts and the support towards white commercial farming, caused the duality within the sector. Prior to these measures, the African farming sector was competitive with the settler farmers and that these typically produced surplus food for the market. In the 21st century, even though these policies have been removed, the dualistic agrarian structure persists. African farming is characterised by lack of resources, relatively low production, and lack of access to markets.

[2]Population figures are weighted by sampling weights

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The definitions used for smallholder farmers differ both internationally and domestically, with no universally excepted method to define them. Definitions typically relates to the characteristics of the farmer such as their access to land and capital, exposure to risk and input technologies, and market orientation. These tend to change in different contexts and various terminologies have used to simplify these definitions. In South Africa, smallholders are divided into “subsistence” and “emerging” farmers which relates to their reason for farming. The former consists of approximately 2.3 million households producing food for household consumption. The latter were said to sell their produce and this group of farming households were approximately 160 000.

South African rural households develop various livelihood strategies in accordance to their specific environment. Livelihood diversification takes place when individuals or households create a living from various sources such as production, wages, trading and transfers (grants and remittances) towards resilience and sustainability. Lastly, support towards smallholder farmers has been limited even though the National and Provincial budget spending on agriculture has increased. Challenges faced with support mechanisms relate to the limited extension personnel in relation to the number of farmers; the invisible nature of many of these farmers and the preference for quality instead of quantity.

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Chapter

3 Literature Review on Typology Development

3.1 Classification within Agriculture

Classification is a process that is central to all facets of life (Bailey, 1994). In the simplest of terms, it is defined as the process of ordering entities into groups or classes based on similarities (Everitt et al., 2011). In particular it is the process of organizing complex and disparate data in order to provide a basis for analysis, decision making and reasoning (Xu & Wunsch, 2009; Everitt et al., 2011).

Agricultural systems are comprised of a basic production unit, i.e. the farm, which has its own distinctive limitations and constraints and faces a heterogeneous decision-making environment. Given this diversity within agricultural systems, various schemes of classification have been developed and evolved over time (van der Ploeg et al., 2009). The early schemes used structural characteristics, such as scale and factor intensity, in order to classify farming units. The rationale of these schemes was exclusively economic in nature with the main criterion between different farm types according to farm income (Andersen et al., 2007). For example, the European farm typology (1985) classified farms according to production orientation and economic size. To do this, the regional gross margin (standard farm income per production unit) for each type of agricultural production (whether crop or livestock) were assigned and multiplied by the volume of production to obtain the income from each production type on the farm unit. The proportion of each production type's contribution to the gross margin was used to classify farmers (Andersen et al., 2007).

It was thought that farms would enter a modernization pathway that would merely be a quantitative process, with modernization occurring through an enlargement of farm sizes and a general increase in productivity, which would cause a convergence towards a new optimum. The outcome of this pathway was expected to cause increasing farm income over time as a result of structural development.

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According to these early models it was expected that only the farmers adopting the newest technologies and realizing the highest levels of intensity and scale (thus higher incomes), would be able to stay in farming (labelled as the "series" farmers). It was expected that the "traditional", "non-professional" and/or "small-scale" farmers would in time move out of farming as agriculture moved towards the modernization optimum. Initially, these classification schemes used characteristics such as regional location that were associated with varying historical trajectories, urban-rural relations, ecological conditions, landscapes and institutional structures. However, by the 1980's it became apparent that the status quo classification system of farmers had two major deficiencies. First, differentiation occurs at the product-level despite similar structural characteristics. Secondly, a large amount of diversity among agricultural systems was not accounted for in these early models since smallholder and/or part-time farmers were largely ignored in the systematization of farms within Europe (Andersen et al., 2007; Van der Ploeg et al., 2009). Fundamentally, these classification schemes failed to deal with the multi-functionality of agriculture and as a result several deviations from these models contributed to the development of two new methodologies to classify agricultural systems (van der Ploeg et al., 2009). These include the Farming Styles approach, which was developed in the Netherlands; and the Farming Activity approach developed in France.

3.1.1 Farming Styles

The basis of the Farming Styles approach is that heterogeneity in agriculture and amongst farmers is not random or just a consequence of physical characteristics or different structural factors affecting farmers. It is rather a reflection of social differences and the diversity can be explained by the manifestation of a range of farming styles (Howden et al., 2007). The approach was developed by Jan Douwe van der Ploeg (1990; 1993; 1994) at the University of Wageningen in the late 1980s and early 1990s. This theoretical approach essentially seeks to explain diversity amongst farmers in a particular setting (Howden & Vanclay, 2000; Howden et al., 2007). It is a way of conceptualizing farming as a social process within a specific cultural, economic, and political context as well as farm management components (Howden & Vanclay, 2000). A farming style is said to be a socially constructed type that reflects the worldview and strategy of one specific farming practice for a particular commodity in a particular region. Van der Ploeg (1994) elaborates:

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> *"A Style of farming then is the complex but integrated set of notions, norms, knowledge element, experiences etc., held by a group of farmers in a specific region, that describes the way farming praxis should be carried out".*

Thus, categorization of farmers can be done by recognizing consistencies across the variety of different social components of farming. The use of farming styles theory in the development of farm typologies is well documented in the literature (van der Ploeg, 1994; Mesiti & Vanclay, 1997; Howden et al., 1998; Howden & Vanclay, 2000; Thompson, 2001; Vanclay et al., 2006; Howden et al., 2007).

The typology studies that have used the Farming Styles theory in their methodologies have emphasized the importance of the farmer as an individual and links land management decisions with social dimensions (Emtage, 2004). Farming Styles theory also places more emphasis on qualitative methods rather than the traditional quantitative techniques used to identify patterns and also often involves the farmer's self-assessment developed by Whatmore (1994) through experiential, deductive reasoning (Howden et al., 2007).

3.1.2 Activity Systems

In French agrarian sciences the agricultural systems approach to classification comes from a long lineage of farming systems research throughout the 1970's and 1980's. A farming system is defined as a population of distinct farm systems that have generally similar resource bases, enterprise patterns, livelihoods and constraints, and for which similar development strategies and interventions would be suitable (Kobrich et al., 2003; Madry et al., 2013). It is seen as consisting of a totality of consumption and production decisions by the farm household, including agricultural orientation, off-farm enterprises and consumption of food, and each one has its own unique farming system (Kobrich et al., 2003).

The farming systems concept was replaced by the "activities system" concept, which broadened the classification of farms by including other factors besides the basic agricultural activities of households (Cochet, 2012). The activity systems approach was introduced to account for the pluriactivity of farmers; the phenomenon where farming is done on a part-time basis and the farmer is involved in many other activities apart from food production (Bessant, 2006). Economists and agricultural economists found it difficult to find farming systems in Sub-Saharan African societies due to the embeddedness of the production process with the household unit, the accumulation unit and the consumption unit of the household (Cochet, 2012).

The “activity” approach realised the need to include not only production functions, but also environmental and social functions to better assess the environmental and social dimensions of agriculture in rural development. Thus, in short, the rationale underlying farming systems can only be understood by making reference to the broader perspective, the activity system, which constitutes the sphere in which farmers’ practises and choices appear coherent (Cochet, 2012). This approach was accompanied by methodologies and concepts that (a) incorporated the multifunctionality of agricultural activities, (b) took on multidisciplinary approaches and (c) were based on broader geographical frameworks (van der Ploeg et al., 2009).

In the discipline of agriculture and rural sociology, an activity system is seen as a set of dynamic and structured interactions carried out by a social entity in a specific agro-ecological and social context (Gasselin et al., 2012). Under the activity classification system, the typologies not only highlighted variation in farm income sources; but also explained the motivations and aims of these activities and functions (van der Ploeg et al., 2009). The use of these classification systems was introduced from a development point of view where diversity was not considered an obstacle or constraint, but rather as an expression of the capacity of the agricultural system to adapt and sustain different scenarios (Laurent et al., 1999). It recognises that agricultural activity has an economic function which is not only driven by commercial farm income, and even if it is, can relate to different systems and norms. Furthermore, the activity system helps to explain the why and the how of a productive process in agriculture, even though agriculture might not be the primary activity of the household (Cochet, 2012).

3.2 **Defining Farm Typologies**

Classification schemes within agriculture have been widely used to describe and analyse diversity in agricultural enterprises (Emtage, 2004). It involves developing a set of formal categories into which a particular field of data is partitioned. In contrast, a typology is a particular type of rigorous classification in which a field of data is divided up into categories that are all defined according to the same set of criteria, and that are mutually exclusive.

In particular, according to Tefera et al., (2004) a typology is defined as a quantitative or qualitative procedure that categorizes households or individuals into homogenous groups, which face similar constraints and incentives and are influenced by external factors in a similar way. In agricultural analysis, diversity within the rural environment manifests itself in various responses and the use of farm typologies is a useful way of describing this diversity. This is achieved by specifying the structural characteristics of different farm types, where each type or group is significantly different from the other in relation to a specified criterion (Laurent et al., 1999; Van der Ploeg et al., 2009). Therefore, the relevance of any farm typology will depend heavily on its ability to capture the diversity of farming systems through maximizing the homogeneity within groups and the heterogeneity between groups (Iraizoz et al., 2007).

3.3 **Rationale for developing smallholder Typologies**

In recent years many studies have focussed on defining farm typologies in various countries. (Dorward, 2002; Johnson, 2002; Kobrich et al., 2003; Emtage, 2004; Bidogeza et al., 2009). This is certainly the case with smallholder farming households in sub-Saharan Africa where production takes place in diverse socio-economic and biophysical environments (Tittonell et al., 2010). In this context rural farming households develop different livelihood strategies according to their different opportunities and constraints.

National governments in many countries are focusing on promoting sustainable natural resource management in terms of achieving objectives in environmental, social and economic development (Emtage, 2004). In this regard, typologies are widely used in the literature in order to understand structural changes in farming with regards to output, employment, farming intensity and impacts of policy reforms (Iraizoz et al., 2007). According to Landais (1998) typologies of farmers are constructed to help those who are administrating and designing development policies and programs in two ways. These are firstly to analyse the functionality of the farms and secondly, to provide useful recommendations on techno-economic matters which will help to optimise farming operations. It is generally accepted that the land management behaviour of farmers and rural households are not exclusively motivated by economic considerations such as maximizing the productivity of the farm unit (Emtage, 2004).

3.4 **Theoretical Background for Creating Typologies**

The theoretical understanding of the phenomenon of interest is used to determine the criteria that underpin a specific typology. This theoretical basis is crucial for defining the relationships between the factors that influence the behaviour of households. According to Emtage (2004) there is a variety of theoretical perspectives that have been used to construct and develop typologies of farmers and rural households. These include Farming styles; Sustainable livelihood; Farming context and Market structure theory. All of these theories strive to account for the behaviour of individuals or households and each designates the behaviour as a consequence of the interaction between factors such as social, cultural, economic, institutional, biophysical and personal factors.

Farming styles theory

Farming styles theory is already discussed earlier in this chapter; it relates to a distinct set of styles which farmers are acutely aware of and from which they make decisions. Studies that have used farming styles as a theoretical background emphasise the importance of the farmer as an individual in terms of decision-making, and tend to place more emphasis on qualitative rather than quantitative methods to identify different types (Emtage, 2004).

Farming context theory

Farming context theory was used by Kaine and Lee (1994) who state that behaviour arises because of a combination of personal, social, biophysical and economic factors. This theory emphasizes examining differences in farming practices within the same type of agricultural enterprises and examines the evolution of the enterprise given the present resources, objectives and practises (Emtage, 2004).

Market structure theory

The market structure theory has been used to create typologies of farmers and uses methodologies from marketing studies to guide the typology development. These seek to use typologies to analyse the diversity of consumers for a particular product. One such study includes Barr (1996) who tried to discover common features in the descriptions of farm types interviewed in the study, aiming to create a regional typology of defining the “market” for perennial pastures (Emtage, 2004).

Sustainable livelihood theory

The Sustainable Livelihood (SL) approach to typology development has a rich history of over 50 years and has profoundly shaped rural development thinking and practice. It is multi-disciplinary in the sense that it incorporates insights from a wide range of disciplines including, political, sociological, agricultural, and/or environmental perspectives (Scoones,

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2009). Thus, it includes complex interactions of how rural livelihoods intersect with political, economic and environmental processes.

Fundamentally, this approach is focused on the objectives, scope and priorities for development of low-income communities with the aim of identifying appropriate policy interventions to address their constraints and/or challenges (Farrington, 2001; Carney, 2003). As such the SL approach has been adopted in order to identify, design and assess new iniatives, to review existing activities, to inform strategic decision-making and for further research (Ashley & Carney, 1999). The SL approach incorporates three key elements. First, it is a set of principles that specify developmental activity which should be people-centred, locally differentiated according to relevant criteria and multi-level for the purpose of understanding livelihoods. Second, SL uses conventional analytical frameworks (economic, social, institutional etc.) that enable the identification of poor people's options and constraints. Third, the developmental objective of SL should be clear i.e. to enhance the overall level of sustainability of livelihoods. In its application to agriculture, the SL approach has routinely been applied to the development of farming household typologies and is synonymous with farming systems analysis (Belsky, 1984; Perret & Kirsten, 2000; Dorward, 2002; Tefera et al., 2004; Perret et al., 2005; Babulo et al., 2008; Tittonell et al., 2010; Righia et al., 2011). The analysis focused on households rather than individual farms thereby recognizing the importance of the household as the primary decision-makers in livelihood choices. Thus, the household is seen as the decision-making hub and the outcome of the SL research is directed to improve the livelihoods of poor households. This is done by improving food security, cash income and the environment (Emtage, 2004).

3.5 **Approaches to Constructing Typologies**

There are three fundamental approaches used to construct typologies in the rural or farming context (Whatmore, 1994). These include; (1) taxonomic, a positivist approach that identifies typologies using empirical data; (2) relational, a realist approach which identifies groupings based on theoretical assumptions on structural relations; and (3) experiential, a hermeneutic approach using human reasoning to identify groups (Busck, 2002).

The taxonomic approach, also referred to as the 'positivist' approach, develops typologies on the basis of empirical data. This approach is used most frequently in developing rural typologies. Second, the 'relational' approach identifies groups by their coherent patterns of socio-economic relations by the object of study and its structural context in terms of theoretical considerations. Third, the 'experiential' approach identifies groups by the interpretation of the human actors that inhabit the land to give meaning to certain 'folk' or 'experiential' groups (Emtage, 2004).

Perret and Kirsten (2000) give another perspective on the different types of typologies by distinguishing between a 'structural' and 'functional' typology. The 'structural' typology examines the factors of production and how these are structured, while the 'functional' typology relates to the decision making of farmers within their biophysical and social environment. The structural typology is equivalent to Whatmore's (1994) relational approach, while the functional typologies are analogous to the taxonomic and experiential approach (Emtage, 2004).

More recently another way of classifying typology studies refers to the classification system used to develop the typology (Emtage, 2004). Previous typology development has followed one of, or a combination of, two main approaches found in the literature: the Qualitative Approach and Quantitative Approach (Iraizoz et al., 2007; Laoubi & Yamoa, 2009; Righia et al., 2011). How these relate to the approaches suggested by Whatmore (1994) and Perret and Kirsten (2000) will be explained in the next section.

3.5.1 Qualitative Approach

Qualitative typologies are often based on *a priori* classification and depend on expert knowledge. These classification schemes, also referred to as deductive systems, rely on the knowledge and judgment of the researcher in order to define the specific segmentation of different groups according to their characteristics (Iraizoz et al., 2007). The focus of this approach is on identifying and describing what is typical for the different types of farmers instead of defining the boundaries that cause differentiation between groups (Van Averbeke & Mohamed, 2006). Studies that have applied the qualitative approach in the development of typologies include wealth rankings, farming styles as well as studies that created constructed types (Emtage, 2004).

Within the qualitative approach, typologies can be built on formal discussions (interviews) between researchers and those being researched in a participatory fashion. Those interviewed will then identify the important differences within the population to be used as criteria in the typology development (Emtage, 2004). Alternatively, in the qualitative approach, typologies can be developed by means of the researcher's expert opinion to define types. These typologies are developed based on a priori knowledge by experts, followed by detailed on-farm questionnaires, to develop a typology on the analysis of the patterns of responses in the quantitative data (Emtage, 2004). Both of these are said to be structural typologies according Perret and Kirsten (2000). In Whatmore's (1994) classification the former corresponds to the 'relational' approach and the latter to the 'experiential' approach. Qualitative typologies have therefore most often been used in the farming styles literature.

The qualitative approach starts off with the establishment of the theoretical framework. After the theoretical framework has been identified, the next step in the typology development would be to select the criteria that will be used to measure differentiation between farm types. This is done by choosing the specific indicator variables that will be used in the analysis. The specific choice of variables will ultimately have the greatest influence on the results of the classification and is in itself a form of classification. The selected variables should be relevant and be investigated before being used in the classification scheme.

Once the theoretical framework and criteria have been selected, the researcher would then seek to formulate a provisional typology based on *a priori* classification that relies formally on the knowledge, understanding and judgment of the researcher to define the characteristics of the segmentation. These methods use mostly arbitrary and ad hoc considerations (Iraizoz et al., 2007; Gelasakis et al., 2012). Following the provisional typology by the researcher, interviews and surveys will follow on a number of the farms in the specific study area in order to verify each farm type and to establish whether or not the provisional typology is valid. Next, revisions of the provisional typology will be based on the results of the interviews until the researcher is satisfied with the results and will then produce a complete typology of the different types of farms. These are the common steps used in the qualitative approach and are illustrated in Figure 2 below.

One of the main advantages of using the qualitative approach lies in the actor-orientation towards the classification which makes sure that the farmers themselves can identify with the groups (Van Averbeke & Mohamed, 2006). Some of the disadvantages of this approach include a high dependence on the researcher; the inability to make full use of the available data; the lack of statistical foundation and the difficulty in reproducing these typologies (Iraizoz et al., 2007).

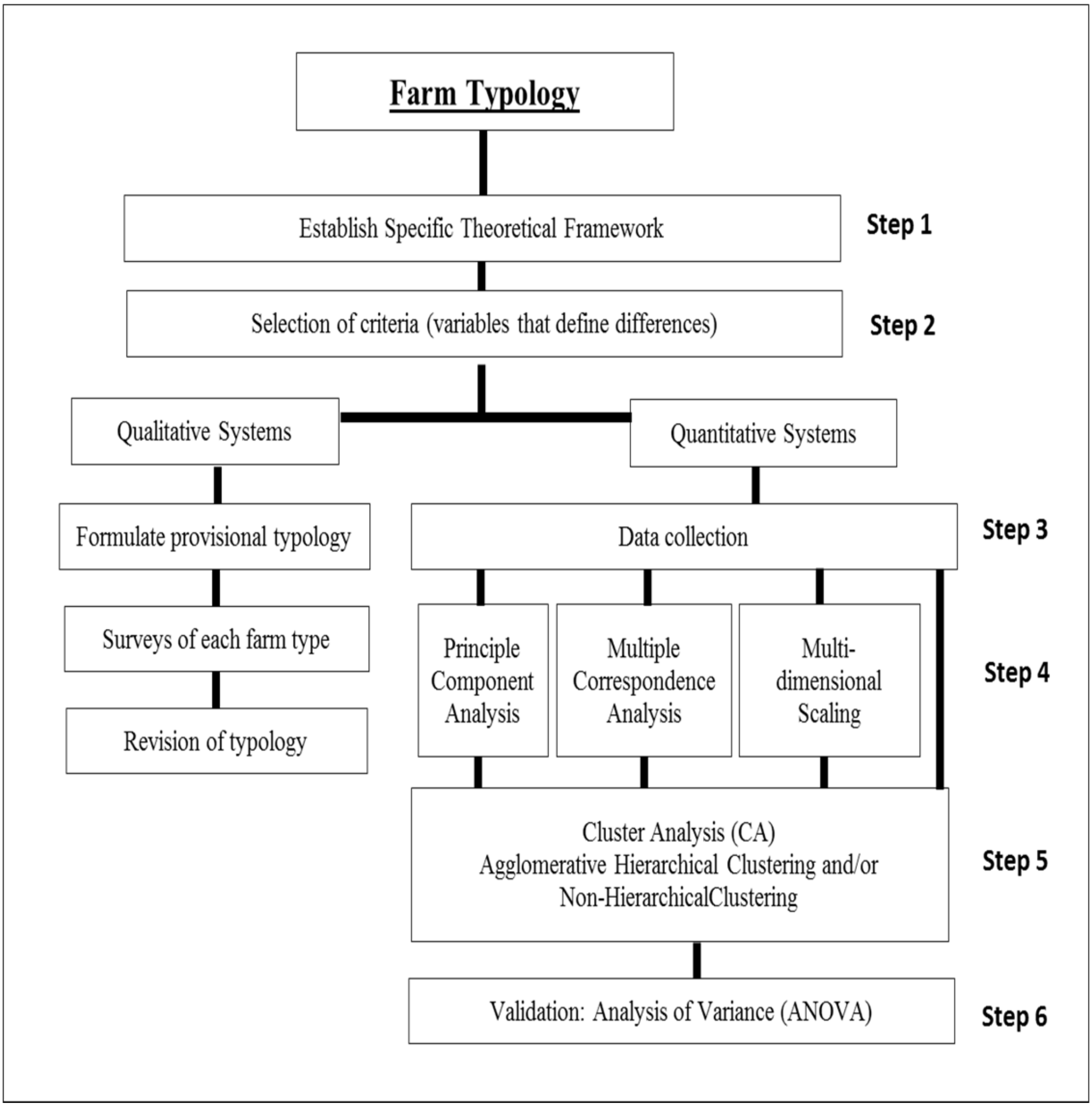

Figure 2: Steps used in both qualitative and quantitative typology development

Source: Own compilation based on Kobric et al., 2003; Emtage et al., 2005

3.5.2 Quantitative Approach

The quantitative identification and characterization process utilize multivariate analysis and study diversity by using a finite number of variables to categorize farms, which is more precise and closer to reality (Van Averbeke & Mohamed, 2006). In recent years many studies have utilized the quantitative approach in order to create farm typologies (Ballas et al., 2003; Emtage et al., 2005; Bidogeza et al., 2009; Laoubi & Yamoa, 2009; Gelasakis et al., 2012).

The quantitative approach follows the same first steps as the qualitative approach as indicated in Figure 2. These steps resemble a combination of pathways used to create farming systems

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types as proposed by Kobric et al. (2003) and Emtage et al. (2005). Figure 2 has been modified to also include the latest statistical techniques used to create typologies.

- *Step 1* and *2* in the quantitative approach, like the qualitative approach, involves the establishment of the theoretical framework and the variable selection. The selected variables should clearly relate to the features that the specific research is concerned with and the variables should have strong discriminating power which will lead to better classification of individuals (Emtage et al., 2005).

  It is important to note; across both qualitative and quantitative approaches, there is no universal rule for selecting specific variables since these would depend on the objective of the study. That being said, in farming systems classification the following variables are commonly used: farm size, income, capital, labour, resource management, production characteristics, soil quality and household demographics. According to Kostrowicki (1977) the best way to select the variables in a classification scheme is to use quantitative variables which are based on the choice of a limited number of variables of a specific characteristic and are universal, significant and representative of differentiation within these systems.

- *Step 3* involves the data collection process. This can be done by using either primary data or secondary data and would also be dependent on the specific research question. In previous studies secondary surveys that have been used include national household surveys or survey used in other studies (Dorward, 2002; Bidogeza et al., 2009; Takeshima & Edeh, 2013). Within this step, the data will also be checked so that variables with little variability, irrelevant to the specific typification, and/or show high levels of correlation should be eliminated as these would influence similarity measures between different groups (Kobrich et al., 2003).
- After the data is ready for analysis, the specific method to create the specific groups within the data is determined and applied in *step 4*. Consequently, the researcher can either move directly to Cluster Analysis (CA), or choose to use one of several data reduction tools or techniques. When CA is used directly after *step 3*, the data needs to be standardized by calculating the z-scores (Dorward, 2002; Jansen et al., 2003; Halder & Urey, 2003; Emtage & Suh 2005).

- When CA is not directly applied to the data, several statistical methods have been used in *step 4* as indicated in Figure 2. The most notable and frequently applied methodologies include Principle Component Analysis (PCA), Multi-dimensional Scaling (MDS), Multiple-correspondence Analysis (MCA) and Categorical Principle Component Analysis (CatPCA) and Principle Component Analysis (PCA) (Dossa et al., 2011; Righia et al., 2011). These techniques are all used for data reduction purposes. Variables that are significantly correlated in the main datasets can be combined or transformed in order to generate fewer variables made up of synthetic factors (Ballas et al., 2003). The new dataset retains the important information in the raw data while also discarding much of the random statistical noise. The different techniques are mostly designed to be able to facilitate different data structures and formats that would best assist the specific research method. In the past, all of these methods have been used for quantitative farming typologies (Milan et al., 2006; Blazy et al., 2009; Dossa et al., 2011; Nainggolan et al., 2011; Righia et al., 2011; Gelasakis et al., 2012; Rouabhi et al., 2012).

Out of all of the abovementioned methods, PCA has been used most consistently in farming typologies worldwide (Machethe, 2004; Maseda et al., 2004; Bidogeza et al., 2009; Dossa et al., 2011; Nainggolan et al., 2011; Madry et al., 2013). These techniques are all used to define the underlying structure in the data matrix and analyse the nature of the linkages between the large variables by a number of dimensions called factors (Iraizoz et al., 2007).

- In *Step 5* CA is applied to either the original standardized data or the new data factors created in *Step 4*. Cluster Analysis refers to a set of multivariate techniques that seek to classify objects (individuals, households, products etc.) according to their characteristics into groups (Hair et al., 1998). The literature on CA and its uses are both voluminous and diverse as this technique has been used by almost every fields of study. The terminology of cluster analysis even differs in the different field of study. Biologists and researchers in the natural sciences would often refer to it as “numerical taxonomy”, while sociologists and economists mostly refer to it as “typologies” (Anderberg, 1973). According to Makhura et al. (1999), CA is better known to be exploratory rather than a hypothesis-testing tool and is used to create groups based on measures of closeness. When the specific similarity measurement has been selected, the researcher will then decide between the two main algorithms used for clustering; Aggregative Hierarchical Clustering (AHC) and Non-Hierarchical Clustering (NHC), which are not mutually exclusive. Often these two methods have been used together which allows for one to benefit from the advantages associated with both while also minimising the drawbacks of each separately (Iraizoz et al., 2007).

- The final step in the Quantitative typification comes in the form of a validation of the results from the CA. It is important that these groups are stable and not merely imposed on the data by the classification process (Kobrich et al., 2003). There is no formal method to test the significance of optimality of the groups. Yet, one alternative is to contrast the groups according to the original hypothesis about its specific structure and with the researcher's perception of the observed empirical results. However, another method that has been often used as a means of cluster validation is one-way analysis of variance (ANOVA) tests. This enables the researcher to identify differences in variances between the clusters from the variables used in the classification (Maseda et al., 2004; Gaspar et al., 2008; Bidogeza et al., 2009; Gelasakis et al., 2012).

For the purposes of this study, a quantitative, inductive typology will be developed by using Whatmore's (1994) positivist approach. PCA is selected due to its consistent application in farming household typologies and because reduction in the dataset is needed. Furthermore, applying PCA in this study transforms the dataset into a new data matrix that does not require standardization of the variables and can be directly used in the next step of the analysis (Dorward, 2002). Hierarchical and non-Hierarchical CA will be used for the typology development, which allows for the benefit from the advantages of both and at the same time minimize the drawback associated with these individually (Punj & Steward, 1983). Lastly, CA is selected in this study as this technique has been successfully applied to typology development of farming households, in South Africa and other countries.

3.6 **Conclusion**

This chapter gives a literature review on the development of classification systems. From section 3.1, it is clear that the process of classifying objects into similar entities is central to life and is used for ordering complex data. Within agricultural systems, various schemes of classification have been developed over time to account for diversity. The earliest models wanted to classify farms according to its production orientation and economic size, expecting farms to develop on a modernization pathway towards larger and more productive farms (Andersen et al., 2007). One of the fundamental deficiencies of these classification systems were the lack of dealing with the multi-functionality within agriculture, with gave rise to new

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methodologies to classify agricultural systems such as the Farming Styles and Farming Activity approaches (Van der Ploeg et al., 2009).

According to Tefera, et al. (2004), a typology is defined as a quantitative or qualitative procedure that categorises farmers into homogenous groups, based on a certain criterion. The rationale for creating farmer typologies is to better understand structural changes in farming concerning output, employment, farming intensity and the impacts of policy. Furthermore, typologies can improve rural development planning by firstly analysing the functionality of a farm, and to provide recommendations on techno-economic matters (Emtage, 2004). From the literature, various theoretical approaches have been used in the development of farming typologies as summarized in section 3.4. These are the Farming styles, Farming context, Market structure and Sustainable Livelihoods (SL) theories. Of these, the SL theory has a history of more than 50 years and is a multi-disciplinary approach that includes complex interaction of how rural livelihoods intersect with political economic and environmental processes. It focusses on the objectives, scope and priorities for development in low-income communities with the aim of identifying policy interventions to address constraints and/or challenges in rural areas (Carney, 2003).

Section 3.5 investigated the approaches used to create typologies, which can be divided into two distinct groups: qualitative and quantitative approaches. Qualitative approaches are said to be deductive classification systems and responds to patterns in qualitative data. Whatmore's (1994) 'relational' and 'experiential' falls in the qualitative approach as well as Perret and Kirsten's (2000) structural typologies. Quantitative classification systems are more complex and utilize multivariate analysis in order to create typologies. Six steps have been identified which were summarized in section 3.5.2. The first two steps entail the establishment of the theoretical framework and the variable selection, while various methodologies can be used to create typologies in the fourth step. PCA, MCA, MDS were all data reduction techniques used to reduce the dimensions in the data. Various studies have not used step 4 and applied CA directly from the original data (Dorward, 2002). CA techniques can be divided into Hierarchical and non-Hierarchical clustering procedures, with a number of typologies using both of these in the same study to minimise the drawbacks from each of these individually. CA will then yield a cluster solution of farmers or farm households based on the selected criterion. To establish the validity of these groups, ANOVA testing is often applied to test whether or not these groups are statistically different from one another in terms of the selected variables.

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This chapter therefore concludes that a quantitative classification, applying PCA and CA would be best suited for the development of a typology of smallholder farming households in South Africa. This is due to data considerations, the need for dimensional reduction and the fact that these techniques have been successfully applied to smallholder typologies to assess livelihood strategies for rural farm households.

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Chapter

4 Methodology

4.1 Introduction

This chapter concentrates on describing the methodology used to create the proposed household typologies for South African smallholder farms situated in the former homeland areas. After careful inspection of the different methods used to create typologies and considering the objective of the research, the quantitative approach towards typologies was selected. As indicated in Chapter three, several different multivariate methods can be applied to create farming typologies. In order to segment smallholder farming households Principle Component Analysis (PCA) and Cluster Analysis (CA) have been selected as the appropriate method to create groups.

4.2 Methods

4.2.1 Step 1: Theoretical Framework

The theoretical framework adopted in this study is the Sustainable Livelihoods (SL) approach introduced in Chapter 3. The SL approach is a multi-disciplinary approach which seeks to not only look at agriculture, but includes economic, social, environmental and political perspectives (Scoones, 2009). According to Ashley and Carney (1999) SL approaches are based on the ever-changing thinking about poverty reduction, the way poor people live their lives and the importance of structural and institutional issues. The premise of sustainable livelihoods is that the effectiveness of development undertakings can be improved by 1) systematic analysis on poverty and its causes; 2) a better informed understanding of the opportunities for development and its impact on livelihoods and 3) placing people and the priorities they define as the central part of the analysis (Ashley & Carney, 1999).

This framework is chosen due to its strong association with rural development research and its strength in describing diversity at a community level. The SL approach is focussed on the objectives, scope and priorities for development in low income communities and is typically aimed at a household level rather than individual level (Emtage, 2004). Rural areas are commonly characterised by the presence of diverse economic activities, whether related to agriculture or not (Alemu, 2012). It is a well understood that rural people in Sub-Saharan Africa have a tendency to move away from natural resource-based occupations (Ellis, 1998) towards non-farm activities. This phenomenon is also found in rural South Africa where this phenomenon leads to diversified rural livelihood systems (Perret et al., 2005). Even though the majority of rural households produce agricultural products, only a very small percentage of these rely on agriculture as a main source of income. Thus, livelihood diversification is a process by which rural families construct a diverse portfolio of activities and social support capabilities in order to secure more sustainable and resilient livelihoods (Ellis, 1998).

This study focusses on socio-economic features at household level of farm households in the rural former homeland areas of South Africa. In order to understand diversification among farming systems in these areas, SL allows for dynamic analysis of the different strategies farming households undertake to attain a higher standard of living. This study uses this multi-disciplinary framework by looking at various characteristics that would define specific farm systems and includes income and expenditure, household characteristics, production activities and food security measures. SL recognises that a specific livelihood encompass more than just income (cash and in kind), but includes social institutions (kin, family, village etc.), gender relations, property rights and a few others which would influence the strategies adopted by rural households (Ellis, 1998).

This approach recognises the importance of the household as the decision-making unit which base decisions on the households' available resources, objectives, personal and socio-economic views and the rules and norms of institutions that govern the use of resources available to the household (Emtage, 2004). This framework has a been used extensively in the development of farm typologies (Belsky, 1984; Perret & Kirsten, 2000; Dorward, 2002 Perret et al., 2005) in the past and the outcome of the SL approach is designed to improve the livelihoods of poor households by improving their levels of well-being, food security, income and biophysical environment (Emtage, 2004).

4.2.2 Step 2: Data and study area

In terms of small-scale agriculture, there exists little, detailed national-level data. To date, the census of agriculture, conducted by Statistics South Africa, only includes formal, commercial farms in the sample set. Datasets that does include smallholder farming on a national level includes the Labour Force Survey (LFS), National Income Dynamics Study (NIDS), Rural Survey, General Household Survey (GHS), Income and Expenditure (IES) and Census 2011

(Aliber, 2009; May & Carter, 2009; StatsSA, 2011a; StatsSA, 2013). Of these, the GHS and IES have more recently included detailed information about farming households. Therefore, in order to develop two distinct typologies of farming households in the former homeland areas of South Africa, the 2010 General Household Survey (GHS) and the 2010/2011 Income and Expenditure Survey (IES) were utilized in this study.

The GHS is an official nationally representative household survey administered by Statistics South Africa (StatsSA) which has been conducted annually since 2002 (StatsSA, 2011a). The latest publication for the purposes of this analysis was for 2010; which consisted of 6448 households that were agriculturally active, household, and will be the one used for the study. Since 2009, the GHS has included more detailed questions on smallholder household production in South Africa (StatsSA, 2011b). Examples include mostly household questions such as: what kinds of products were produced; did the household sell produce; did the household receive government agricultural support; size of land; stock numbers; where does the household plant crops and on what basis does the household have access to land.

The IES is also a national household survey conducted by StatsSA but is only conducted once every five years. This survey captures income and expenditure data at the household level, which is then used to calculate the Consumer Price Index (CPI) of goods and services in South Africa (StatsSA, 2012). This dataset also includes detailed questions regarding smallholder agriculture, not only on their income and expenditure on household goods, but also on their agricultural production systems.

The sampling framework for both of these surveys is based on StatsSA’s Master Sample (MS) that is based on the Population Census of 2001 enumeration areas. Both of these surveys had a two-stage stratified design sample with a probability proportional to size selection of the primary sampling units (PSU) in the first stage. After allocating the sample into provinces, the primary stratification was defined by geographic area type, which was divided into metropolitan and non-metropolitan areas. Secondary stratification was based on the 2001 Census data and used the following variables: household size, education, occupation, gender, industry and income (StatsSA, 2011b).

In order to sample smallholder farming households located in the former homeland areas of South Africa, Geographic Information Systems (GIS) were used and applied to both the GHS and IES. A geographic shape file from the Department of Rural Development and Land

Reform (2004) was used to locate the former TBVC/Homeland areas as they were spatially administered under the Land Acts of 1913 and 1936 (Table 3).

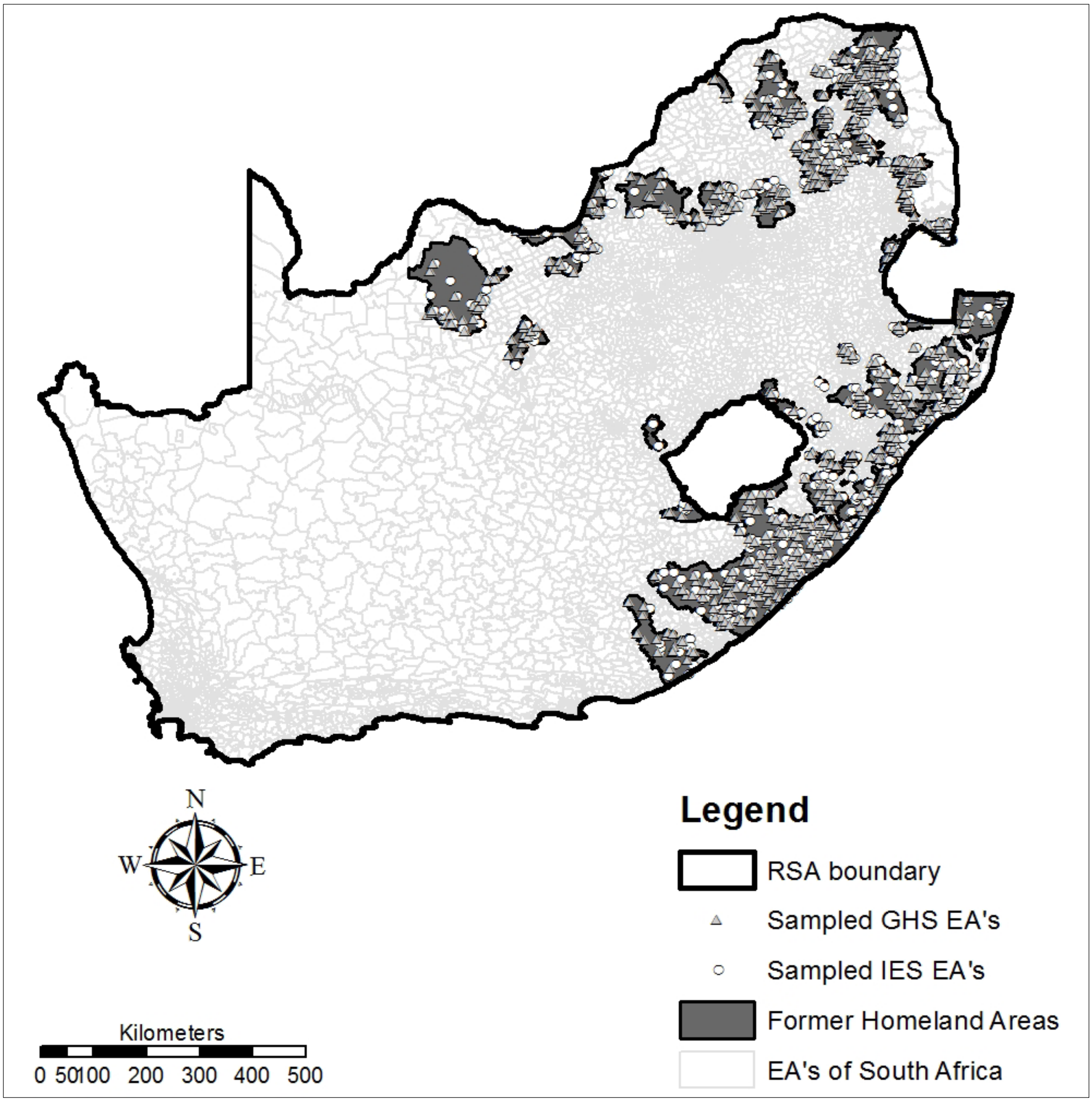
Table 3: Land area of the Former Homelands

Former Homeland States	Hectares	% of Total RSA
Transkei	4426338	3.63
Bophuthatswana	3801642	3.12
KwaZulu	3606063	2.96
Lebowa	2217131	1.82
Ciskei	799223	0.66
Gazankulu	739838	0.61
Venda	648729	0.53
Kangwane	351214	0.29
Kwandebele	325893	0.27
Qwaqwa	104985	0.09
Total Area	17021056	13.96

Source: DRDLR, 2004

The former Homeland/Bantustan areas consisted of 10 distinct "states" which made up 13.96% of the total 122.1 million hectares of land in South Africa. Out of the ten former "states", the Transkei area was the largest with 4.42 million hectares, followed by Bophuthatswana and KwaZulu with 3.80 and 3.61 million hectares respectively. The geographic boundary information of the former homeland areas allows for the effective sampling of households located in the former homeland areas. This was done by using the smallest geographical unit, Enumerator Areas (EA) that enumerate or divide a country for census purposes, which are used in StatsSA's survey methodology to spatially administer these surveys (Mokgokolo, 2011). Thus, each household would have an EA number and can therefore be broadly spatially located.

Using GIS techniques, all of the included files were transformed to the Hartebeesthoek 1994 Geographic Coordinate System (GCS) for consistency and the "joins" and "relate" function in ArcGIS (geographic computer software) were used to join the relevant geographic information together. In other words, by joining the EA codes together with the boundaries of the former homeland areas, only EA's whose centroids (most central point) were located inside the former homeland boundary were selected. This enabled the effective extraction of only the EA's that are situated inside these invisible boundaries. Using this new "Attributes Table" in ArcGIS, it is possible to extract these EA numbers as a variable into the main survey datasets and to generate a dummy variable (value of 1 if inside and value of 0 if not) for every household within the GHS and IES respectively. The result of this process is given in Map 1 below. Here the former homeland areas are indicated in dark grey while all the EA’s within South Africa are indicated with light grey lines. The small, darkened triangles represent the specific EA’s that were sampled within the GHS, while the white dots indicated those from the IES.



Map 1: Location of homelands and enumerator areas in GHS 2010 and IES 2010/11

Source: Own compilation based on DRDLR, 2004

The sample used in the study thus included only households situated geographically within these areas. Further, for both the GHS and the IES datasets, only households involved in agricultural production within the specific survey year and which were located in the former homeland areas were identified and extracted to form the sample set used in the analysis (see Table 4 below).

Table 4: Sample size of smallholder households

Survey	Number of households	Population
GHS 2010	3540	1585683
IES 2010/2011	2999	1403411

Source: GHS 2010 and IES 2010/11

It is important to note is that when these households were identified, 99% were listed as living in black (household head being black) households in both of these surveys. It was decided to therefore only include the black farming households in this study as this was the majority, in the context of separate development and the South African history of the study area. The data was checked for both samples and missing values for the relevant variables and data corrections reduced the sample for the analysis to 3540 households in the GHS sample, while the IES sample had 2999 households as indicated in Table 4. By using the household weights this amounted to approximately 1.59 million households in the GHS and 1.4 million households in the IES sample.

4.2.3 Step 3: Variable selection

The selection of the variables is one of the most important steps in the analysis and will have the greatest impact on the ultimate results (Kobrich et al., 2003). Based on the selected SL framework, variables were selected to describe differentiation between households in terms of livelihood strategies. According to Kobrich et al. (2003) variables selection is generally based on three grounds; 1) the researchers' experience and knowledge of the study area, 2) the objectives of the specific typology and 3) the quantitative information that is available. Variables selection in this study is also guided by the variables selection in various other farm typologies found in the literature. Important to note; the data from both the GHS and IES had only a limited number of variables that could be used in the analysis as these survey instruments are not designed to specifically facilitate typology development and needed to be appropriate for the multivariate statistical analysis.

Prior to PCA, the two datasets used in the analysis were investigated for the appropriateness of PCA; to ensure that variables were dependent on each other and that they were not too strongly correlated to one another. Two tests generally applied in the literature to assess the validity of the data and variable selection for PCA were used (Bidogeza et al., 2009). The Kaiser-Meyer-Olkim (KMO) (1970) measure for sampling adequacy was firstly used which measure the strength of connection between variables and gives a value between 0 and 1. This measure is a summary that indicates the proportion of variance in the selected variables that might be caused by underlying factors. A value of 0 indicates that the sum of partial correlations is large relative to the sum of the correlations, suggesting that a form of factoring the selected variables would be inappropriate. A value close to 1 would however indicate the correlation between variables is relatively compact and PCA should yield stable and reliable factors (Field, 2009). The general rule states that if the KMO value is greater than 0.5, the amount of correlation among the selected variables in the data is acceptable. Thus, a KMO measure of greater than 0.5 would suggest that the selected variables are indeed dependent on one another and acceptable for use in PCA.

Secondly, Bartlett's test of sphericity was used which tests the null hypothesis that the original correlation matrix of the proposed dataset is an identity matrix. If this is the case, all the correlation coefficients between the variables would be zero and it shows that all the variables are perfectly independent from one another and therefore does not add to the proposed finding of factors that measure similar things (Field, 2009). Thus, a p-value of smaller than 0.001 would suggest that the null hypothesis is rejected, indicating that the correlation matrix is significantly different from an identity matrix, and that there is sufficient correlation between variables (Iraizoz et al., 2007). Both of these tests were performed and applied to the two datasets used in the study. These were applied based on the fact that these two tests are standard statistical test applied to PCA analyses and for its wide application in farm typology studies that have used PCA in its classification systems (Maseda et al., 2004; Bidogeza et al., 2009; Riveiro et al., 2013)

These selected variables are listed in Table 5 which aggregates these variables into four categories; namely, household characteristics, income & expenditure, production characteristics and food security. This Table also shows the different variables used in the development of the typology from both the GHS and IES datasets.

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Table 5: Variables used in the typology of smallholder farming households

Category of Variable	Variable Name	Definition	GHS	IES
Household characteristics	Head_age	age of head	Yes	Yes
	Head_education	years of education of head	Yes	Yes
	Head_gender	gender of head	Yes	Yes
	Married	marriage status of head	Yes	Yes
	HHsize	size of the household	Yes	Yes
	Grant_receivers	number of grant receivers in hh	Yes	No
	Economically_active	number of economically active in hh	Yes	No
	HH_children	number of children in household	Yes	Yes
Income and Expenditure	Income_salary	monthly total hh salary income	Yes	Yes
	Income_childgrant	monthly total hh child-grant income	Yes	Yes
	Income_oldagegrant	monthly total hh old-age grant income	Yes	Yes
	Income_remittance	monthly total hh remittance income	Yes	Yes
	Expenditure_total	monthly total hh expenditure	Yes	Yes
Production Orientation	Hectares	size of farming land	Yes	No
	Land_farmland	produced on farmland	Yes	No
	Land_backyard	produced in backyard	Yes	No
	Inventory_cattle	cattle livestock units	Yes	No
	Inventory_sheep	sheep livestock units	Yes	No
	Inventory_goats	goat livestock units	Yes	No
	Inventory_chicken	chicken livestock units	Yes	No
	Agric_gov_support	did household receive farmer support	Yes	No
	Whyprod_mainincome	why produce, as main income source	Yes	No
	Whyprod_extraincome	why produce, as extra income source	Yes	No
	Whyprod_extrafood	why produce, as extra food source	Yes	No
	Business_act	business activity	No	Yes
	Inputcost_crop	monthly crop input expenditure	No	Yes
	Inputcost_livestock	monthly livestock input expenditure	No	Yes
	Inputcost_services	monthly agricultural services expenditure	No	Yes
Food security	Hunger_child+adult	hh members went hungry during year	Yes	No
	Percap_food_exp	total food expenditure divided by hh size	No	Yes

Household characteristics

In livelihood analysis, the household demographics play an important part in understanding diversity and have routinely been included in typology research (Perret et al., 2005; Bidogeza et al., 2009). The variables included in this category are the age, education, gender and marital status of the household head as well the household size, the number of grant receivers and economically active households members, these matter because a livelihood

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encompasses social and kinship networks for facilitating diverse income portfolios as well as gender relations (Ellis, 1998). Furthermore, the household characteristics would also influence the different income sources within the household and would therefore influence livelihood decisions.

Income and Expenditure

The income and expenditure variables are very important for the analysis. In this study, only the main income sources of the rural households were included. These were salary income, old age grant income, child grant income and remittance income and included as monthly rand values. Expenditure was included in the study as total monthly household expenditure, because this was the only question asked regarding expenditure patterns in the GHS. For consistency purposes, this exact variable is also used even though more expenditure variables are available in the IES survey.

Production Orientation

These variables typically characterise the production systems within households. In this category there are big differences in measurement between GHS and IES. Again, the selection of variables is dependent on the specific dataset and the questions asked during the survey year. In the GHS, farm characteristics include farm size; number of cattle, sheep, goats and chickens; the place where crop production takes place (farmland or backyard) and the reasons for production as binary variables. The other two included variables relates to whether or not households received agricultural support from government and whether or not a household was involved in business activities.

In the IES dataset, production orientation is defined by the expenditure patterns on farming. This would give valuable insight into the farm cost structures of the household and is divided into crop, livestock and services inputs. These were the only variables that characterised households in the IES on their production orientation and are included as total monthly household expenditure on these inputs.

Food Security

The most basic definition of food security refers to the ability of an individual to obtain or have access to sufficient food (Du Toit, 2011). To determine food security has, however, become a complex exercise because of the multiple definitions and indicator that exist in a wide range of disciplines (Altman et al., 2009). In South Africa, various different methods to access food security at a household level have been used (De Cock et al., 2013). Of these, the

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GHS and IES are often used to assess household food security and each will probe a different dimension, as is the case in the selection of indicators in this study (Aliber, 2009; Altman, et al., 2009). In the GHS, food security is based on the self-reported experience of food security by the prevalence of hunger within households. The variable included in the GHS is binary giving a value of 1 if the household had an adult or child who indicated that they experienced hunger in the last 12 months[3].

In the IES, a variable was created and includes the per capita expenditure on food within each household. It is expected that this variable would indicate the levels of food security in the sense that food insecure households are expected to spend less money on food per individual within the household. The complex and multi-dimensionality of food security makes it very difficult to measure and no perfect singe measure exist that capture all aspects of food insecurity (Webb et al., 2006). However, these variables are still important and included as indicators to account for food insecurity in the development of the household typology.

4.2.4 Step 4: Principle Component Analysis

The central idea behind Principle Component Analysis (PCA) involves the reduction of dimensions found in a set of data containing a large number of interrelated variables, while simultaneously retaining the maximum amount of variation in the dataset (Jolliffe, 2005). This is accomplished by transforming the data into a new dataset comprised of a new set of variables, the principle components, which are scores, calculated for the underlying dimensions in the data. These resulting components are then syntheses of the original raw data and by using these new variables will avoid the need to standardise or transform the variables for the next step in the analysis (Gaspar et al., 2008).

To generate these synthesized data sets, a statistical technique, which condenses the selection of initial set of variables into a smaller number of discrete, non-correlated components or set of factors, is undertaken (Jackson, 1991; Everitt & Dunn, 2001; Joliffe, 2005; Nainggolan et al., 2011). The resulting absence of correlation between the factors is a useful property indicating different dimensions in the data (Manly, 1986).

The analysis starts by taking p variables X_1, X_2,...,X_p, across *n*-households and finding combinations of these to produce a new set of indices, Z_1, Z_2,…, Z_n, that are uncorrelated

[3] Hunger is defined as “Always” or “Often” going hungry due to a lack of sufficient food in the preceding 12 months. The variable of interest presented here considers the question for adults and children, though they are similar when analyzing, and are also robust to classifying “Sometimes” as hungry.

(Manly, 1986). The first principle component is then the linear combination of the variables $X_1, X_2, \ldots, X_p$, and is given by:

$$Z_{1i} = \alpha_{11}X_{1i} + \alpha_{12}X_{2i} + \cdots \alpha_{1i}X_{pi} \qquad (1)$$

where;

$$\alpha_{11}^2 + \alpha_{12}^2 + \cdots \alpha_{1p}^2 = 1 \qquad (2)$$

This linear combination maximises the variance for the *X* variables amongst all such linear combinations and the coefficients are found as the eigenvectors (α) of the sample covariance matrix (Everitt et al., 2011). The first component contributes the most to the variance as contained in the *n* number of the original variables (Essa & Nieuwoudt, 2003). The second principle component, Z_2, is defined as the linear combination of the original variables that accounts for the remaining variance, subject to being uncorrelated with the first principle component, i.e.;

$$Z_2 = \alpha_{21}X_{1i} + \alpha_{22}X_{2i} + \cdots \alpha_{2i}X_{pi} \qquad (3)$$

Further principle components are defined in the same way following Z_1 and Z_2. These Z-scores are uncorrelated to one another and if there are *p* variables then there can only be *p* principle components (Manly, 1986). This method was applied to both datasets used within the study and the variables selected to conduct the quantitative analysis were used to construct factors by using PCA.

Once the factors from PCA are extracted, it is possible to apply a technique called factor rotation. Rotating factors involves the rotating of factors such that variables are loaded maximally to only one factor (Field, 2009). This is often needed when factors have high loadings on the most important factor and small loadings on others. Thus, factor rotations ensure that the loadings of the variables are maximized onto one factor and minimized on the remaining factors (Field, 2009). In this study, the factors from PCA were rotated using the orthogonal vari-max rotation which ensures that a smaller number of highly correlated factors be loaded into each factor for easier interpretation purposes and to ensure that the new factors are uncorrelated (Bidogeza et al., 2009). This rotation maximizes the sum of these variances for all of the factors (Manly, 1986).

In the PCA the Kaiser criterion was used which retains all factors with an eigenvalue greater than one, which is considered to be accurate if the number of variables in the analysis is less than 30 (Bidogeza et al., 2009). The eigenvalue is the sum of squared loadings for a factor and conceptually represents the amount of variance accounted for by a factor. Statistica and SPSS were used to generate the outputs for the PCA. The output from PCA is a complete new data matrix comprised of a few principle components that explain most of the dimensions in the original dataset and can now be used in the next step of the typology development.

An important and useful output from PCA is the factor loadings table, which will be used for interpretation in the results section of this study. Factor loadings give valuable understanding of the relative contribution that an initial variable makes to a specific factor from the PCA (Field, 2009). Factor loadings in any given analysis can both be given as correlation coefficients or regression coefficients, depending on the different rotation applied. In the case of using an orthogonal rotation, as in this study, the factor loadings are the correlation coefficients between the specific factor and the original variables (Field, 2009). These factor loadings therefore would give valuable understanding of the underlying nature of a particular factor; by indicating the variables that are strongly associated (correlated) with it. This shows which original variables "load" onto the same factor and would identify common theme in the data. In order to simplify interpretation of these factor loadings, Stevens (2002) suggests highlighting loading greater than 0.4. This is widely applied to PCA analysis for easier analysis of results and will also be done in this study (Bidogeza et al., 2009; Field, 2009).

4.2.5 Step 5: Cluster Analysis

In order to segment smallholder farming households, Cluster Analysis (CA) was chosen due to its strength in finding homogenous groups based on a wide range of variables. Cluster Analysis is a generic name given to a variety of mathematic methods used to find which object in a set are similar (Romesburg, 2004). The literature on cluster analysis and its uses is both voluminous and diverse, as this technique has been used in almost every field of study. Biologists and researchers in the field of natural sciences often refer to it as 'numerical taxonomy', while sociologists and economists mostly refer to it as 'typologies' (Anderberg, 1973). Most applications of cluster analysis consist of mathematical partitioning of the data in some form or another, where each individual, in this case households, belongs to a single group.

In a typical example in this study, households are described by various indicators such as household size, farm size, years of education, income, livestock numbers and all of the variables included in Table 5 indicated in section 4.2.3. This specific household with various characteristics is analysed in PCA to realise the most important factors which explain variation with the data. Each factor from PCA will explain a trend in the underlying data and will now be considered to be the explanatory variables in CA. As in many other farming typology cases, the results from the PCA will be used as the input variables for the clustering (Ballas et al., 2003; Maseda et al., 2004; Gaspar et al., 2008; De Graaf, 2011). Thus, these variables need no further standardization or transformation to be used in CA, and also do not have the problem of dealing with different kinds of variables.

The objective or primary use of CA is to find optimal groupings of households which are similar so that each group has a high degree of natural association within the groups and natural disassociation between groups. In order to identify clusters in the data it is necessary to have knowledge on how 'close' individuals are to one another. The resulting z-scores from PCA can now be used for cluster analysis and is ordered in the usual *n x p* multivariate data matrix given by equation 4 below. The different values of each explanatory variable are given by **Z**, which describes each household to be clustered:

$$\mathbf{Z} = \begin{bmatrix} Z_{11} & Z_{12} & Z_{1p} \\ Z_{21} & Z_{22} & Z_{2p} \\ Z_{31} & Z_{32} & Z_{3p} \\ \vdots & \vdots & \vdots \\ Z_{ni} & Z_{ni} & Z_{np} \end{bmatrix} \qquad (4)$$

In this matrix, Z_{ij} in **Z** gives the z-score of the i_{th} variable on the j_{th} household. The rows correspond to the variables of interest (in this case the factors form the PCA output) while the columns correspond to the different households in the data. In order to understand the closeness between different households, proximity measures are used to identify dissimilarities, similarities and distance between elements in the data (Everitt et al., 2011). In clustering households in the data, the units of proximity are usually expressed as a distance, and will be dependent on the format of the specific data used in the clustering procedure. In the case of using the components from the PCA results, the distance measure most commonly used is the Euclidean distance, which is also employed in this study. It is given by:

$$D_{12} = \left[\sum_{k=1}^{p} (z_{1k} - z_{2k})^2 \right]^{0.5} \qquad (5)$$

Where D is the Euclidean distance between the 1st and 2nd households in the data matrix, determined by the *p* number of *z* variables, within the d-dimensional dataset. This commonly used distance function satisfies all of the conditions for a metric similarity measure according to Xu and Wunsch (2009) which include symmetry, positivity triangle inequality and reflectivity.

The Cluster Analysis conducted in this study was performed in two distinct stages. First, a hierarchical clustering method was used to create clusters of households within the sample. This method uses the similarity matrix to create a dendogram used to depict the relationships among the different households (Anderberg, 1973). The dendogram is a two-dimensional diagram illustrating the way partitioning was done with the clustering procedure at each level and will be used to illustrate the hierarchical clustering results in this study (Everitt, 1974). The technique starts with each cluster comprising of exactly one household and combines the nearest clusters until there is only one cluster left, consisting of all of the households in the sample (Chandra & Prabuddha, 2009). This clustering method fuses individuals together which are the closest to each other and can vary in terms of the specific agglomerative techniques used. The algorithm used in this analysis was Ward's (1963) method and as mentioned earlier, the Euclidean distance measure. Ward's method encompass most of the different hierarchical clustering methods by merges chosen at each stage as to maximize an objective function which is an error sum of squares objective function.

The second, non-hierarchical method was then used which followed the abovementioned method by clustering the data units into a single classification of cluster determined by *a priori* selection (Anderberg, 1973). Using the results from the hierarchical clustering, it is possible to decide on the number of clusters in the data by referring back to the dendogram. Similar to hierarchical clustering, non-hierarchical clustering procedures have a wide range of different algorithms used. The k-means, non-hierarchical clustering method is one of the most popular and it forms clusters by specifying the number of clusters into *k* number of clusters or groups with each partition representing a cluster. Its name refers to the k-means algorithm used to calculate the mean (centroid) of each cluster (Yan, 2005). This algorithm is not based on a distance measure as used in hierarchical clustering, but uses within-cluster variation as a measure of homogeneity to segment the data so that within-cluster variation is minimized (Mooi & Sarstedt, 2011). It defines a group or prototype in terms of a centroid, usually the mean of a group of points, and it makes use of within-cluster variation measure, to create groups so that within-group variance is minimized (Kumar et al., 2006; Mooi & Sarstedt, 2011).

A fundamental problem within cluster analysis relates to the determination of the number of clusters to be used in the CA. Cluster solutions may vary as different cluster solutions are specified and there have been a number of strategies employed to find the optimal number of clusters in a dataset (Yan, 2005). According to Bidogeza et al. (2009) there is no single method to determine the most suitable number of clusters and therefore both hierarchical and non-hierarchical methods are often used together to enable stability within the approach. According to Kobrich et al. (2003), these methods can be divided into heuristic procedures and formal tests to establish the optimal number of clusters to be retained. Of these two, the former is most often used and it relates to using the dendogram from the hierarchical clustering output. The dendogram can be dissected through subjective inspection of the cluster solution or can be more formally done by plotting the number of clusters against the change in the fusion coefficient. In both of these heuristic procedures, subjectivity is involved to find the optimal number of clusters in CA (Kobrich et al., 2003). Furthermore, the number of clusters must be realistic with regards to the empirical situation of the specific analysis in order for meaningful classification (Bidogeza et al., 2009). In this study, the dendogram will be used to find the optimal cluster solution and will be based on cutting the dendogram at linkage distance where an additional combination of clusters would occur at a much higher distance (Mooi & Sarstedt, 2011).

4.2.6 Step 6: Cluster Validation - ANOVA

When the CA is completed and clusters within both of the samples have been identified they need to be validated to make sure these groups are not merely imposed on the data. According to Kobrich et al. (2003) there is no formal method to validate typologies on the basis of optimality or significance. In general, the validation of the proposed clusters can be done by using the analysis of variance (ANOVA) to test whether or not the groups differ in terms of specific quantitative variables, while the Chi^2 test was performed for quantitative variables in the analysis (Maseda et al., 2004; Gaspar et al., 2008; Blazy et al., 2009; Bidogeza et al., 2009; Joffre & Bosma, 2009).

The ANOVA tests the null hypothesis that all the means of the specific groups are equal. This produces an F-statistic which compares the amount of systematic variance in the data to the unsystematic variance (Field, 2009). Thus, the F-statistic indicates whether or not the means of three or more groups are not equal. The P-value would then indicate to what statistical degree one could reject the null hypothesis. This study used the ANOVA test and the results are given together with the final cluster results in the next chapter.

4.3 Conclusion

This chapter have concentrated on describing the methodology used in this study. In section 4.2.1 the selection of the Sustainability Livelihoods (SL) approach, as the theoretical framework to be used in the analysis, are explained. It stems from the strong association with rural development research and in describing diversity among farming households. SL approaches recognize the presence of diverse economic and social activities within rural communities, whether farm related or not. SL approaches tends to analyse the households as the economic unit, which base decisions on the households' available resources, objectives and socio-economic views (Scoones, 2009).

In Section 4.2.2, the data and study area for the research is introduced. The GHS and IES national household surveys are used for the development of the smallholder typologies of South African smallholders. In order to sample former homeland households, GIS techniques are utilized as a means to geographically locate the farming families. The former homeland areas consisted of 13.96 % of the total South African land area and the farming household sample population was between 1.4 and 1.5 million in total. The variable selection, a very important step in the analysis, was guided by various factors and the variables are grouped into four broad categories: household characteristics, income and expenditure, production orientation and food security.

Section 4.2.3 and 4.2.4 gives detailed descriptions of the methodology regarding PCA and CA respectively. PCA involves the reduction of dimensions within the original dataset, while retaining the maximum amount of variation (Jolliffe, 2005). This procedure gives principle component factors that are linear combinations from the original variables, each explaining a different "dimension". These dimensions can be characterised by the factor loadings from PCA indicating the correlation coefficients between the specific component and the original variables (Field, 2009). The next step in the analyses uses the resulting factor-scores from PCA, which needs no further standardization, to be used in CA as the explanatory variables. In CA, optimal groupings are found so that within-group variance is maximised and between-group variance minimised (Iraizoz et al., 2007). This is done by firstly using a Hierarchical clustering procedure that fuses households into clusters based on a measure of proximity, in this case the Euclidean distance (Xu & Wunsch, 2009). These results are typically given in the form of a dendogram; a two-dimensional diagram illustrating the cluster partitioning. Secondly, non-hierarchical clustering follows by *a priori* selection of the number of clusters

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(guided by the results from the dendogram). The k-means clustering procedure is used which relates to the k-means algorithm used to calculate the mean of each cluster, and segments clusters so that within cluster variation is minimised (Mooi & Sarstedt, 2011).

Finally, this chapter ends with section 4.2.6 by suggesting a possible cluster validation. The suggested method, and often used, is the ANOVA test which tests the null hypothesis that all the means of the specific groups are equal. The hypothesis is rejected if the ANOVA yield high f-values or alternatively p-value of smaller than 0.01.

Chapter

5 Results and Classification of Smallholder Farming Households

5.1 Introduction

This chapter will provide the detailed results of the findings of the study. Firstly, a descriptive analysis of the variables used in the analysis will give context on the current welfare of the smallholder farming sector in the former homeland areas of South Africa. The General Households Survey (GHS) and the Income and Expenditure Surveys (IES) will be used interchangeably to assess different dynamics within the sector. Next, the results from the Principle Component Analysis will be presented and the key factors will be identified and discussed. Lastly, the results of the two different typologies from the Cluster Analysis will be provided for both the hierarchical and non-hierarchical methods, followed by some discussions on the main findings.

5.2 Descriptive Analysis

In order to provide a basic understanding of the sample population under analysis, descriptive statistics on key variables that define the smallholder farming sector in the former homeland areas, are presented and discussed. Table 6 below summarizes the mean and standard deviation of these variables across the two datasets, aggregated into the four main categories; namely, household characteristics, Income and expenditure, Agriculture orientation and Food security. The subsequent descriptive analysis will discuss the main findings within the different categories by referring to Table 6 and at the same time will give additional information form the datasets used within each category.

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Table 6: Descriptive statistics

Category	Variable Name	Units	GHS (n = 3540) Mean	GHS (n = 3540) St. Dev.	IES (n = 2999) Mean	IES (n = 2999) St. Dev.
Household characteristics	Head_age	year	55.27	16.42	56.52	15.54
	Head_education	year	5.19	4.46	5.12	4.34
	Head_gender	% yes	42.68	49.46	41.01	49.19
	Married	% yes	49.15	50.00	34.11	47.42
	HHsize	#	4.89	2.65	5.21	2.63
	Grant_receivers	#	2.28	0.04	-	-
	Economically_act	#	0.49	0.71	-	-
	HH_children	#	1.90	1.69	2.00	1.64
Income and Expenditure	Total Income[4]	ZAR	1765.00	3229.08	1856.08	3361.17
	Income_salary[4]	ZAR	0.00	3286.35	0.00	3372.94
	Income_childgrant[4]	ZAR	250.00	405.68	256.00	380.88
	Income_oldagegrant[4]	ZAR	0.00	719.82	0.00	717.21
	Income_remittance[4]	ZAR	0.00	505.30	0.00	604.53
	Expenditure_total	ZAR	1247.45	1255.10	3461.52	3143.51
Production Orientation	Hectares	ha	0.32	0.51	-	-
	Land_farmland	% yes	12.88	33.50	-	-
	Land_backyard	% yes	73.45	44.17	-	-
	Inventory_cattle	#	2.44	6.92	-	-
	Inventory_sheep	#	2.84	14.61	-	-
	Inventory_goats	#	2.49	6.40	-	-
	Inventory_chicken	#	7.66	13.82	-	-
	Agric_gov_support	% yes	18.25	38.63	-	-
	Whyprod_mainincome	% yes	0.88	9.32	-	-
	Whyprod_extraincome	% yes	4.52	20.78	-	-
	Whyprod_extrafood	% yes	86.84	33.81	-	-
	Subsistence_buss_income	% yes	-	-	2.77	0.16
	Inputcost_crop	ZAR	-	-	23.81	65.27
	Inputcost_livestock	ZAR	-	-	157.05	725.57
	Inputcost_services	ZAR	-	-	8.81	34.82
Food security	Hunger_child+adult	% yes	16.55	37.17	-	-
	Percap_food_exp	ZAR	-	-	240.77	290.22

Source: GHS 2010 and the IES 2010/2011

5.2.1 Household characteristics

The average age of the heads of households across both datasets was relatively advanced in age with an average of 55.2 years in the GHS sample and 56.5 for the IES. Figure 3 gives the

[4] The central tendency of the income variables are given as the median. Seeing that these income variables were highly skewed, median values give a more clear understanding of the distribution of income. Section 5.2.2 give more detailed explanation on this phenomenon.

age distribution of all the individuals who are located in households involved in agricultural production that were included in the GHS dataset. This represents 8.08 million individuals located in 1.58 million black households involved in some kind of agricultural activity. The age structure of the population indicates that there were approximately 3.87 million children (age 17 years and younger) living in these households. Females represented 53% of the total population, which was a higher proportion of individuals compared to males (47%).

After the age group of 10-14 years, the population total decreases substantially up until 44 years of age, thereafter stabilizing to approximately 87 000 for males and 180 000 for females. This indicates a tendency of younger adults in these areas to migrate out of these rural areas; males did so at an increasing rate.

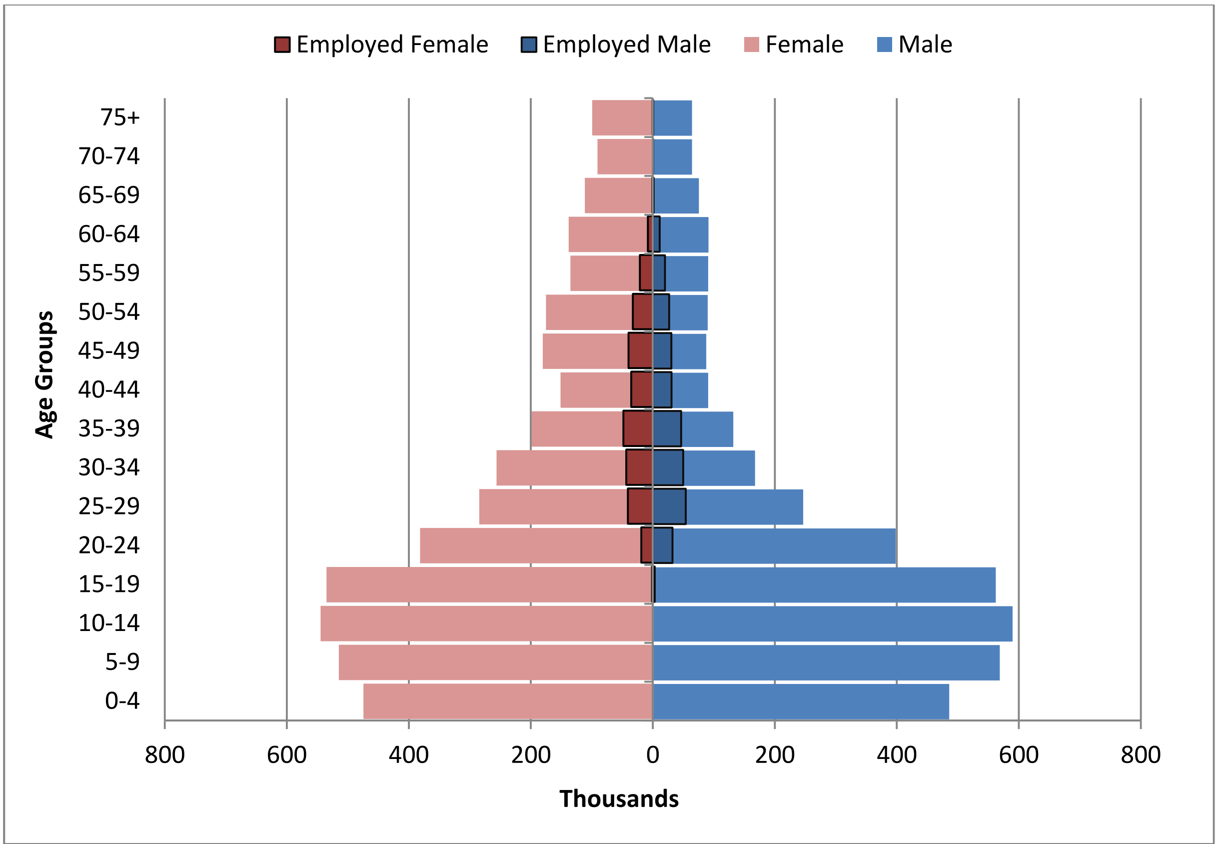

Figure 3: Age distribution and employment numbers of the former homeland farming population

Source GHS 2010

This phenomenon can be explained by the general urban rural migration of individuals to places of employment (Posel, 2010). From the age groups greater than 25 years, the female population increasingly outnumbers the male. Women outnumber men because men often become migrant workers sending remittance payments to family members back home

(Fenyes & Meyer, 2003). Thus, agricultural households mostly consist of elderly (typically grandmothers) with a high child dependency burden. Figure 3 also indicates the number of employed people living in these agriculturally active households that were of working age (between 15 and 65 years). It indicates very low levels of formal employment with only 15% of males and 12% of females working for wages.

By further inspection within the age structure of these households involved in farming, Figure 4 gives the age distribution of the household heads. It suggests an ageing population structure without many younger families being established. Households, on average, were led by household heads that were older than 50 years of age, while there were still many children living in these families. There were substantially more female household heads, on average, compared to males of the same age groups. It is concerning to see that there are not many younger households being established in these areas and therefore suggests that farming households would decrease in the future with not enough replacement for the older households involved in farming. From the ages of 15 to 54, there are relatively more female household heads compared to males in agriculturally active households. This would suggest that younger males, on average, would be less likely to settle in these rural areas with a family. It is only from age group 55-59 that the male/female ratio becomes closer to unity.

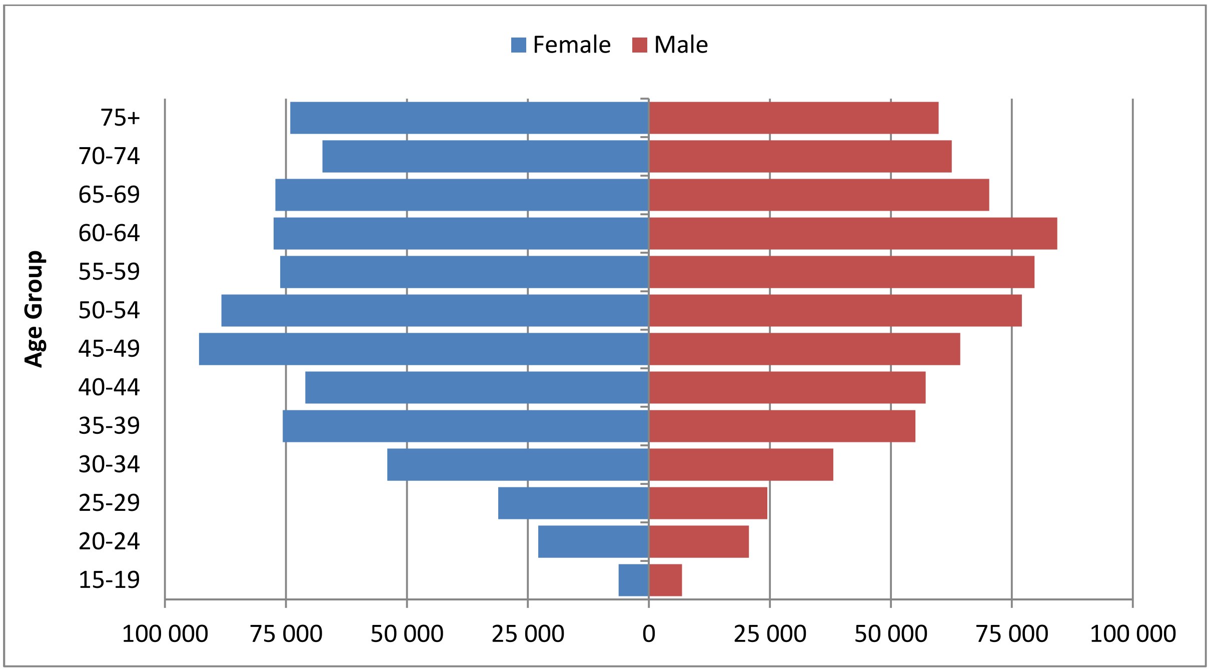

Figure 4: Age distribution of household heads within agricultural households

Source: GHS 2010

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The average levels of education were low, with most of the household heads having completed approximately 5 years of education; the equivalent of grade 5. In both samples there is an inverse relationship between the age and years of education among the household heads. This relationship is illustrated in Figure 5 by showing the years of educational attainment over time in the form of the different age groups. It clearly shows that the older these households' heads were the lower the years of education.

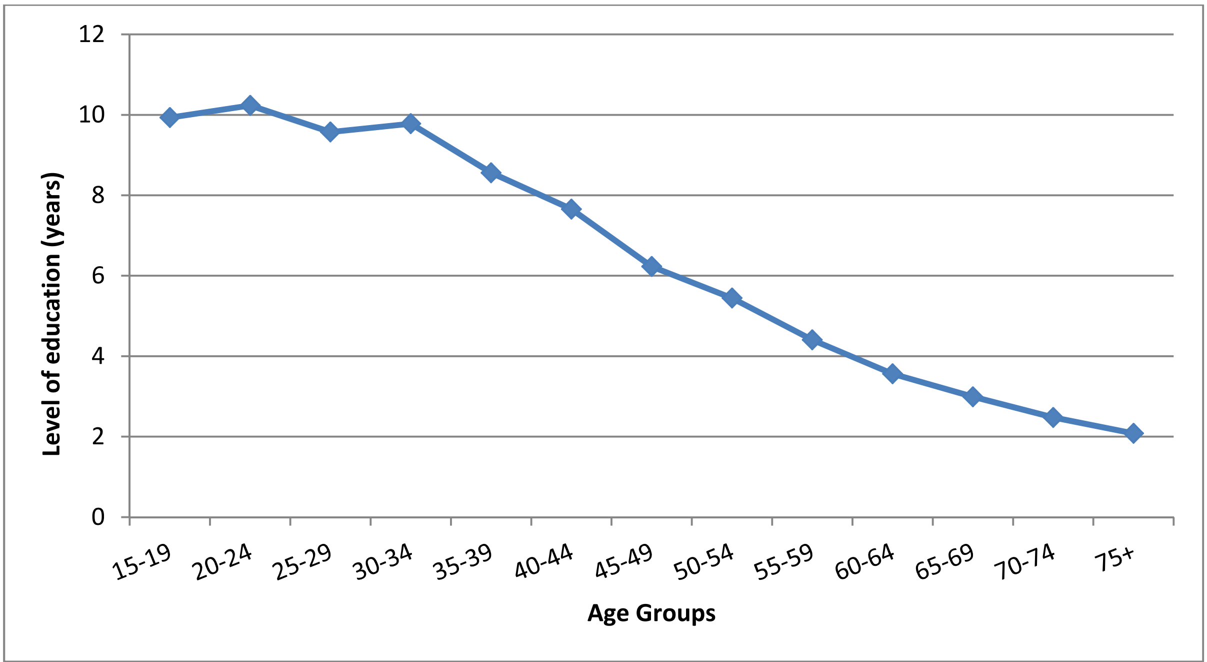

Figure 5: Level of education across age groups of household heads

Source: GHS 2010

This phenomenon is widely associated with the older black household heads in the former homeland areas which were heavily impacted by the various discriminatory policies in terms of education under the Apartheid regime. In short, older black South Africans who grew up under apartheid had much lower levels of education.

Households were, on average, led mostly by females (57-59%) and fewer than 50% were listed as legally married, or stayed together with a spouse as if married. The difference in married counts between the two samples can be explained by the fact that this variable was imputed in the IES as this question was not specifically asked during interviews[5].

[5] The GHS mean value for married household heads are considered to be a more accurate representation of the marriage structure within the farming household community in this study. The married variable in the IES were obtained by using the question on the relationship to head and not by asking directly whether or not the individual was married.

The mean household size of these households was approximately 5 persons and was consistent for both the surveys used in the analysis. These households consisted, on average, of 2 children per household and the rest would be older adults. Table 6 also shows that these households received on average 2 grants from government transfers.

5.2.2 Income and Expenditure

For the descriptive analysis on income, the IES 2010/2011 sample of African farming households was used as this survey is designed to capture detailed information on income and expenditure at a household level. Table 6 gives the central tendency of the different incomes as the median value. The median income for these households was in the range of R1765 to R1856 per month, depending on the data set. Furthermore, when monthly income is disaggregated by source, salary, old age grants and remittances had a median of zero. This phenomenon occurs because of the spread of the income between the various sources. For each of this income source, more than two thirds had zero values.

Figure 6 illustrates this skewed average monthly income distribution by disaggregating between income sources, distributed across 10 income groups, with 1 being the lowest income bracket and 10 the highest. The highest income earners, on average, received incomes that were substantially higher than the rest, which caused the average to be very high. In reality, approximately 70% of these farming households received less than R2700 per month, while only a small minority had household incomes that were substantially higher.

The primary source of income for the poorest households (income categories 1 – 2) consisted largely of child grants (56% of total income) while old-age grants were the main source of income (37%) for categories 3 to 8 as illustrated in Figure 6. From income group 7, the average monthly household income increased significantly as salary incomes increase. These were typically economically active households with one or more of the household members employed in the formal economy working for wages. Thus, from Figure 6 the indication is that the most farming households are very poor, old and heavily dependent on grant payments from government as their source of livelihoods, while a smaller minority were much wealthier. Unfortunately, the IES does not specifically include a category for farm income. The average total income was less than the total expenditure. This phenomenon can be

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Those households that had individuals who indicated that they were the spouse or were married to the head, were listed as married.

explained by the fact that households tended to receive various in kind income in the community and the debt of these households was not included in the analysis.

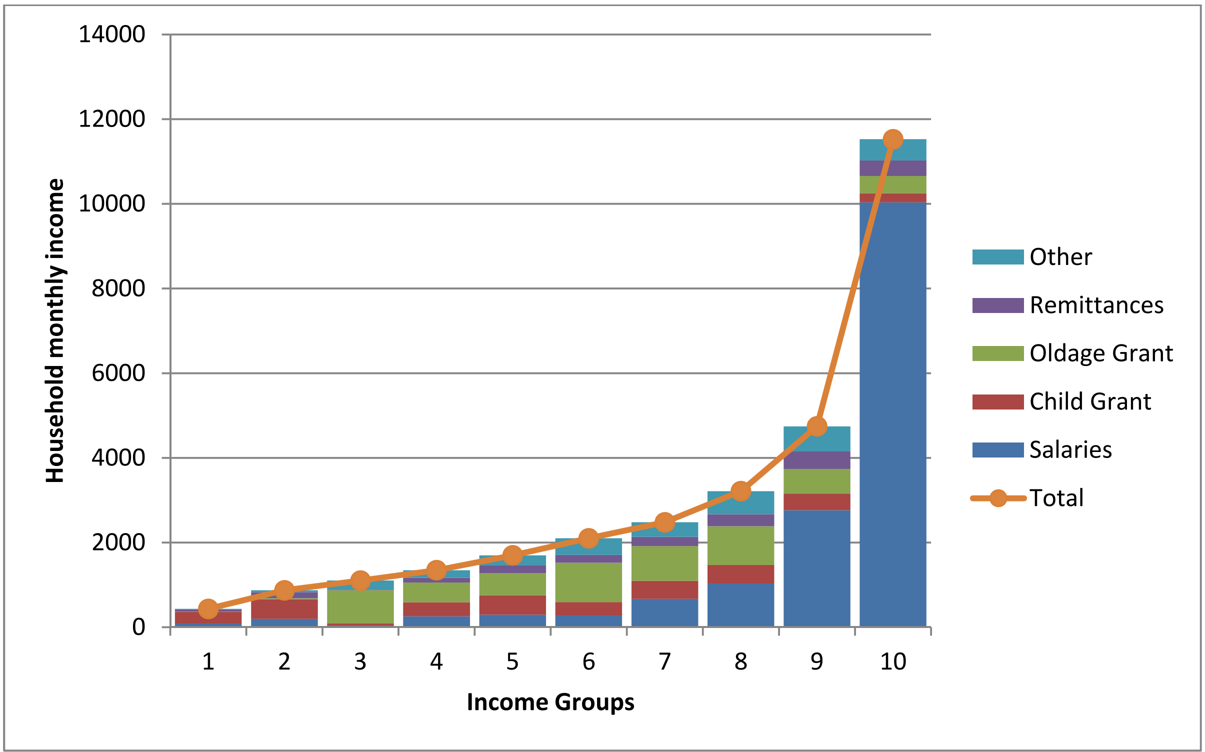

Figure 6: Household monthly income distribution according to 10 income groups

Source: IES 2010/2011

5.2.3 Agricultural Orientation

The production systems characteristics of households in the former homeland areas are summarized in this section. In general, very little information exists on the scale and efficiency of these agricultural systems. Table 7 gives the distribution of land sizes for crop production purposes of those households involved in planting. The majority (69%) of crop producers had access to less than 0.5 hectares, which is consistent with other studies on land size of smallholder farmers in this area (Lahiff, 2000). Households producing crops on larger pieces of land occurred less frequently with only 8.3% and 2.7% of the sample producing on land between 0.5 – 1 hectares and between 1 – 2 hectares respectively. Of the remaining households within the sample, fewer than 1% had landholdings greater than 5 ha. In Table 7, 18.6% of households listed in the sample were included as communal grazing. These households were only producing/keeping livestock and did not grow crops. Since this question was asked only for households who did plant crops and because livestock graze mostly on communal rangeland, these households did not have a specific farm size.

Table 7: Distribution of land sizes of crop producing households

Land size	Sample	Population[6]	%
Less than 0.5	2460	1073888	69.49
Between 0.5 – 1	294	146476	8.31
Between 1 – 2	95	47402	2.68
Between 2 – 5	29	11271	0.82
Between 5 -10	3	1481	0.08
Between 10-20	1	246	0.03
Communal Grazing (Livestock)	658	304919	18.59
Total	3540	1585683	100

Source: GHS 2010

In terms of animal production, the number of stock (livestock and small stock) is used as a measure of agricultural orientation. These categories are listed across the 10 income groups in Figure 7. Farming households had a mixture of cattle, sheep, goats, pigs and chickens in their possession. Chicken numbers was generally high across all of these households, suggesting that the scale of these production activities is not as dependent on income as the other stock categories. It is clear from Figure 7 that as income increases, households tended to have higher livestock units for all the categories; cattle, sheep, goats and chickens.

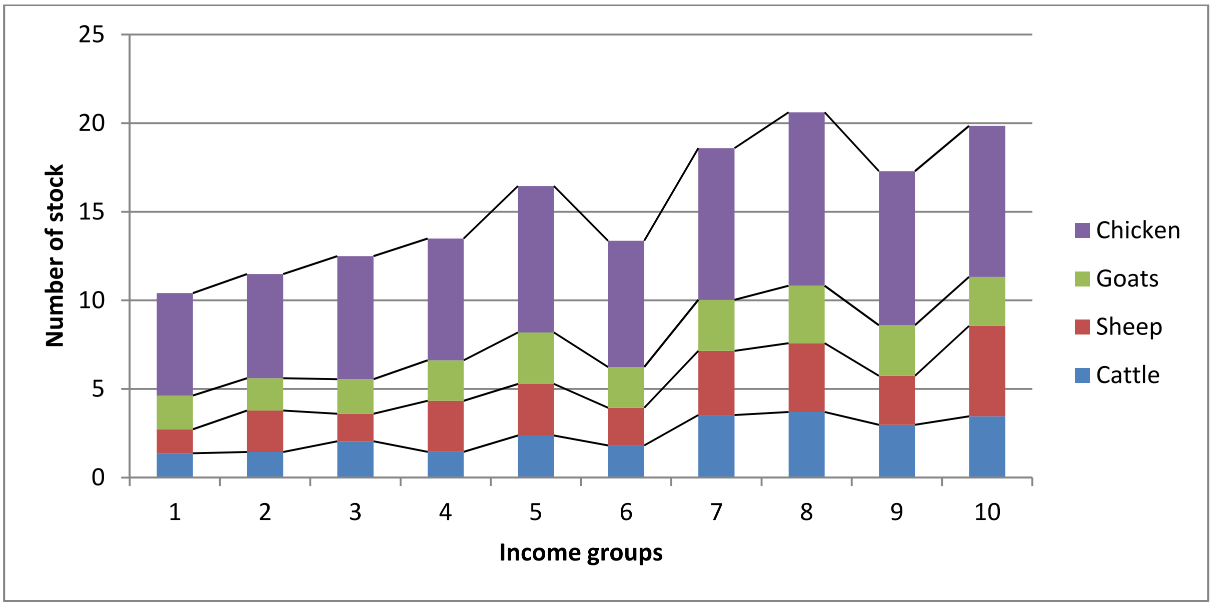

Figure 7: Livestock ownership across 10 income groups

Source: GHS 2010

The poorest households, income group 1, had relatively low livestock units suggesting that many of these households had only 1 or 2 livestock units, whether sheep, goat or cattle.

[6] Population figures are weighted by sampling weights.

Moving from group 5, these households had more than one of each of the three main livestock animals (cattle, sheep and goats). These were farming units bigger in scale and, moving towards group 10, livestock numbers increase substantially. Thus, a limited number of households farmed with animals on a much bigger scale and intensity. The highest livestock inventory was for income group 8 with an average of 4 cattle, 4 sheep, 3 goats and 10 chickens.

In terms of farming costs, the IES gives a valuable insight into the cost structure of smallholder farming households. This survey captures the annual expenditures of the most important input costs for farming. Table 8 summarizes the distribution of farming cost by input categories as a percentage of the total expenditure per category. Households with very low levels of expenditure on inputs (between R100 and R200), tends to buy less seed and fertilizer, but the percentage share of total expenditure is higher. As the total expenditure increases, livestock farm inputs' percentage share increases significantly. There is however a limited number of these households (24) that spent more than R1000 per year on seed.

Table 8: Percentage share of farm expenditure categories of household farm inputs per annum

Range	Seed	Fertilizer	Feed	Livestock	Medium Stock	Small Stock	Services	Processing	Other	Total Farm cost
R 0	41.4	72.7	76.2	92.8	88.8	77.8	81.1	92.0	83.1	5.0
R0 - R100	34.1	10.5	2.9	0.1	0.2	4.0	1.6	2.6	3.1	17.5
R101-R200	14.2	6.6	3.6	0.2	0.5	4.4	3.6	2.1	2.0	12.4
R201-R400	6.6	5.6	4.9	0.2	1.1	5.7	7.6	2.0	3.1	14.6
R401-R800	2.7	3.2	5.3	0.4	2.2	5.2	4.5	0.9	3.6	17.6
R800-R1200	0.4	0.8	2.9	0.3	1.6	1.7	0.7	0.1	0.6	9.1
R1201-R2000	0.2	0.4	2.5	0.3	1.8	0.7	0.6	0.2	1.8	8.3
R2001-R4000	0.2	0.1	1.2	0.7	1.5	0.2	0.4	0.0	1.4	5.9
R4001-R6000	0.1	0.0	0.2	1.0	1.0	0.1	0.0	0.0	0.7	2.4
>R6000	0.0	0.0	0.2	4.0	1.3	0.2	0.0	0.0	0.6	7.0
Total (%)	100	100	100	100	100	100	100	100	100	100

Source: IES 2010/2011

Fertilizer expenditure in the sample was also very low at R7.65 per year, indicating that very few households were fertilizing their land for crop production, which raises questions on soil quality and maintenance. The total farm cost percentages for farming families in the former homeland areas indicate the low levels of production taking place.

The majority of these have farm operations with production inputs of less than R800 annually. There were however approximately 30% of these households who were farming on a bigger scale with production input expenditure greater than R1000 per year. However, it should be noted that households might source inputs from various other informal sources such as in kind transfers and government input supplies. Table 9 shows to what extent former homeland farming households received direct farmer support from the government.

Table 9: Government agricultural support to farming households

Type of support	Number	Population[7]	Share
Training	61	32204	1.27
Visits from Extension officers	85	44159	2.40
Grants	5	3010	0.14
Loans	2	994	0.06
Input as part of loan	36	20504	1.29
Inputs for free	183	105301	5.17
Livestock health services	436	204059	12.32
Total	645	326011	18.22

Source: GHS 2010

Government agricultural support mostly comes in the form of livestock services (12.32%) such as dipping and vaccination services for livestock. Other form of agricultural support comes in the form of free inputs received (5.17%), while 1.29% received inputs as a loan. In terms of extension services, only 2.4% received visits from extension personnel from the Department of Agriculture. These were the main types of support received by these households, and in general, amounted to a total of approximately 18% who received some kind of support from government that would not have been included in the input costs in Table 8. Households were not restricted to only one type of support and thus could receive more than one.

Table 10 gives additional descriptive information on the agriculturally active households in the study. The reason why the majority of former homeland households produce agricultural products is for extra food in the household. By contrast, only 5.28% produced as a form of deriving extra income for the households, while only 0.88% did so as a main income source. This indicates that farming in these areas is mainly on a subsistence basis and very few produce as a livelihood income stream.

[7] Population figures are weighted by sampling weights.

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Table 10: Key variables of farming households

Name of Variable	Sample	Population[3]	%
Why Produce	Households	Households	
Extra food source	3074	1374992	86.84
Main Food Source	187	91030	5.28
Extra Income Source	160	65740	4.52
Leisure Activities	65	31588	1.86
Main Income Source	31	13654	0.88
Land Ownership			
Owns the land	1881	766308	53.14
Tribal authority	966	479007	27.29
Communal Grazing	658	311557	18.59
Other	10	5831	0.28
Sharecropping	8	3762	0.23
State land	5	3681	0.14
Rents the land	4	1355	0.11
Sell Produce			
Do not Sell	3324	1480340	93.90
Local buyers from this district	177	73071	5.00
Buyers from neighbouring cities and towns	13	6231	0.37
Formal markets in South Africa	19	4591	0.05
Other	7	2923	0.20

Source: GHS 2010

Tenure arrangements for these households for crop planting are also given in Table 10. The majority of households own the land on which they planted crops; these were mainly the backyard of their main dwelling. Next, 27.59% of the households were farming on tribal land and only very limited number of farmers planted by means of sharecropping, on state land, or rented land. These tenure arrangements are further disaggregated in Table 11, which indicates the average size of cropland and the average livestock units (only cattle, sheep and goats).

Those that indicated that they owned the land were households with very small pieces of land, typically backyard gardeners farming for extra food (94%) and with the smallest number of livestock units. For all of these tenure arrangements, producing for extra food had very high percentage shares, while producing for income had only relatively high shares for sharecropping, state land and those farming only with livestock. Farming on rented land and state land occurs, on average, on bigger pieces of land of 2.06 ha and 1.25 ha respectively.

Table 11: Tenure arrangement specifications

Tenure arrangement	Ave farm size (ha)	Aver Livestock Units	Percentage share (%)						
			Extra food source	Main Food Source	Extra Income Source	Leis Act	Main Income Source	Other	Total
Owns the land	0.32	4.17	93.62	2.23	2.23	0.90	0.16	0.86	100
Rents the land	2.06	21.75	75.00	0.00	0.00	25.00	0.00	0.00	100
Sharecropping	0.69	6.25	87.50	0.00	12.50	0.00	0.00	0.00	100
Tribal author	0.52	9.74	88.20	8.39	1.76	0.62	0.62	0.41	100
State land	1.25	9.40	80.00	0.00	20.00	0.00	0.00	0.00	100
Other	0.28	6.38	88.75	11.25	0.00	0.00	0.00	0.00	100
Only Livestock	0.00	15.19	65.50	9.42	15.20	6.38	3.19	0.31	100

Source: GHS 2010.

Lastly, referring back to Table 10, only 5.43% of the households (estimated to be close to 90 000 households in our sample) sold their produce. Those that did sell their produce, sold to buyers from the same geographical area where they were located and only 0.05% sold to local markets in South Africa.

5.3 Results

5.3.1 Principle Component Analysis Results

Principle Component Analysis was applied to both samples for the proposed typology of smallholder farming households situated in the former homeland areas of South Africa. For practical purposes the GHS sample and subsequent classification will be referred to, from this point onward, as GHS Typology 1, while that of the IES data as IES Typology 1. Both databases used in the development of the classification systems were tested to assess the validity of factor analysis. The Kaiser-Meyer-Olkim (KMO) (1970) measure for sampling adequacy and Bartlett's test of sphericity (Bidogeza et al., 2009) were utilized. The results of these two tests on both the GHS and IES data are given in Table 12.

Table 12: Validation for Factor Analysis

Test used	**Measure**	**(GHS)**	**(IES)**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	Value	0.66191	0.63051
Bartlett's Test of Sphericity	P-value	0.0000	0.0000

The KMO measure of sampling adequacy yielded values greater than 0.5, indicating sufficient correlation among the selected variables for PCA. Barlett's test of sphericity had high statistically significant ($p<0.01$) p-values, thus rejecting the hypothesis that the correlation matrix is the identity matrix. These results give sufficient evidence that the selected variables can be used in PCA (Iraizoz et al., 2007). PCA was applied to both the GHS and the IES datasets for the development of the two typologies.

5.3.2 GHS Typology 1

The sample from the 2010 GHS consisted of 3540 households and included 25 variables. Using this dataset from the GHS 2010, PCA was applied to the data to obtain the linear relationships within the data known as the principle components. These components are given by the following equation:

$$Z_{1i} = \alpha_{11}(Age)_{1i} + \alpha_{12}(Educ)_{2i} + \alpha_{13}(Male)_{3i} + \alpha_{14}(Married)_{4i} + \alpha_{15}(HHSize)_{5i} + \cdots \alpha_{19}(Hunger)_{25i} \quad (6)$$

This procedure is continued for all of the observations within the GHS dataset as illustrated in the previous chapter. The output from the PCA is a new dataset comprised of the 3540 (n) households, with each having a new set of principle component factors as the new variables. For the PCA, the varimax rotation was adopted which ensures that the resulting components are orthogonal and avoid possible problems with multicollinearity between the resulting variables (Iraizoz et al., 2007). The summarized tabled results for the PCA z-scores is included in the Appendix, while only the results of the factor loadings are given in Table 13, indicating that nine Z factors were retained. These factors had eigenvalues greater than 1, thereby satisfying the Kaiser criterion (Kobrich et al., 2003). Factor loadings give the correlation coefficients between the original variables and the newly retained factors. In order to make identification of relatively large loadings easier (indicating strong association); factor loadings greater than 0.40 are indicated in bold as suggested by Stevens (2002).

The resulting nine Z factors (Principle component factors) obtained from PCA explain approximately 67% of the variation within the original dataset; these will be discussed in detail below. It is now possible to explain each of the resulting factors according to the variables that are strongly correlated with the specific factor. This output is considered as correlation coefficients because of the orthogonal nature of the factor caused by the rotation used in the PCA (Field, 2009).

Table 13: Output of factor loadings from PCA for GHS Typology 1

Variables	Principle Component Factors								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Inc_Child-grant	**0.94**	-0.06	-0.11	0.02	0.00	-0.01	0.00	-0.04	-0.01
hh_children	**0.94**	-0.08	0.04	0.05	0.01	-0.02	0.00	0.02	0.01
HH Size	**0.88**	0.07	0.16	0.09	-0.02	0.07	0.04	-0.04	0.03
Num_Grants	**0.89**	0.29	-0.11	0.08	0.01	0.03	0.01	-0.03	-0.02
Age	0.02	**0.90**	0.03	0.09	-0.02	-0.08	0.02	-0.02	0.02
Education	-0.12	**-0.67**	0.29	-0.02	0.03	0.13	-0.04	0.17	-0.04
Inc_Old age-grant	0.02	**0.87**	-0.05	0.12	0.00	0.11	0.03	0.05	-0.03
Economically Active	-0.01	-0.18	**0.75**	-0.12	-0.02	0.09	-0.01	-0.16	0.01
Inc_Salary	-0.08	-0.14	**0.89**	0.04	0.00	0.06	-0.01	0.03	-0.01
Total HH Expenditure	0.09	0.10	**0.79**	0.12	0.08	0.02	0.05	0.22	0.02
Cattle_Inventory	0.03	0.10	0.03	**0.60**	-0.21	0.09	-0.01	0.11	0.08
Sheep_Inventory	-0.02	-0.01	0.08	**0.61**	0.01	-0.01	0.00	-0.09	-0.20
Goat_Inventory	0.07	-0.01	-0.04	**0.62**	-0.16	0.08	-0.03	0.02	0.13
Chicken_Inventory	0.07	0.13	-0.01	**0.46**	0.04	0.03	0.07	0.12	-0.14
Gov_Agri_Support	0.08	0.01	-0.02	**0.56**	0.05	-0.08	0.10	-0.17	0.26
whyprod_extraincome	-0.02	-0.04	0.04	0.05	**-0.83**	-0.01	-0.02	-0.05	-0.17
whyprod_extrafood	0.03	-0.03	-0.04	0.02	**0.83**	-0.01	0.01	0.02	-0.21
Plant_Backyard	-0.04	-0.04	0.14	-0.25	**0.53**	-0.03	0.01	-0.04	-0.11
Gender	-0.09	0.05	0.11	0.07	-0.04	**0.86**	-0.01	-0.17	-0.02
Married	0.15	-0.12	0.05	0.06	0.01	**0.84**	0.04	0.15	0.04
Hectares	0.00	0.02	0.07	-0.02	0.13	-0.02	**0.81**	-0.09	0.09
Plant_Farmland	0.03	0.05	-0.05	0.11	-0.09	0.04	**0.80**	0.11	-0.09
Inc_Remittances	0.04	-0.26	-0.11	0.13	0.07	-0.15	0.05	**0.68**	0.20
Food_Sec_Hunger	0.10	-0.08	-0.15	0.08	0.03	-0.08	0.03	**-0.69**	0.16
whyprod_mainincome	-0.01	0.03	0.02	0.02	-0.12	0.02	-0.01	-0.01	0.90
Eigenvalue	3.68	2.64	2.28	1.88	1.51	1.39	1.22	1.12	1.03
% Variance explained	14.73	10.58	9.11	7.54	6.05	5.58	4.89	4.47	4.12

Z_1

Z_1 explained the biggest part of the variation found in the data with 14.73% as shown in Table 13. Child grant income, the number of children in the households, household size and the number of grants per household give high loadings on Z_1. These strong positive correlations between these variables and Z_1, suggest that this is an indicator of household composition and the role of child grants.

Z_2

This factor is positively correlated to higher age and old age grant income. At the same time, Z_2 is negatively associated with the years of educational attainment among household heads. This factor then seems to indicate a typical welfare impact relating to the effect of the apartheid regime on households. Typically, older household heads that grew up in the apartheid era had much lower educational attainment, and at the same time were more likely to be receiving old age grants from government (those above 60 years of age). Z_2 explains 10.58% of the variation in the data and will characterise households based on their dependence on old-age grants as a primary source of income, age and education.

Z_3

Explaining 9.11% of the variation within the chosen variables, Z_3 loads highly on salary income, number of economically active household members and total household expenditure. These variables are all strong and positively correlated with Z_3 and would therefore be a proxy measure for the households' ability to be part of the formal economy in terms of being employed and earning a salary. It will give a higher z-score for households consisting of members who are employed in the formal economy and therefore have relatively higher income levels. This factor is also positively associated with higher household expenditure, which would be expected among higher income households.

Z_4

Z_4 is a measure for livestock farming orientation and has high loadings for all of the livestock variables; cattle, sheep, goats and chicken. Furthermore, Z_4 is also positively correlated with households that received government support, which in this case would amount to dipping and vaccination for animals. This factor representing an index of the scale of livestock production, would give high factor scores for households that had high livestock numbers and received government support. It is expected that those households with more livestock (any type) are more likely to have higher units of the other animals as various factors of production such as infrastructure, knowledge and available rangeland would already be established for these particular households. This factor explains 7.54% of the variation within the original data, and would give higher factor loading for households with intensified livestock production farming practises.

Z_5

This factor explains the rationale for farming among households in the sample. Z_5 is positively correlated with households that produce as a means of extra income, typically those farming in the backyard. It is then also negatively associated with those households that farm for income. This factor is then a measure of the reason for farming and will give low z-scores for households that sell their produce while those that farm on a subsistence basis in their backyard would have higher z-scores. This factor explains 6.05% of the variation.

Z_6

Z_6 explains 5.58% of the variation and is an indicator of household dynamics in terms of gender and marital status. It is positively correlated to both male household heads and those who were married. This factor gives some understanding of the spousal relationships within these farming households and will give high scores for married, male-headed households, while the opposite will yield lower scores. This could be explained by the distribution of male and females in the study area, as there were on average more female rural inhabitants. The majority of these households were headed by single, female household heads.

Z_7

Size of land for crop production is positively associated with factor 7. It is also loaded highly with farming households that produced food on separated farmland, as opposed to those farming in the backyard or school gardens. This factor, while explaining only 5.58 % of the variation in the dataset, is an important index that would give high factor loadings to those households that are surplus producers, operating on a larger scale.

Z_8

Z_8 is a measure of food security. The hunger variable, indicating hunger status of households had a high negative correlation coefficient of -0.69. Furthermore, factor 8 was also negatively correlated to remittance income. This factor represents a measure of food security and remittance income will therefore allow for classification between those with higher remittance income at the expense of those vulnerable to food insecurity. This factor explained 4.47% of the variation in the data.

Z_9

The final factor, which explains 4.12% of the variation in the data, had only one high correlation and associated positively with households that were producing as a source of main income to the household. Thus, this factor therefore identifies households according to their commercial orientation and would give a high z-score if a household was selling produce as a main source of income.

5.3.3 IES Typology 1

The same procedure used for the GHS Typology 1 was used for the IES sample of farming households. This sample consisted of 2999 households and 16 different variables were used in the PCA. Of these 16 variables, 12 were similar to those that had been included in the analysis of the GHS Typology 1; thereby allowing for consistency and robustness in the resulting typology that captures the diversity among farming households within the former homeland. Table 14 below summarizes the results from the PCA on the 16 selected variables. From this table it is clear, unlike the GHS dataset, that six principal factors were retained with an eigenvalue of greater than one and were found to be key in explaining 67% of the variation within the IES dataset.

Table 14: Output of factor loadings from PCA for IES Typology 1

Variables	**Principle Component Factors**					
	1	**2**	**3**	**4**	**5**	**6**
Income_Childgrant	**0.82**	-0.15	-0.03	-0.13	0.02	0.00
HH_Children	**0.93**	-0.03	-0.05	0.05	0.00	0.05
HH_Size	**0.90**	0.14	0.10	0.14	0.00	0.03
Percap_HH_Foodexpenditure	**-0.43**	0.03	-0.14	0.37	0.02	0.13
Head_Age	-0.05	**0.91**	-0.01	0.04	0.03	-0.04
Head_Educ	-0.09	**-0.69**	0.11	0.34	-0.01	0.01
Income_Oldagegrant	-0.07	**0.85**	0.14	0.03	-0.02	-0.03
Head_Gender	-0.05	0.00	**0.92**	0.06	0.01	-0.01
Head_Married	0.13	0.04	**0.92**	0.10	0.02	-0.02
Income_Salary	-0.03	-0.19	0.15	**0.74**	0.13	-0.10
HH_Consumption	0.05	0.01	0.07	**0.86**	0.17	0.12
Input_Crop	0.01	-0.05	-0.01	0.15	**0.68**	-0.19
Input_Services	0.00	0.07	-0.03	0.18	**0.36**	0.00
Bussiness	0.00	-0.04	0.09	-0.06	**0.78**	0.23
Income_Remittance	0.00	-0.13	-0.15	0.14	-0.19	**0.75**
Input_Livestock	0.02	0.06	0.16	-0.11	0.37	**0.63**
Eigenvalue	2.59	2.33	2.12	1.48	1.22	1.00
% Variance explained	16.21	14.57	13.25	9.23	7.61	6.28

Z_1

This factor has the same explanation as factor 1 in GHS Typology 1. Child grant income, household size and the number of children living in the household are positively correlated with Z_1. Furthermore, in the IES results, Z_1 has an additional negative association with per capita food expenditure, which indicates that big households with many children spend less on food per person in the household. This factor explains 16.21% of the variation in the data.

Z_2

Factor 2 explains 14.57% of the variation in the data and is similar to the Factor 2 from the GHS dataset, which will give high factor scores to households with old, uneducated heads and livelihood strategies aimed at generating income mainly through old age grants.

Z_3

This factor is related to factor 6 in the GHS typology and gives a high correlation between Z_3 and those households who had married and male household heads. This factor explains 13.25% in the data.

Z_4

Z_4 is a proxy measure for livelihood strategies for economically active households with high salary incomes and high household expenditures. In explaining 9.23% of the variation in the data, this factor gives high factor values for households within the formal economy and is similar to Z_3 as estimated for the GHS Typology 1.

Z_5

This factor, the first that are not similar to those generated from the GHS dataset, relates to the production and scale of crop production in terms of input expenditure. This factor correlates positively with higher input costs, both crops and services, and to households involved in business activities. This factor will give higher scores to households with an inclination for higher production cost and a relatively larger-scale production system and those involved in entrepreneurial activities.

Z_6

This factor is positively correlated to livestock input costs and remittance income. This positive correlation suggests that in the classification of remittances other income source were also included and might be correlated to farm income. Thus, households with higher livestock costs (mostly from buying new livestock units) would have higher z-scores, and these would have higher remittance/farm income. This factor explains 6.28% of the variation in the data and is the final factor retained with an eigenvalue of greater than one.

5.4 Cluster Analysis Results

In this section the final typology results will be given for both GHS Typology 1 and IES Typology 1. From the results of the PCA in the previous step, GHS Typology 1 had nine new factor variables, while IES Typology 1 had six. These new factors are used in the next step of the analysis. First, the hierarchical and non-hierarchical clustering results for each typology will be presented and discussed.

5.4.1 GHS Typology 1

The results of the hierarchical clustering procedure for the GHS dataset are given in Figure 8 as a dendogram, which depicts the sequence by which households were merged into clusters. The algorithm used was Ward's method, which is based on Euclidean distances. Moving from top to bottom, the dendogram increasingly disaggregates the households into more clusters at smaller linkage distances. The ultimate cluster result can be obtained by cutting the dendogram at a linkage distance of approximately 9, indicated by the red dotted line in Figure 8. The 8-cluster solution was found to be a realistic representation of the cluster analysis and at a distance where the linkage distance at any other distance would occur at a much higher linkage distance (Mooi & Sarstedt, 2011). Furthermore, when cluster solutions tend to be more than 10, it becomes increasingly difficult to conceptualise and operationalize the findings of the research (Emtage et al., 2005).

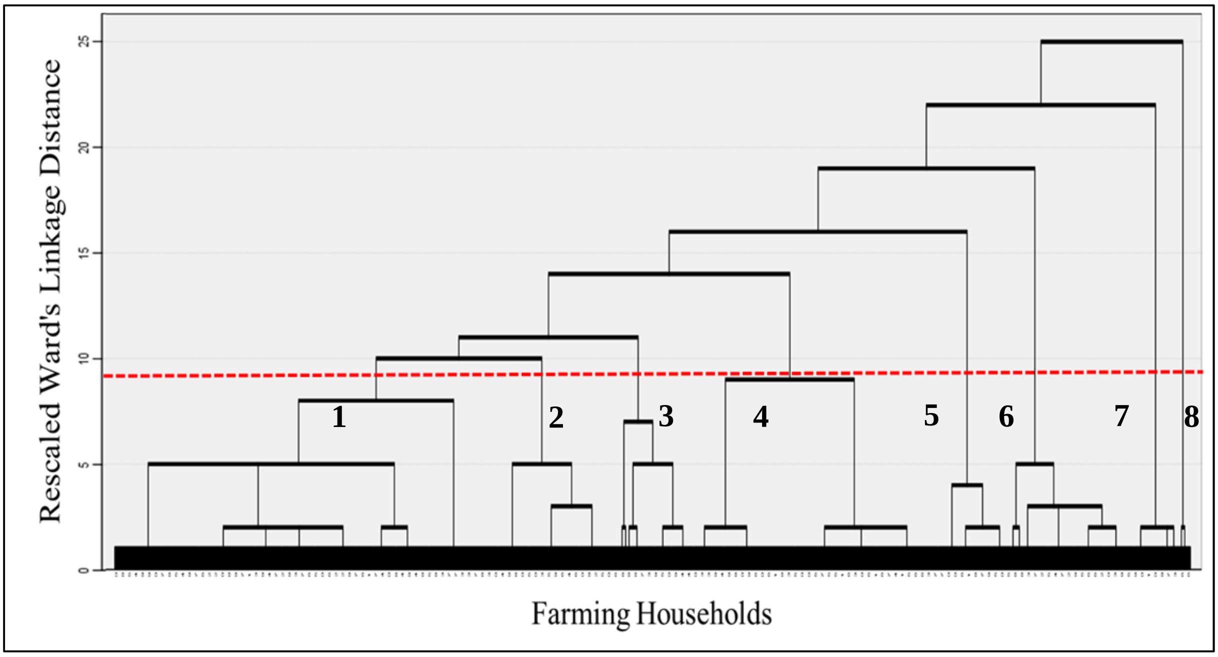

Figure 8: Dendogram of GHS Typology 1 showing the 8-cluster solution of farming households

The next step in the analysis created the ultimate cluster results in the form of a k-mean clustering technique selecting eight clusters as indicated from the findings of the hierarchical clustering results. The k-means, non-hierarchical method uses within-cluster variation as a measure of homogeneity to segment the data so that within-cluster variation is minimized (Mooi & Sarstedt, 2011). Table 15 gives the final cluster results with the important aspects of each cluster indicated in bold and the mean values for each variable is given between the groups. The p-values and f-values from the ANOVA results are statistically significant and indicate that the proposed cluster results are valid in the sense that these groups are significantly different from one another based on all of the selected variables.

Cluster 1: Salary dependent; male; high education; subsistence producers.

This cluster represents 22% of the households in the sample. This group of farming households is characterised by livelihood strategies where earned salaries are the main source of household income and had on average more individuals employed in the formal economy, working for wages. The household head was typically male, married and had higher education levels compared to household heads in the other clusters. Agricultural production for these households tends (90%) to be for extra food to the households and crops were produced in the backyard. This cluster had households with high total incomes (R2746.11 per month) and expenditures (R1639.99 per month) and is classified as one of the better-off groups from a welfare point of view.

Cluster 2: Old age grant dependent; low educated, female subsistence producers

Cluster 2 households' livelihood strategy involved sourcing income mainly through old age grants and salary incomes. The average age of the household heads in this cluster was 66 years of age, with very low levels of education (3 years). These household heads were generally unmarried females with an average household size of three persons of whom one was, on average, a child. Agricultural production also takes place on a subsistence basis on very small pieces of land (0.23 ha), mostly in the backyard, while they had only a limited number of livestock units. The main reason for farming for 90% of these households was to ensure extra food to the household and is therefore considered to be subsistence producers.

Cluster 3: Food insecure; mixed, low incomes; below subsistence producers

The results from *Cluster 3* show that 91% of these households were classified as being food insecure. Looking at all of the income categories suggests that these households were the poorest among the different groups, with the lowest total household income of R1483.20 per

Table 15: Cluster results for GHS Typology 1 with mean values of each variable

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	P-value	F-Value
Head_age	56.62	**66.83**	**51.42**	57.58	54.74	59.08	**37.78**	59.05	0.0000	240.03
Head_education	**5.97**	**3.04**	**4.30**	**3.72**	5.54	4.38	**8.67**	5.64	0.0000	113.75
Head_gender	**0.98**	0.08	0.43	0.23	0.56	0.46	**0.21**	0.55	0.0000	395.48
Married	**0.96**	0.02	0.35	0.43	0.53	0.59	0.53	0.57	0.0000	336.36
HHsize	5.00	3.70	4.98	**8.84**	4.65	4.76	3.69	5.55	0.0000	253.05
HH_children	1.62	1.12	1.93	**4.72**	1.60	1.67	1.58	2.07	0.0000	305.44
Grants_Receivers	2.07	1.77	2.18	**5.30**	2.07	2.23	1.30	2.71	0.0000	320.98
Economically_active	0.83	0.42	0.43	0.43	0.51	0.38	0.31	0.46	0.0000	36.22
Income_salary	**2746.11**	1057.05	449.36	622.79	**1675.19**	916.74	558.66	**2443.07**	0.0000	37.67
Income_childgrant	300.83	205.38	426.62	**1107.23**	343.55	337.54	301.05	388.16	0.0000	366.86
Income_oldagegrant	705.73	**837.64**	277.71	600.60	564.39	741.18	24.31	895.26	0.0000	100.84
Income_remittances	48.15	173.44	114.94	200.72	153.09	251.04	**637.58**	375.66	0.0000	83.14
Total Income	4043.72	2456.06	**1483.20**	2847.55	2963.70	2482.09	1605.08	4554.51	0.0000	45.73
Expenditure_Total	1639.99	1217.67	**771.66**	1364.95	1205.20	1299.85	885.41	**2100.35**	0.0000	34.00
Hectares	0.24	0.23	0.36	0.26	0.13	**0.94**	0.22	0.27	0.0000	106.60
Inventory_cattle	2.05	1.34	1.96	2.12	**6.34**	**3.16**	1.25	**20.00**	0.0000	100.11
Inventory_sheep	1.47	1.05	1.99	1.76	**4.44**	**2.50**	1.16	**56.76**	0.0000	218.11
Inventory_goats	2.30	1.12	2.72	2.34	**5.06**	**2.53**	1.53	**20.45**	0.0000	118.72
Inventory_chicken	7.83	6.35	5.90	9.15	**7.26**	**10.03**	5.08	**31.03**	0.0000	41.26
Agri_gov_support	0.12	0.11	0.38	0.21	0.25	0.21	0.12	**0.63**	0.0000	43.07
Whyprod_mainincome	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.05	0.0000	34.29
Whyprod_extraincome	0.00	0.00	0.00	0.00	**0.99**	0.01	0.00	**0.91**	0.0000	10880.87
Whyprod_extrafood	0.90	0.90	0.86	0.93	0.00	**0.90**	0.94	0.01	0.0000	326.91
Land_farmland	0.01	0.00	0.04	0.09	0.08	**0.98**	0.02	0.24	0.0000	1405.12
Land_backyard	0.81	0.81	0.72	0.72	0.28	0.55	0.80	0.61	0.0000	44.18
Hunger_child+adult	0.05	0.06	**0.91**	0.16	0.20	0.10	0.02	0.09	0.0000	527.30
Observation	782	762	385	401	155	357	622	76	3540	

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month. This is in conjunction with very low levels of total household expenditure of R771.66 per month, which needs to support a household with approximately five household members. These households sourced incomes from a mixture of grants (mostly child grants), salaries and remittances, but at much lower levels, giving rise to the food insecurity. From the data, it does not appear as if the household's agriculture production had a big impact on their food security status, despite the fact that these households had land sizes that were on average larger than most of the other clusters. This would imply that agricultural production is not at a scale to address the food shortages faced by these households and is therefore below the subsistence level. These households were on average headed by unmarried females with an average age of 51 years. This implies that these household heads were not eligible for old age grants, which are considerably higher than child support grants. This cluster represented 11% of the households in the study.

Cluster 4: Child grant dependent; big households; subsistence producers

Cluster 4 represents large households with livelihood strategies largely dependent on child grants. On average, this group received R1107.23 per month, which is the equivalent of receiving more than four child grants per household. The average household size was eight persons per household of which four were, on average, children. Agricultural orientation is also at subsistence levels for extra food and this group did have a smaller proportion (16%) of food insecure households compared to *Cluster 3*. The average land size was 0.26 hectares and production took place on a subsistence basis, typically to feed the many children, which in turn allows for more household members involved in the production practises in terms of family labour.

Cluster 5: Salary dependent; emerging livestock producers

Cluster 5 is characterized by having male household heads with an average age of 55 years and smaller household sizes of four persons per households. These households had higher monthly salary incomes of R1675.19 compared to those in *Clusters 2*, *3* and *4*. These households typically have members working for a salary while the household heads were involved in livestock farming. The livestock numbers were substantially higher on average; 6 cattle, 4 sheep, 5 goats and 7 chicken. The sizes of land were very small with an average of 0.13 ha, indicating a focus almost entirely on livestock farming with 99% of these households selling their produce as a source of extra income for the household. This group is therefore classified as emerging livestock farming households, which have high livestock units grazing on communal land.

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One of the important findings in *Cluster 5* relates to the fact that these households, with a livelihood strategy of selling livestock for income, had high salary incomes. These salaries would probably finance farming operations and the higher household incomes allowed them to take higher risks associated with agricultural production. Of concern however is that only 25% of these households received agricultural support from government.

Cluster 6: Salary and grant dependent; access to bigger farmland; subsistence producers

Cluster 6 represents households that produce crops on a bigger scale compared to all of the other clusters, with the land size averaging 0.91 ha. The majority (98%) planted on allotted farmland, which was separated land for farming purposes, while 55% of these households were also farming in the backyard. Thus, these households had access to additional land (which could include private or communal) which was separate from cultivated backyard gardens and yet, 90% of these households primarily farm as a source of extra food for the household. It is not clear why only 6% of these households were selling their produce, as these would have the means to produce crops on a much bigger scale compared to the subsistence groups in the cluster results. It is of concern that only 21% of these farming households received direct government support for their agricultural production. These households source income from both salaries and old age grants as the main source and were headed by females, with an average age of 59 years.

Cluster 7: Remittance dependent; low income; subsistence producers

Cluster 7 is the group with the youngest household heads (37) and represented younger families. These were mostly headed by females with an average of 8 years of education who were unemployed and consisted of smaller households of approximately 3.6 household members. The main income is generated by means of remittances payments (R637.58 per month), suggesting that these are families with household members working away from home, while the rest of the household resided in the rural areas. The average total household income was low at R1605.08, but seeing that these households were smaller there was no evidence of food insecurity related problems in this group. Production is considered to be at a subsistence level for extra food to the household and took place mostly in the backyard at the place of the main dwelling.

Cluster 8: Salary dependent; large-scale, emerging livestock farmers; supported

Cluster 8 represents only 2.1% of the households in the sample. These were a group of emerging livestock farmers with relatively high inventory for all of the livestock units. On average, these households had 20 cattle, 56 sheep, 20 goats and 31 chickens, which were substantially higher than any other group within the GHS dataset. The households produced food almost exclusively as a source of income, 91% for extra income and 5% as a main source of income. The majority of these households (63%) received direct agricultural support from government of which 50% was in the form of dipping and vaccination services for livestock. The heads of households were mostly married males and the main sources of income were salaries with R2443.07 and old age grants of R895.26. This ensured high levels of total income of R4554.51, which was the highest among the different groups. This is not even accounting for farm income from the agricultural sales, which suggest that these households have even bigger incomes, enabling the management of larger production units compared to the other clusters. Like in *Cluster 5*, these households typically had high incomes that would ultimately finance farming activities, which would in turn become a livelihood source of income.

5.4.2 IES Typology 1

The clustering of the IES dataset followed the exact same procedure as with the GHS data; however, the distinction being the mixture of different variables used in the analysis. The resulting factors in PCA were used in CA and the result of the hierarchical cluster procedure is illustrated in Figure 9. The red line dissects the dendogram at a linkage distance resulting

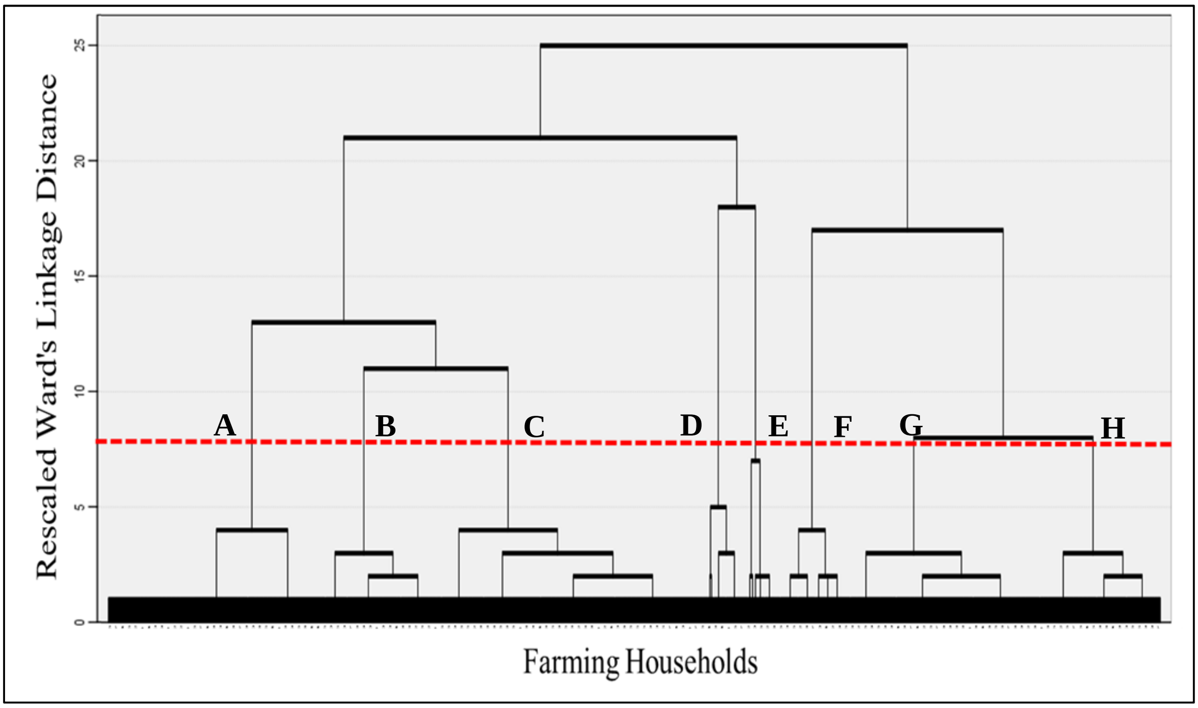

Figure 9: Dendogram of IES Typology 1 showing the 8-cluster solution of farming households

in eight clusters. As before, the Ward's algorithm was applied and the Euclidean distance measure was used to find similarities among the farming households in the sample. The 8-cluster solution was selected in the k-means clustering procedure and the results are given in Table 16 with the important characteristics of each group highlighted in bold. Each of these clusters will be explained, similar to the GHS typology.

Cluster A: Old age grant dependent; low educated, male subsistence producers

Cluster A represents 12% of the households in the IES sample. This type of farming households has livelihood strategies of sourcing incomes primarily through old age grants with an average of R1644.75 per month. The families were headed by uneducated (3 years of education), married males and farming practises were on a subsistence basis considering the low expenditure on farming inputs of R178.34 per month. This farm expenditure was relatively high because a few individual households had high livestock expenditure; otherwise these households had very low farming expenditures and are considered subsistence farming households.

Cluster B: Remittance dependant, mixed incomes; subsistence producers

Cluster B is characterized by farming households with a younger, female household heads with an average age of 43 years. These households source income from a mixture of salaries, grants and relatively high remittance payments. This cluster correlates strongly to *Cluster 7* from GHS Typology 1 in that the family size is relatively small while reliance on remittance payments from family members is high and agricultural production expenditures are relatively low, averaging approximately R75.36 per month.

Cluster C: *Food insecure; low incomes; below subsistence producers*

The farming households in *Cluster C* represent 15.7% of the households and source incomes mainly through salaries from work, and have total monthly incomes of approximately R2947.60, on average. Farming activities involving crops and livestock were conducted at low levels with total monthly farm expenditure of R100.34 per month. This group however shared similar characteristics with those in Cluster 3 from GHS Typology 1; for instance, vulnerability to food insecurity and an inability to feed the household. They had very low levels of food expenditure per person in the household, averaging R168.58 per month. Even though this value was higher than the one found in *Cluster D*, these households had more adults in the family, which results in higher food expenditure. These households had an

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Table 16: Cluster results for IES Typology 1 with mean values of each variable

Variable	Cluster A	Cluster B	Cluster C	Cluster D	Cluster E	Cluster F	Cluster G	Cluster H	P-value	F-Value
Head_age	**70.02**	**43.33**	47.55	56.79	**71.65**	52.45	**52.60**	**55.63**	0.0000	444.70
Head_education	**3.01**	**7.17**	6.84	3.84	**2.27**	6.26	**10.20**	**5.77**	0.0000	166.15
Head_gender	**0.97**	**0.19**	0.96	**0.07**	**0.12**	0.31	0.56	**0.61**	0.0000	559.20
Married	**0.96**	**0.02**	0.97	**0.06**	**0.01**	0.24	0.51	**0.55**	0.0000	1448.42
HHsize	5.85	3.52	**5.98**	**8.04**	3.66	5.60	5.07	5.50	0.0000	265.82
Income_salary	581.61	792.87	1897.57	735.34	402.17	1029.10	**11198.66**	**3147.42**	0.0000	392.81
Income_childgrant	243.20	234.17	467.62	**733.68**	101.15	291.46	92.65	386.71	0.0000	208.07
Income_oldagegrant	**1644.75**	32.45	65.78	428.37	**1092.04**	312.43	335.02	464.29	0.0000	679.56
Income_Remitt&Other	56.53	**207.87**	47.26	122.21	84.22	**2503.55**	180.54	117.06	0.0000	399.43
Total Income	2918.01	1582.77	**2797.76**	2381.88	1899.71	4412.51	**12023.70**	**4267.38**	0.0000	338.84
Expenditure_Total	3442.20	2389.68	**2947.60**	3230.87	2532.97	4778.09	**12186.34**	5803.33	0.0000	368.37
Inputcost_crop	16.46	15.96	18.68	20.35	16.91	17.23	37.40	**184.87**	0.0000	108.20
Inputcost_livestock	151.76	53.85	76.14	76.32	69.56	**1490.49**	113.17	**1084.14**	0.0000	86.87
Inputcost_services	10.12	5.55	5.52	8.49	8.94	8.57	12.06	40.03	0.0000	12.88
Inputcost_total	178.34	75.36	100.34	105.16	95.41	**1516.29**	162.62	**1309.03**	0.0000	99.69
percap_food_exp	206.78	756.06	**168.58**	150.57	301.04	252.57	524.53	277.73	0.0000	184.34
HH_children	1.88	1.28	2.32	**4.00**	0.99	2.23	1.61	2.10	0.0000	265.38
Business_act	0.00	0.00	0.00	0.00	0.00	0.03	0.01	**0.84**	0.0000	1636.77
Observations	378	690	473	513	605	94	152	94	2999	

average size of six members of whom two were on average younger than 16 years of age, and they had very low levels of total expenditure per household.

Cluster D: Child grant dependent; big households; subsistence producers

Cluster D is equivalent to the *Cluster 4* from the GHS typology. These households have, on average, four children and the livelihood strategies are largely dependent on receiving R733.68 per month through child grants. These were large households (8), with unmarried female heads and farming tended to be on a subsistence level in order to generate extra food for the households. As with *Cluster 4*, these households are typically backyard farmers with small pieces of land. This group represents 17% of the households in the sample.

Cluster E: Old age grant dependent; low educated, female; subsistence producers

The general livelihood strategy of households in *Cluster E* is very similar to the households in *Cluster 1* in GHS Typology 1. Heads of households are mostly female (88%) and unmarried (99%), and heavily dependent on old age grants as a source of household income (R1092.04 per month). The years of education were the lowest compared to the other cluster groups, with two years. These were also subsistence producers with an average farm input expenditure of R95 per month.

Cluster F: Salary dependent; emerging livestock producers

Cluster F represents only 3.1% of the households in the sample. This cluster is characterized by high income from salaries (R1029.10 per month) and other income (R2503.55). This group is similar to *Cluster 5* in the GHS typology, suggesting that livestock farming were practised on a much larger scale compared to the other clusters. Livestock production expenditure was very high at R1490.49 per month. This expenditure can be broken up in the buying of cattle (R1249.28), medium stock (R187.74), and feed (R28.43). It is also possible that the high other income could be farm income generated by these households. Unfortunately, the IES does not specify the source of the "other" earned income.

Cluster G: Salary dependent; male; high education; subsistence producers

Cluster G is the household farming group that is entirely dependent on salary incomes and is considered to be economically active households, with the highest levels of education of the household heads (10 years). It represents the wealthy among farming households with substantially higher incomes than all of the other clusters within the IES dataset, with an average salary income of R11198.66 per month. These households were not as dependent on grants such as the other cluster groups and farming also tended to be more on a subsistence basis, considering the relatively low expenditure on farming expenses of only R162.62 per month. This Cluster represents approximately 5% of all households in the data and resembles the characteristics from *Cluster 1* in GHS Typology 1.

Cluster H: Salary dependent; large-scale, emerging livestock farmers

The final cluster, *Cluster H*, is considered to be emerging farmers within the former homeland areas of South Africa. As with *Cluster 8*, these households are characterised by having high monthly salary incomes of R3147, and were mainly headed by married men (61%). These households spend approximately R1080.14 on livestock inputs, R184.78 on crop inputs and R40.03 on services (included ploughing, veterinary, processing, grinding, milling and slaughtering) per month. These were farming households who were actively involved in farming for income as 84% were listed as either having income from subsistence production or business activities. These households also had high total consumption and incomes, which suggest that these were able to finance farming operations sufficiently. This cluster of farming households also share some characteristic with *Cluster 6* in the GHS typology with this group having the highest expenditure on crop production and services (R224.90 per month), compared to the other cluster groups of which all were lower than R50 per month. However, the livestock production of *Cluster 6* was much lower than *Cluster H* and the latter could have sourced income from crop production as opposed to the subsistence orientation of *Cluster 6.*

5.3 **Discussions and Conclusion**

The results from the study indicate various important findings. This section will seek to give detailed discussions on the main findings from the proposed typologies for both the GHS Typology 1 and the IES Typology 1. Next, the cluster solutions will be compared to previous typology studies of smallholder farming households in the former homeland regions to conclude the chapter.

5.3.1 Main findings

One of the main findings for both typologies in this study comes from the PCA results and relates to the role of grants, which were instrumental in determining livelihood strategies of farming households. In both typologies, the first factor (and the most important) was positively correlated to higher child grant income, larger household size and the number of children in the household. This phenomenon also plays a key part in the livelihood strategies of

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these farming households as can be seen in the cluster results. Both *Cluster 4* and *Cluster D* in the respective typologies is characterised by child support grants of between R730 and R1100 per month. These household heads were typically not eligible for old age grants because of their younger age (average 56-57 years), but received the equivalent of one old age grant in the form of four child support grants per household. These households were mostly headed by females and farming tended to be on subsistence basis (93%); i.e. for feeding the many mouths, typically children. These households planted in backyard gardens (0.26 ha) and had very low stock numbers. Possible trajectories of these two groups would be to move towards *Cluster 2* in the GHS typology, while either to *Cluster A* or *E* in the IES typology. This will happen when the household heads ages and gain access to pensions.

The second factor for both typologies measures the dimension in the data associated with higher old age grant income. This represented a livelihood strategy of rural households with older household heads, who had very low levels of educational attainment, to source income primarily from old age grants. As indicted from the descriptive statistics in the study, the population is ageing within these areas, which will cause more individuals to become eligible for these grants in the future. Furthermore, the results from CA indicate an important impact of the social grants on these farming households. *Cluster 2* in GHS Typology 1 and both *Cluster A* and *E* in IES Typology 1 shows the livelihood strategies of these farming households to source income mainly through old age grants. These households are characterised by having household heads above 60 years of age, very low levels of educational attainment and farming on a subsistence level. From *Cluster A* and *E*, it is obvious that these households and its members were not economically active, with only 25% of these households sourcing income from the labour market. Possible future trajectories of these households could be to develop towards *Cluster 1* or *Cluster G* (through job creation once head is deceased) or evolve towards *Cluster 3* or *Cluster C* (will become food insecure if no alternative income is sourced when head is deceased).

The abovementioned findings suggest that farming households are very dependent on welfare transfers from government, which serves as a safety net for the rural poor and isolates individuals from labour market incomes. *Cluster 2* & *4* in the GHS typology and *Cluster A, D* & *E* in the IES typology is heavily dependent on either old age grants or child support grants. Unfortunately, these households tended to have family member of working age that did not work. Hence, grants represent a double-edged sword: on the one hand they reduce socioeconomic distress; on the other hand they perpetuate a reliance on resources outside of the labour market. The typology result reflects this in that very few of these households were selling their produce, even though these combined income were equivalent of the emerging farmers found in *Cluster 5*.

It is clear from the analysis, both PCA and CA, that households with high salary incomes had typical household arrangements where one person in the household would work for wages, while being supplemented with a mixture of other sources. Being formally employed in the economy placed a small number of farming households at a distinct advantage relative to the others in terms of levels of poverty and food security vulnerability. Furthermore, the characteristics of *Cluster 5 & 8* in the GHS Typology 1 and *Cluster F & H* from IES Typology 1 suggest that higher salary incomes are crucial for the enablement of households to market their produce. These farming types had average monthly salary incomes of more than a R1000, which could finance farming operations in the short term and would allow households to undertake higher risk associated with farming activities in these areas. *Cluster 5* and *F* represented medium-scale livestock producers compared to *Cluster 7* and *H*, which had higher incomes, stock numbers and farm expenditure. Possible trajectories would suggest that *Cluster 5* and *F* could evolve towards *Cluster 7* and *H* respectively, if improved livestock support and access to markets are established, and/or if more capital for farming can be sourced from increased salary incomes.

Farming activities then, are not only a source of food to the household, but also generate supplementary income for the household as a livelihood strategy. These results points to an important link between labour market outcomes and the marketing of agricultural produce. It is clear from the characteristics of *Cluster 5 & 8* in the GHS Typology 1 and *Cluster F & H* from IES Typology 1 that higher salary incomes are crucial for the enablement of households to market their produce. Thus, there is an important capital constraint for farming households in the former homeland areas. Those connected to the labour market not only provided better livelihoods for their households, but the connection to the market enabled famers to sell their produce. This phenomenon occurs either because those connected to the market has better connections and knowledge/information of the possible market opportunities, and/or these households has the ability to finance larger farming operations, afford better technologies and take higher risks.

In terms of food insecurity, *Cluster 3* and *Cluster C*, was particularly susceptible to hunger prevalence and low food expenditures. Of the households in *Cluster 3*, 91% had family member that has gone hunger during the past 12 months. This cluster is characterized by having the lowest monthly income (R1483) and expenditure (R771.66) compared to the other groups. These households were headed by uneducated individuals with an average age of 51 years. This would suggest that these were not eligible to receive old age grants, while typically 2 children in the household enabled R426 of child support grants on average per month. This is in line with the descriptive statistics which indicate the lowest income groups were dependent on child grants, while salaries, remittance and old-age grants were very low. The food production for the majority (86%) of these households was for extra food on small pieces of land (0.36 ha), which suggests that their farming system did not provide enough food to feed the household members sufficiently. The question here would be to what extent these households are able to improve production capacity in order to have more food available to the household. *Cluster 3* has the potential to move towards *Cluster 7* if family member are able to find work away from home, or towards *Cluster 6* if more land is made available for crop production. These trajectories will possibly reduce food insecurity among these households.

Cluster 7 and *Cluster B* in the respective typologies represented households characterized by younger families, mostly headed by females (79% – 80%). These families were typically dependent on remittance payments from a family member (migrant worker) not staying in the household. *Cluster 7* had an average monthly remittance income of R637.58 compared to a much lower R207.87 for *Cluster B*. Other similarities between these groups relates to their generally higher years of education of the household heads' (both above 7 years). Another similarity of these two groups is in relation to the agricultural orientation. Production was mostly at a subsistence level with 94% of *Cluster 7* producing for extra food to the household, while *Cluster 7* only spent a total of R75.36 on production inputs per month. These remittance dependent families will be able to move towards *Cluster 1* or *G* (if jobs were created within areas closer to home) or towards becoming emerging famers (Cluster 5 and *Cluster H)* with additional agricultural support services from government. Important to note, also, is that these farming households were successful at curtailing food insecurity, even though these households had very low levels of combined income.

Each typology had distinct groups with livelihood strategies of sourcing incomes almost exclusively from the formal economy. This was *Cluster 1* and *Cluster G* in the respective typologies. These farming households are characterized by having higher educated heads (5.9 years for GHS and 10.2 for IES), with a much lower dependence on social grant payment from government. Furthermore, these households were subsistence producers with 90% of the households in *Cluster 1* farming for extra food and total monthly expenditure on production only R161.62 for *Cluster G*. Differences between these groups are the magnitude of the salary incomes. *Cluster G* had an average monthly salary of R11198.66, while that of *Cluster 1* was only R2746.11. These households could possibly become more agriculturally inclined and move towards investment in agriculture as a source of extra income, although these would probably receive higher return from the labour market.

Cluster 6 of GHS Typology 1 does not particularly relate to any of the groups found in IES Typology 1. Although, this groups' crop orientation resemble the expenditure of crop and service inputs of *Cluster H*. The farming households in *Cluster 6* were headed by older (59 years), females (54%) and sources income from a mixture of sources. These households had access to much larger pieces of land; mostly three times more than the other groups with 0.96 hectares. This group consisted of almost all of the households with farm sizes bigger than 0.5 and had land which was separated farmland. It is of concern that only 1% of these households sold their produce. These results pronounce the findings regarding the capital constraint among farming households. These households, with access to bigger pieces of land, did not have the capability to market their produce. Various factors such as market access, access to capital, improved infrastructure and high transaction costs hinder the establishment of more farmers that sell their produce. Yet, these households should develop into emerging crop producers such as *Cluster H* in IES Typology 1 which could sell produce their produce for improved livelihoods and create employment in these areas. Improved farmer support will be needed to establish these farmers as emerging farmers.

5.3.2 Results compared to other South African smallholder typologies

The results from the GHS and IES typologies can be compared to findings from similar studies in South Africa. These studies were limited to typologies of the same study areas and that included farming households.

A typology study by Perret et al. (2000) in the Eastern Cape found six farming household groups for three different districts. Type 1 represents very poor, female-headed households that closely resemble *Cluster 3* and *Cluster C* (although not exclusively female-headed) in that these are typically food insecure, have low incomes and are subsistence producers. The second type represents single pensioners-headed households typically dependent on one old age pension and a mixture of other income sources (similar to *Cluster 2* in GHS and *Cluster*

A and *E* in IES). Production of these households was on subsistence basis and low stock numbers. Type 3 were characterised as souring income from external sources, mostly remittances. These households are similar to the findings from *Cluster 7* and *Cluster B*. Type 4 and Type 5 was stock-keeping households with relatively high combined incomes, of which farming also contributes. These households were headed by males and had relatively high average stock numbers (6 cattle, 37 sheep and 4 goats). Their average annual farm expenditure was R550 for Type 4 and R770 for Type 5, and these groups of farmers show similar characteristics to *Cluster 5* and *Cluster F*. Finally, Type 6 was fulltime, farming households headed by adults (younger than 60). Their farming activities generate, on average, R2220 annually and many of these households grow crops, but not for the market. The average stock numbers were 6 cattle, 64 sheep and 10 goats, while average farm expenditure was R770 per annum. This group closely resemble the characteristics of the large-scale emerging livestock households of *Cluster 8* and *Cluster H*.

In a study of the Khambashe area of the Eastern Cape, Laurent et al. (1999) proposed a 7-cluster typology of rural households. Type 1 was "moneyless" households, characterised by low incomes, subsistence production, and low farm expenditure. This group of farming households can be associated with household in *Cluster 3* in GHS Typology 1 and *Cluster C* in IES Typology 1. Type 2 was "households depending on social welfare grants and family remittances" and resembles *Clusters 2*, *4*, *A*, *D* and *E*. Type 3 was households that exclusively sourced income from non-farm activities such as those in *Cluster 1* and *Cluster G*. Furthermore, Type 4 was a group that does not specifically relate to any cluster from the GHS or IES typologies as these were households with farming as a main source of income, but would be the closest to *Cluster 8* and *Cluster H* (these were emerging farmers, but only a small percentage farmed as a main source of income). Type 5 shared the same characteristics found in *Cluster 5* and *Cluster F*, which were households deriving extra income from farming activities. Type 6 and Type 7 were non-farming households and is therefore not similar to any of the groups found in the respective typologies in this study.

Chapter

6 Conclusions and Recommendations

The overall objective of this study was to provide an empirical framework that would classify smallholder farmers in the former homeland areas of South Africa. This was achieved in three distinct ways. The first was to provide an overview of the development of the smallholder farming sector in South Africa from to 19th century to the early 21st century. This was achieved in chapter 2 and will not be further discussed in this chapter. The second was to utilize GIS techniques to successfully identify farming households situated in the former homeland areas as it was demarcated according to the Land Acts under the apartheid government. This enabled the successful sampling of farming households located in the former homeland areas in both the GHS and IES instruments. These processes were explained in chapter 3. The third was developing a classification system using multivariate statistical techniques; Principle Component Analysis (PCA) and Cluster Analysis (CA). Finally, these proposed typologies were tested for its validity and robustness in the form of an ANOVA testing; to test significant differences between cluster groups. The development of the classification system is explained in chapter 3, 4 and 5.

6.1 Thesis Overview

In this thesis a typology of smallholder farming in South Africa's former homelands was developed. In Chapter 3, a review on the literature towards classification systems within agriculture provided the necessary framework for the development of farming typologies. This chapter introduced the various classification techniques, starting from the early models in 1960's to the most recent. The review suggests that a typology is defined as a quantitative or qualitative procedure that categorises farmers into homogenous groups, based on certain criterion (Tefera et al., 2004). The rationale for creating farmer typologies is to better understand structural changes in farming concerning output, employment, farming intensity and the impacts of policy. In general, previous typology development has followed one of, or a combination of, two main approaches found in the literature: the Qualitative Approach and Quantitative Approach (Righia et al., 2011). Qualitative approaches are said to be deductive classification systems and responds to patterns in qualitative data, while quantitative approaches utilize multivariate analysis in order to create typologies. Chapter 3 identifies six distinct steps in the development of quantitative typologies, of which PCA and CA make out step four and five respectively. These applied methodologies have been consistently applied in the creation of farmer typologies (Dossa et al., 2011; Nainggolan et al., 2011; Madry et al., 2013). This quantitative classification system, applying PCA and CA, were selected as the most suitable for the development of a typology of smallholder farming sector.

In Chapter 4 the methodology used in the development of the typology of smallholder farming households in South Africa's former homelands is described. It does so by following the same steps proposed in Figure 2 of chapter 3. Firstly, the Sustainable Livelihoods (SL) theory was selected as the theoretical framework for the development of the typology. Secondly, the chapter explained the use of the data and gave information regarding the study area. This explained the different techniques used to sample farming households in the former homeland areas using GIS techniques applied to both the GHS and IES instruments. Thirdly, the variable selection gave detailed discussions on the included variables in the study. Fourthly, PCA was introduced and explained, followed by CA in the fifth step. Finally, in step 6, the validation of typologies were explained and comes in the form of ANOVA tests. This chapter gave detailed descriptions of the methods used to create the two proposed typology: GHS Typology 1 and IES Typology 1.

In chapter 5 the results and findings from the study were analysed. The descriptive analysis reveals important characteristics about the smallholder sector in the former homeland areas. This population is ageing, representing 8 million individual living in 1.28 million households. These households had on average five members, of which two were children. The analyses also reveal the apparent impact on education by the apartheid regime. There is an inverse relationship between the years of education and the age of these farming households. The welfare impact of this phenomenon is also visible terms of the income distributions amongst these households. A minority of these households had high incomes; these were typically associated with connections to the labour market with at least one person in the households working for wages. In contrast, those with the lowest household incomes were typically dependent on child support grants from government. In between these income groups were those dependent on old age grants, supplemented with a mixture of incomes from all the other available income sources.

The analysis on agricultural production reveal the mainly subsistence orientation of the households in the sample, with 87% produced for extra food to the household. As suggested by Lahiff (2000), the majority (69.5%) of these households farm on less than 0.5 hectares.

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The average stock numbers, mostly grazing on communal land, were 2 cattle, 2 sheep, 2 goats and 7 chickens. In terms of direct agricultural support, only 18% of the households in the sample were supported by government. For these, support came mostly in the form of livestock health services (12%) and free input supply (5%). Only 5.28% of the farming households in the former homeland areas sell their produce for income.

The second part of chapter 5 gives detailed outcomes from PCA and CA, yielding an 8-cluster solution for both the GHS and IES typologies. Each cluster was explained by referring to the mean values of the included variables in the study. From the results it is obvious that government grants play a crucial role in determining livelihood strategies for farming households in these areas. Specifically, old age and child support grants, were the main sources of income for *Cluster 2 & 4* in GHS Typology 1 and *Clusters A, D* & *E* in IES Typology 1. The results for both typologies yielded similar groups. *Cluster 3* and *C* were typically, poor, food insecure farming households, while *Cluster 7* and *B* were dependent on remittance payments from family member working away from home. These four groups were characterised as subsistence producers.

Households that were typically dependent on salary incomes, with more educated household heads, were *Cluster 1* and *G*. *Cluster 5* and *F* represented medium-scale emerging livestock farmers. These households sold their produce and had comparatively higher salary incomes compared to the other cluster groups. *Cluster 7* and *Cluster H* were large-scale emerging livestock farmers with the highest stock numbers and farm expenditures. These also had high salary incomes and were connected to the market. The final cluster from GHS Typology 1, *Cluster 6*, was unique and did not compare closely to any of the groups in IES Typology 1. This group was characterised by female household heads, particularly with access to larger pieces of farmland. These households did not sell their produce, even though the average size of land was three times bigger than the other clusters and had higher livestock units compared to *Clusters 1, 2, 3, 4* and *5*.

The typology results were similar to previous finding in the literature, although some exceptions were noted (Laurent, et al., 1999; Perret, et al., 2000).

6.2 **Key Findings**

In the rural development literature, agriculture is considered as one of the best vehicles for poverty alleviation and employment opportunities in rural areas (Machethe, 2004). One of the biggest challenges for the South African government relates to improving livelihoods for a large number of African inhabitants, of whom many reside in the former homeland areas (Kirsten, et al., 1998). Agriculture has been identified as the main sector to drive rural development in South Africa former homeland areas, through agricultural development, improved land management, infrastructure and targeted support to rural women. (NPC, 2011). The main question that needs answering is whether or not an expanded smallholder sector will be able to contribute significantly to rural development, employment creation and poverty reduction (Cousins, 2013).

This study developed a household typology of smallholder farmers in the former homeland areas of South Africa. Eight distinct farming household types, each having different livelihood strategies were identified. The key factors that underpin the classification of smallholder farmers and determine livelihood strategies include;

1. Social welfare grants:
    - The role of government grants, specifically old age pensions and child support grants, remain an important part of livelihoods in the former homeland areas. These grants were instrumental in defining the livelihood strategies among farming households clearly indicated in both the PCA and CA results. These grants typically serve as a safety net for the rural poor and isolates individuals from the labour market outcomes. Hence, on the hand these transfers reduce socioeconomic distress; on the other they perpetuate a reliance on resources outside the labour market.
2. Off-farm income and labor markets
    - This study has also identified the importance of linkages to markets. There is a capital constraint on farming in the former homeland areas, with those employed (higher incomes) being able to market their produce as a result of both the social connections related to employment and the ability to finance farming operations. Furthermore, these households are able to provide improved livelihoods mainly through wage employment, while farming gives an additional income as a sustainable livelihood source.
3. Household characteristics and family structure
    - Household arrangements also play an important part in the livelihood strategies of farming households in the former homeland areas. Families dependent on remittance payments from migrant workers were typically younger families established in these areas. Household characteristics such as

marriage status, gender, age and household size were all instrumental in creating distinct livelihood strategies.

4. Production activities and household food-security
    - In terms of food security, the typology identified households typically prone to food insecurity. These were characterized by low incomes and below subsistence levels of production. However, production systems in these areas were positively contributing to food insecurity in the sense that many poor households were able to feed their families sufficiently with their own produce, even though these had equivalently low incomes compared to the food insecure households mentioned above.

This study agrees that the smallholder farming sector can contribute the development goals set out by the government of South Africa. However, the contribution should be seen in the light of the historical context of African farming in the former homeland areas and the apparent constraints towards production. Furthermore, the development targets, such as the creation of one million jobs and the expansion of another 500 000 hectares under irrigation in these areas are clearly ambitious, given that the number of smallholder farmers have remain relatively at the same level. However, the success of an expanded smallholder sector will be dependent on various factors such as targeted support programs which are both sustainable and reliable.

6.3 Policy recommendations

Various policy recommendations can be drawn from this study. As pointed out in chapter one, the NDP have indicated the important role of agriculture in the development of South Africa's rural economies (NPC, 2011). One of the key policy objectives relating to smallholder farming in South Africa has been framed in a very broad perspective; to help smallholders to become commercial and to expand (Aliber & Hall, 2012). This view propose that all black farming households must/should be supported to gradually move from subsistence production towards large-scale commercial farmers on the "bigger is better" principle, is a misconception. A continued misperception that a clear progress towards becoming a large-scale farmer is what is assumed to be a success needs to change.

In this study, it would be unwise to seek to support *Clusters 1, 2, 3, 4* and *7* to become more commercially inclined, as these would typically not have the means, nor the ambition to do so. Policy towards supporting these smallholder households should be aimed at increasing livelihood sources and to improve food security with improved production practises. Government should therefore target households with characteristics such as those included in *Cluster 3* and *Cluster C* with establishing well-functioning food gardens. Supporting these groups will typically improve productivity of the farming systems for an improved welfare point of view to give access to more food. It seems that trying to turn these smallholder farmers into large-scale commercial farmers is counterproductive in terms of efficiency and equity (Aliber & Hall, 2010). It is very unlikely that these farming households would be able to create jobs through farming activities in the future.

Then, those able to commercialise should be supported, especially crop producers with access to bigger sizes of land. The results from this study indicate that very few households (18%) received direct agricultural support from government, even though spending has increases over the past few years. Furthermore, support was mostly geared at giving livestock support, while crop farmers in these areas received close to zero support. Typically, households included in *Cluster 6 and Cluster H* needs to be targeted and supported to become emerging farmers producing crops for the market. These will need access to capital, infrastructure, and extension services from government. The capital constraint on farming in these areas was one of the main factors affecting the marketing of produce. Furthermore, the already established emerging farming groups such as *Cluster 5, 8, F* and *H*, should all be supported so that farm income can become a bigger part of the household income. Improved productivity of these farming systems, whether crop or livestock, are more likely to create jobs. Thus, whether to support smallholder agriculture from a welfare or a commercialization point of view, will enable self-sufficiency as well as overall market supply and would generate greater livelihood benefits for a large number of the rural population (Aliber et al., 2009; Cousins, 2010; Greenberg, 2010).

An important consideration also needs to be taken note of in the development of rural development planning. If agriculture is to fulfill the mandate of being the main driver within the former homeland areas in the future, it needs to establish younger farming households. The ageing population structure of this sector seems to suggest that the smallholder farming numbers will decline in the future. Furthermore, any improvement in employment opportunities would benefit market penetration as this study showed the possible causal relationship between farming for the market and being employed.

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8 Appendix

8.1 GHS Typology 1

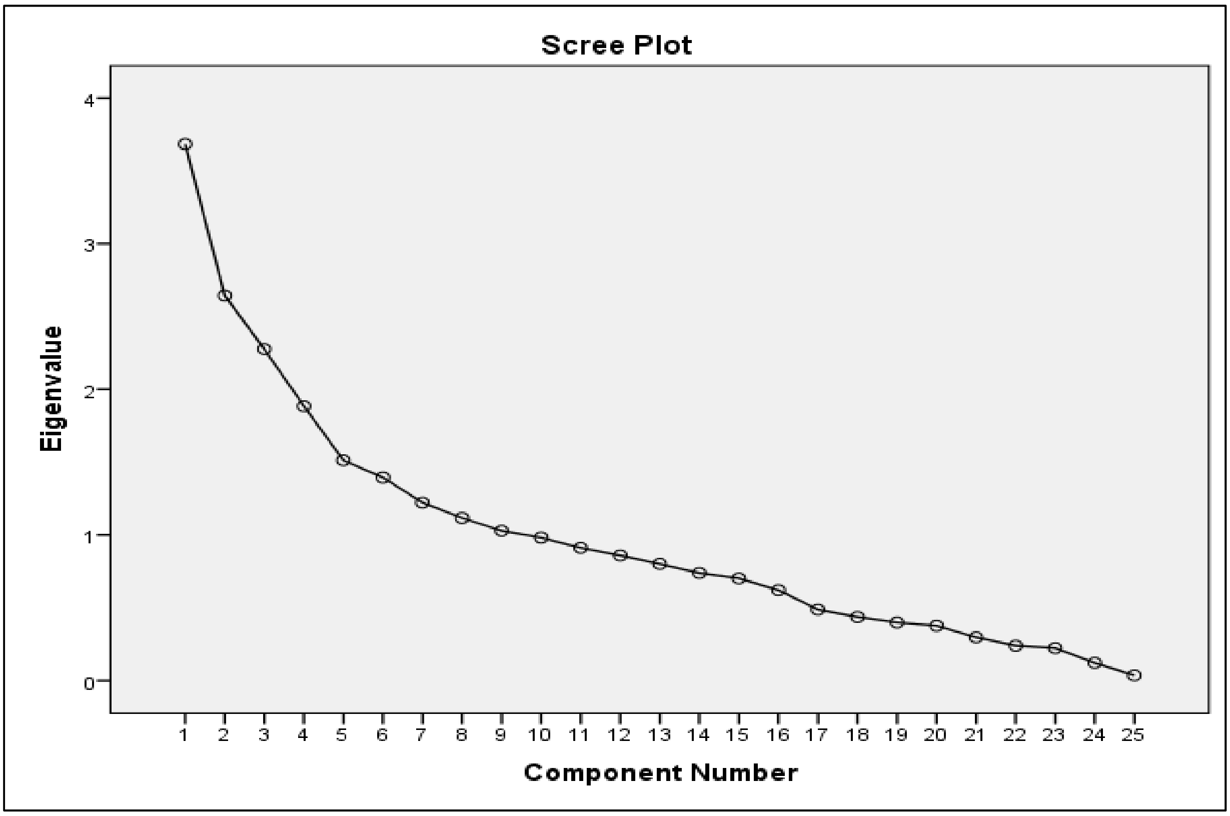

Figure 10: Screeplot from PCA results for GHS Typology 1

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Table 17: Total variance explained with rotation included in GHS Typology 1

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.68	14.73	14.73	3.43	13.74	13.74
2	2.64	10.58	25.31	2.31	9.25	22.99
3	2.28	9.11	34.42	2.21	8.85	31.84
4	1.88	7.54	41.95	1.83	7.32	39.15
5	1.51	6.05	48.01	1.79	7.15	46.30
6	1.39	5.58	53.58	1.56	6.24	52.54
7	1.22	4.89	58.47	1.33	5.32	57.86
8	1.12	4.47	62.94	1.18	4.72	62.58
9	1.03	4.12	67.05	1.12	4.48	67.05
10	0.98	3.93	70.98			
11	0.91	3.65	74.63			
12	0.86	3.44	78.06			
13	0.80	3.21	81.27			
14	0.74	2.96	84.23			
15	0.70	2.81	87.04			
16	0.62	2.48	89.52			
17	0.49	1.95	91.47			
18	0.44	1.75	93.22			
19	0.40	1.60	94.82			
20	0.38	1.51	96.32			
21	0.30	1.19	97.51			
22	0.24	0.96	98.47			
23	0.22	0.89	99.37			
24	0.12	0.49	99.86			
25	0.04	0.14	100.00			

Table 18: Summarized table of z-scores from PCA used for CA in GHS Typology 1

	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9
1	-1.16	1.25	-0.40	-0.12	0.22	-0.82	1.48	0.57	-0.78
2	0.80	-1.29	-0.03	8.23	-3.03	0.25	0.81	-1.68	-4.98
3	-0.90	-0.25	-0.54	-0.48	0.40	-1.01	-0.28	0.51	-0.05
4	-0.42	1.02	-0.31	0.27	0.75	1.12	-0.26	-0.30	0.42
5	-0.40	-0.53	0.87	-0.02	0.34	1.20	-0.40	-0.09	-0.01
6	-0.62	0.35	-0.49	0.97	0.31	1.56	-0.60	0.44	-0.01
7	-1.68	-0.36	-0.36	5.10	0.33	-0.51	-1.12	-1.69	-2.94
8	1.33	0.09	-0.84	-0.04	-0.16	1.23	-0.61	0.16	-0.47
9	0.75	-0.35	-0.76	1.37	0.32	1.37	-0.66	-0.05	0.07
10	-0.58	0.46	0.95	6.33	0.95	-0.50	-1.03	-1.57	-3.01
11	-0.51	-0.46	-0.89	-0.21	0.48	0.12	-0.25	0.77	-0.07
12	1.13	1.05	1.12	-0.71	0.31	-1.06	-0.40	-0.06	-0.25
13	0.80	1.62	0.13	1.35	0.19	-0.95	-0.62	0.34	-0.42
14	-0.31	-1.14	-0.61	0.18	0.35	-0.77	-0.38	0.09	-0.49
15	-0.40	0.51	0.11	1.78	0.45	-0.87	-0.60	0.41	-0.65
16	-0.23	1.65	-0.13	0.39	0.61	1.40	-0.46	1.28	0.04
17	0.69	1.21	-0.13	1.85	0.79	1.16	-0.60	1.09	-0.82
18	-0.41	-0.90	-0.76	-0.05	0.42	0.20	-0.32	0.80	0.07
19	-1.35	-0.44	-0.83	0.42	-0.23	0.19	-0.72	0.55	0.13
20	-1.29	-1.15	0.11	0.17	0.48	0.17	-0.30	0.35	-0.17
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
3539	-0.74	-1.36	-0.64	-0.15	0.66	-0.04	-0.16	2.74	0.46
3540	0.48	-0.80	0.64	-0.64	0.40	1.27	-0.32	0.00	-0.17

Table 19: Correlation matrix of the 25 included GHS Typology 1 variables in PCA[8]

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
V1	**1**	-0.6	0.0	-0.1	0.1	0.2	-0.1	0.0	-0.1	0.0	0.7	-0.2	0.1	0.0	0.1	-0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
V2	-0.6	**1**	0.1	0.1	-0.1	-0.3	0.2	-0.1	0.3	-0.1	-0.4	0.1	0.2	0.0	-0.1	0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
V3	0.0	0.1	**1**	0.5	0.0	0.0	0.2	-0.1	0.1	-0.1	0.1	-0.2	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	-0.1	0.0
V4	-0.1	0.1	0.5	**1**	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
V5	0.1	-0.1	0.0	0.2	**1**	0.7	0.1	0.8	0.1	0.7	0.1	0.0	0.2	0.0	0.1	-0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
V6	0.2	-0.3	0.0	0.1	0.7	**1**	-0.2	0.8	-0.2	0.9	0.3	-0.1	0.0	0.0	0.1	-0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
V7	-0.1	0.2	0.2	0.1	0.1	-0.2	**1**	0.0	0.6	-0.1	-0.2	-0.1	0.4	0.0	0.0	0.1	0.0	0.0	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0
V8	0.0	-0.1	-0.1	0.1	0.8	0.8	0.0	**1**	0.0	0.8	-0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
V9	-0.1	0.3	0.1	0.1	0.1	-0.2	0.6	0.0	**1**	-0.2	-0.2	0.0	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V10	0.0	-0.1	-0.1	0.1	0.7	0.9	-0.1	0.8	-0.2	**1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
V11	0.7	-0.4	0.1	0.0	0.1	0.3	-0.2	-0.1	-0.2	0.0	**1**	-0.2	0.1	0.0	0.1	-0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
V12	-0.2	0.1	-0.2	0.1	0.0	-0.1	-0.1	0.1	0.0	0.0	-0.2	**1**	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V13	0.1	0.2	0.1	0.1	0.2	0.0	0.4	0.1	0.6	0.0	0.1	0.1	**1**	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
V14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**1**	0.3	0.2	0.0	0.0	0.0	0.0	0.1	0.0	-0.1	0.0	0.0
V15	0.1	-0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	**1**	-0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
V16	-0.1	0.1	0.0	0.0	-0.1	-0.1	0.1	0.0	0.1	0.0	-0.1	0.0	0.1	0.2	-0.2	**1**	-0.2	0.0	-0.2	-0.1	-0.1	-0.1	-0.2	0.3	0.2
V17	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.1	-0.2	**1**	0.2	0.3	0.2	0.2	0.1	0.1	-0.2	-0.1
V18	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2	**1**	0.2	0.1	0.1	0.0	0.1	0.0	0.0
V19	0.0	0.0	0.1	0.1	0.1	0.1	-0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.1	-0.2	0.3	0.2	**1**	0.2	0.2	0.1	0.1	-0.1	0.0
V20	0.1	-0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.1	-0.1	0.2	0.1	0.2	**1**	0.1	0.0	0.0	0.0	0.0
V21	0.1	0.0	0.0	0.0	0.1	0.1	-0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	-0.1	0.2	0.1	0.2	0.1	**1**	0.1	0.0	0.0	0.0
V22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	0.0	0.1	0.0	0.1	**1**	0.0	-0.2	-0.3
V23	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.2	0.1	0.1	0.1	0.0	0.0	0.0	**1**	-0.6	0.1
V24	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	-0.2	0.0	-0.1	0.0	0.0	-0.2	-0.6	**1**	0.8
V25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	-0.1	0.0	0.0	0.0	0.0	-0.3	0.1	0.8	**1**

[8] Variables are renamed according to the same order as Table 5 and are given here as V1 – V25

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8.2 IES Typology 1

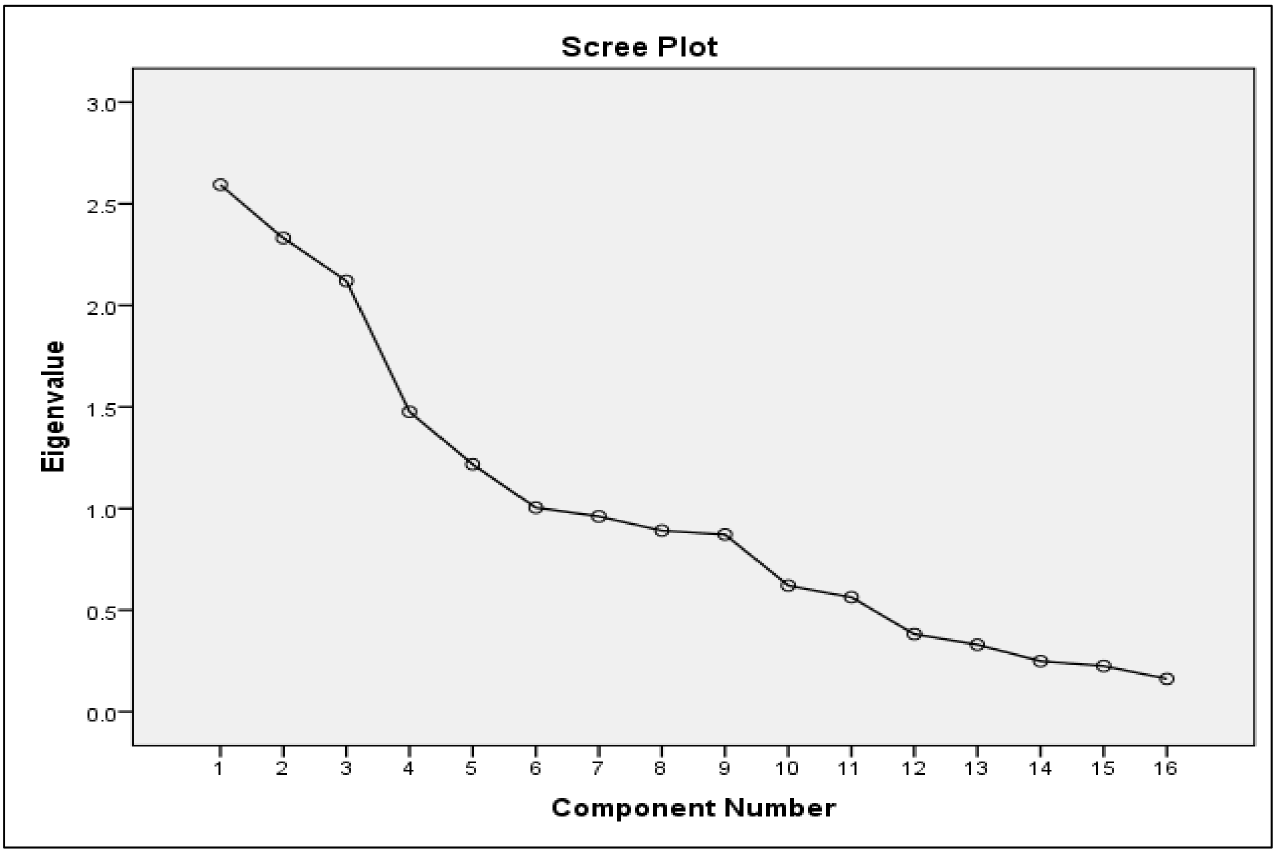

Figure 11: Screeplot from PCA results of IES Typology 1

Table 20: Total variance explained with rotation included for IES Typology 1

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.59	16.21	16.21	2.59	16.21	16.21
2	2.33	14.57	30.78	2.33	14.57	30.78
3	2.12	13.25	44.04	2.12	13.25	44.04
4	1.48	9.23	53.26	1.48	9.23	53.26
5	1.22	7.61	60.87	1.22	7.61	60.87
6	1.00	6.28	67.15	1.00	6.28	67.15
7	0.96	6.01	73.16			
8	0.89	5.57	78.73			
9	0.87	5.45	84.18			
10	0.62	3.88	88.06			
11	0.56	3.52	91.58			
12	0.38	2.39	93.97			
13	0.33	2.06	96.03			
14	0.25	1.55	97.58			
15	0.22	1.41	98.99			
16	0.16	1.01	100.00			

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Table 21: Summarized table of z-scores from PCA used for CA in IES Typology 1

	Z1	Z2	Z3	Z4	Z5	Z6
1	-1.44	-0.91	-0.81	-0.91	-0.06	-0.24
2	-0.60	-0.55	1.39	-0.97	-0.35	-0.19
3	0.06	-0.83	0.29	-0.38	-0.13	-0.40
4	0.37	1.36	-0.70	3.08	-0.14	-0.15
5	-1.28	0.72	-0.67	-0.81	-0.17	-0.36
6	-1.15	0.84	-0.73	-0.17	-0.21	0.14
7	0.73	0.70	-0.77	0.98	-0.16	-0.37
8	2.30	-0.91	-0.89	-0.40	-0.21	-0.27
9	-0.41	-0.77	-0.86	0.16	0.02	-0.26
10	-1.00	0.73	-1.07	0.52	0.87	-0.39
11	-1.31	0.28	-0.96	0.63	1.70	-1.16
12	-1.42	-1.03	0.44	-0.86	-0.25	-0.38
13	0.66	-1.21	0.35	-0.41	-0.10	-0.31
14	0.28	0.19	1.22	-0.05	0.70	-0.71
15	0.67	0.25	-0.66	-0.35	-0.26	-0.36
16	0.47	0.41	-0.77	-0.26	4.35	0.48
17	-0.50	1.21	-0.90	-0.43	0.37	-0.44
18	0.29	0.71	0.20	-0.34	0.07	-0.44
19	0.35	0.86	1.03	0.60	-0.67	1.21
20	0.06	-0.72	-0.82	-0.81	0.29	-0.54
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
2998	-0.25	0.98	-0.74	-0.55	-0.20	-0.29
2999	0.83	0.22	1.28	-0.23	-0.40	-0.15

Table 22: Correlation matrix of the 16 included IES Typology 1 variables in PCA[9]

	V1	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*	*V11*	*V12*	*V13*	*V14*	*V15*	*V16*
V1	**1**	-0.52	0.00	0.03	0.07	-0.09	-0.10	-0.17	0.70	-0.11	0.00	-0.01	-0.01	0.03	0.05	0.00
V2	-0.52	**1**	0.08	0.07	-0.11	-0.04	0.32	-0.01	-0.37	0.11	0.24	0.03	0.06	-0.03	0.03	0.06
V3	0.00	0.08	**1**	0.76	0.05	-0.07	0.14	-0.05	0.11	-0.09	0.12	0.08	0.06	0.06	0.03	-0.01
V4	0.03	0.07	0.76	**1**	0.21	0.07	0.16	0.07	0.14	-0.10	0.16	0.09	0.06	0.08	0.03	-0.09
V5	0.07	-0.11	0.05	0.21	**1**	0.80	0.06	0.58	0.05	0.00	0.14	0.02	0.01	0.04	0.02	-0.33
V6	-0.09	-0.04	-0.07	0.07	0.80	**1**	-0.05	0.69	-0.09	0.03	0.06	0.01	0.01	0.03	0.00	-0.27
V7	-0.10	0.32	0.14	0.16	0.06	-0.05	**1**	-0.13	-0.15	-0.02	0.51	0.09	0.12	0.03	0.10	0.05
V8	-0.17	-0.01	-0.05	0.07	0.58	0.69	-0.13	**1**	-0.16	-0.03	-0.05	0.02	-0.01	0.02	-0.03	-0.21
V9	0.70	-0.37	0.11	0.14	0.05	-0.09	-0.15	-0.16	**1**	-0.12	0.00	-0.02	-0.02	0.03	0.01	0.01
V10	-0.11	0.11	-0.09	-0.10	0.00	0.03	-0.02	-0.03	-0.12	**1**	0.09	0.03	-0.01	0.05	0.02	0.04
V11	0.00	0.24	0.12	0.16	0.14	0.06	0.51	-0.05	0.00	0.09	**1**	0.13	0.21	0.09	0.11	0.27
V12	-0.01	0.03	0.08	0.09	0.02	0.01	0.09	0.02	-0.02	0.03	0.13	**1**	0.28	0.26	0.16	0.03
V13	-0.01	0.06	0.06	0.06	0.01	0.01	0.12	-0.01	-0.02	-0.01	0.21	0.28	**1**	0.05	0.05	0.04
V14	0.03	-0.03	0.06	0.08	0.04	0.03	0.03	0.02	0.03	0.05	0.09	0.26	0.05	**1**	0.03	0.00
V15	0.05	0.03	0.03	0.03	0.02	0.00	0.10	-0.03	0.01	0.02	0.11	0.16	0.05	0.03	**1**	0.04
V16	0.00	0.06	-0.01	-0.09	-0.33	-0.27	0.05	-0.21	0.01	0.04	0.27	0.03	0.04	0.00	0.04	**1**

[9] Variables are renamed according to the same order as Table 5 and are given here as V1 – V16