Open access • Journal Article • DOI:10.1007/S12571-017-0700-4

Threats to food sufficiency among smallholder farmers in Choma, Zambia

— Source link

Kabwe Harnadih Mubanga, J. Willem H. Ferguson

Institutions: University of Pretoria

Published on: 12 Jul 2017 - Food Security (Springer Netherlands)

Topics: Agriculture

Running title: Smallholder food sufficiency in Choma

Threats to food sufficiency among smallholder farmers in Choma, Zambia

Kabwe Harnadih Mubanga[1*] · Willem Ferguson[1]

[1]Department of Geography, Centre for Environmental Studies, University of Pretoria, Private Bag X20, Hatfield, 0028, Pretoria, South Africa

*Corresponding author

E-mail: kabwe.mubanga@live.com Mobile: +27608908560. Fax: +27 012 4203210

Abstract

Relationships involving maize (*Zea mays*) production, maize retained for household consumption, household maize requirement, household size, rainfall and temperatures were assessed in order to explain food insufficiency among smallholder farmers in Choma, Zambia. Post-harvest agricultural data for 1976 to 2014 were collected from the Central Statistics Office while a survey of 319 smallholder farmers and eight key informants provided data on mean annual household maize requirements and crop preference. Despite maize production in Choma increasing at an annual rate of 230.8 t/year, maize insufficiency persisted as maize retained for household consumption could not sustain the 185.2 kg *per capita* maize requirement by farmers in the area. While extending the maize area planted was responsible for increasing annual maize production by 1.8 t for each additional ha planted, Choma's annual percentage population increase was larger at 2.6 %, requiring an increase of 821 t/year for maize sufficiency. Maize produced was usually enough for annual consumption before sales. However, farmers sold about 50 % of what they produced making the amount of maize retained for household consumption insufficient. Government incentives attached to maize production and marketing encouraged a maize-centric farming culture among farmers. Maize which had a guaranteed market from the Zambia Food Reserve Agency was allocated 73.4 % of the available land over the study period. The maize centric system has encouraged mono-cropping of maize. Farmer preference for maize, rooted in cultural norms, further encouraged maize mono-cropping at the expense of food sufficiency. In conclusion, government incentivising production and marketing of other agronomical suitable crops for the region could reduce food insufficiency.

Keywords Consumption · Farmers · Food sufficiency · Maize · Markets · Preference

Threats to food sufficiency among smallholder farmers in Choma, Zambia

Kabwe Harnadih Mubanga* · **Willem Ferguson**

Centre for Environmental Studies, Department of Geography, University of Pretoria, Private Bag X20, Hatfield, 0028, Pretoria, South Africa

*Corresponding author

E-mail: kabwe.mubanga@live.com Mobile: +27608908560. Fax: +27 012 4203210

Introduction

The last half century has experienced an increase in global food production and agricultural productivity leading to a reduction in the number of people lacking food (Godfray et al. 2010). In spite of this, at least one person out of seven still lacks sufficient energy and proteins in their diet (The World Bank 2008), in part due to the increased population as well as insufficient food production within rural communities (Godfray et al. 2010). For Zambia, the trends have been slightly different (Sitko et al. 2011). Over the period 1980 to 1999, Zambia's food production remained fairly constant with no significant longer-term increase. Since the 2006/2007 agricultural season, production of most crops has trended upwards, often associated with favourable weather (Sitko et al. 2011). For most rural households in Zambia, the acquisition of sufficient maize to meet annual household consumption guarantees annual food sufficiency, with other foods and crops being viewed as supplements (Simatele 2006). Food sufficiency is the ability of households to have adequate food whereby its members are not likely to go hungry (Bertmann 2011).

The general upturn in Zambian agricultural production since 2006 featured bumper harvests between the 2009/10 and 2011/12 agricultural seasons (Sitko et al. 2011), attributed to a few seasons of favourable weather as well as increased support from government to agriculture (GRZ 2013a). Despite this, 80 % of rural households in Zambia still face food insufficiency (Sitko et al. 2011). However, over the longer term, in Choma in southwest Zambia (as in many other parts of sub-Saharan Africa), climate variability and change has directly or indirectly affected crop production (Brown et al. 2015) and as a result the well-being of farmers (Collier et al. 2008a; Gregory et al. 2009). Such phenomena as decreased land suitability for agriculture, changes to the timing of rainfall and a reduced length of the crop growing season constrain farmers' crop yields (Tadross et al. 2009). A few days of high temperatures near to flowering can affect the yields of crops such as groundnut (*Arachis hypogaea*), maize (*Zea mays*) and soyabean (*Glycine max*) (Challinor et al. 2006). Such extreme weather with increased temperatures is projected to become more frequent and is likely to create higher annual variability in crop production (Collier et al. 2008b).

The Agro Ecological Regions (AERs) which make up Zambia's southern region are prone to droughts and crop losses. The susceptibility of the Choma area to food insecurity and its location in the low and medium rainfall regions of Zambia make it an ideal study site. Choma also has large numbers of smallholder farmers and is representative of other agricultural areas in southern Zambia.

The objectives of this study were (i) to establish the state of maize sufficiency among smallholder farmers in Choma District, and (ii) to determine why food sufficiency continues to elude smallholder farmers in Choma.

Theoretical and conceptual perspectives

Vulnerability, sensitivity and adaptive capacity of smallholder agriculture

Vulnerability of smallholder agriculture is a function of farm exposure to a perturbation, farm sensitivity to such a perturbation, and household adaptive capacity against perturbation (Eakin et al. 2006). Exposure to climatic hazards is one of the most important risks with agriculture and is considered a product of the social construction through political and economic factors affecting the geographical distribution of farms, physical infrastructure and human population size. Viewed at the level of a household, these differences in exposure are captured in differential sensitivities to climate impacts (Eakin et al. 2006) and measured in terms of levels of yield reduction, profit or loss, increase in production costs or loss in the quality of produce (Reilly and Schilmmelpfenning 1999). Agricultural sensitivity is a product of farm system management, available technology, and farmers' access to information (Smithers and Smit 1997). However, farmers' perception of their risk also determines their sensitivity, and hence Dessai et al (2003) summarised sensitivity as a function of risk perception and risk tolerance.

The degree of an agricultural system's flexibility, stability and access to key resources defines its adaptive capacity. The capability of farmers to respond to climatic stress or social stress is usually dependent on access to a variety of capital resources such as agricultural equipment, credit facilities, education, age, technical assistance, information, degree of crop and production system diversification, as well as income diversification (Ellis 2000). These factors determine how quickly an agricultural system can bounce back once hit by a shock or stress.

Risks rendering smallholder agriculture vulnerable

Smallholder agriculture is exposed to various risks, including pest and disease outbreaks, extreme weather events, changes in agriculture policies, and market shocks (Morton 2007). Failure to diversify livelihoods among smallholder farmers, coupled with their limited available resources, are expected to reduce their capacity to cope with stresses and shocks, and the loss of yield tends to have adverse impacts on household well-being (McDowell and Hess 2012).

The need to understand the causes of vulnerability in Zambian smallholder agriculture is important because 88 % of its farming population is involved in smallholder agriculture and over 90 % of the rural population are smallholder farmers. Poverty levels among these farmers have remained relatively high at about 80 % over the last 15 years (Hichaambwa and Jayne 2014) and 83 % of the farmers live below the international poverty threshold of US$ 1.25 per day (World Bank 2012). According to the Rural Agriculture Livelihood Survey (RALS 2012), 64 % of smallholder farmers in Zambia own less than two hectares (ha) of land and over 70 % cultivate less than two ha of land annually (Hichaambwa and Jayne 2014). Generally, a lack of crop and income diversification has contributed to this poverty (Lipton 2006). Off-farm employment among smallholder farmers is infrequent and only an estimated 39 % of income is attributed to off-farm activities (Hichaambwa and Jayne 2014).

Policy and economic factors affecting smallholder farmers' adaptive capacity

The production and marketing of maize has driven Zambian agricultural policies (Govereh et al. 2008). The Government of Zambia has been the major supporter of smallholder agriculture in Zambia, from inputs to markets, with maize crop production receiving subsidised inputs and market support. In the 1990s, policies involving privatisation, decentralisation, and liberalisation under a structural adjustment program (SAP) were introduced to open up the Zambian economy. During this period, government withdrew from its earlier provision of subsidies and market support for agriculture products (Milimo et al. 2002). This resulted in increased crop diversification among innovative farmers who concentrated more on producing cotton which had a ready market from private ginneries (Thurlow and Wobst 2004). Less innovative farmers continued to concentrate on mono-cropping of maize, but with reduced production due to a lack of government support.

A recognized need to increase the production of food crops resulted in the implementation in 2001 of the Farmers Input Support Programme (FISP) to again help smallholder farmers with subsidized inputs (GRZ 2013b). Initially beneficiaries received input packs for 1 ha (20 kg of maize seed, 4 x 50 kg basal dressing fertilizer and 4 x 50 kg of top dressing fertilizer). From 2008, that support to farmers was halved, with each beneficiary farmer receiving one maize pack typically comprising 10 kg of seed, and the appropriate basal fertilizer and top dressing fertilizer (Mason et al.

2013). Since 2013, in addition to maize, these packs have included sorghum (*Sorghum bicolor*), groundnut and cotton (*Gossypium barbadense*), sufficient for the cultivation of 0.5 ha of land. Beneficiary farmers under FISP had to belong to a registered farmer cooperative and to cultivate between 0.5 and five ha of land (GRZ 2013b).

Zambia's government has also provided markets for white maize from smallholder farmers through the Food Reserve Agency (FRA) by setting seasonal prices at which the government bought maize. These prices, announced at the beginning of each marketing season, were above market price (Mason and Myers 2011) and were the same across the country for a particular season. Conveniently located depots throughout the country provided market locations for the FRA. Choma District had 17 FRA depots.

These types of rapid change in agricultural policies tend to affect farmers' relations with their markets, the use of technology, and the management of resources (Berdegué et al. 2001). The introduction of FISP input support to maize farmers as well as FRA to maize markets has resulted in most farmers being engaged in maize agriculture to the extent that 86 % of Zambian farmers are reported to be engaged in maize production (Zulu et al. 2006). Such specialization in cropping reduces the capacity of smallholder farmers to adapt during periods of change, shocks or stress.

Methods

Study area

Choma District (Fig. 1) is located in the central part of the Southern Province of Zambia, covering an area of 7,249 km^2 with 42,000 registered farmers, most of whom are engaged in conventional forms of agriculture using oxen ploughing and hand hoeing while some farmers have adopted aspects of conservation agriculture (GRZ 2013b). The district is located at the confluence of Zambia's Agro-Ecological Regions (AER) I and II, which are the low and middle rainfall regions. Choma receives between 800-1000 mm of annual rainfall and has a growing period of 100-140 days. Mbabala, Singani and Batoka were used as study sites as they represented the different rainfall regimes within Choma District. Mbabala in the north was in the medium rainfall zone (AER II) while Singani and Batoka were in the low rainfall zones (AER I).

Fig 1 Map of Choma District in Zambia, showing the location of the study sites

Sampling

Post-harvest crop production, rainfall and temperature data

National post-harvest data collection in Zambia is done by the Ministry of Agriculture and Livestock (MAL) and the Central Statistics Office (CSO) and stored in the CSO agriculture database. It includes data on crop production, crop areas planted, crop sales, fertilizer usage and crop production at district, provincial and national levels for smallholder farmers. Data are collected annually from July to November. Post-harvest data from 1976 to 2012 for Choma were used in this study and was extracted from the CSO data base. That for 2013 and 2014 was extracted from MAL annual reports for Choma collected from the District Agriculture Coordinator's Office (DACO). These annual reports dated from 2004 to 2014 and the overlap between the CSO and MAL data enabled us to ascertain the accuracy of data before merging the data sets. Accurate and reliable data was a major limitation for this study. The CSO database lumped post-harvest data for small-scale farmers with that of medium scale farmers with a field size not exceeding 9 ha. Thus, only farmers who cultivated less than 9 ha of land were sampled. These farmers are collectively referred to as 'smallholder farmers' and were conceptualized to be farmers cultivating between 0.5 ha and 9 ha of land, mostly utilizing their own household labor and with partial engagement in local input and output agriculture markets (Ellis 2000). Annual rainfall and temperature data for the period 1976 to 2014 were obtained from the Zambia Meteorological Department database.

Semi-structured interviews

We sampled 319 smallholder farmers in Choma in three geographical areas; Singani, Mbabala and Batoka (Fig. 1), using semi-structured interviews. Interviews were conducted with household heads who were randomly sampled using a village register supplied by traditional authorities; either the Chief (in Singani) or the village Headmen (in Batoka and Mbabala). The random sampling included both male and female headed households. While females were interviewed in the 106 female-headed households, in male-headed households females were allowed to sit in interviews as they provided a different perspective and could remember information which the males may have forgotten. Suitability of the sample size was confirmed through a post-hoc power analysis using the GPower 3.1 data analysis software.

Information collected involved household maize requirements, crop preferences, and possible factors affecting maize sufficiency. Farmer crop preference was determined by asking farmers to name three crops they preferred to plant. The frequency of the named crops determined the preferred and less preferred crops among farmers. Interviews were conducted in English or the prevalent local languages *ChiTonga or ChiNyanja.* The period of data collection was from November 2014 to March 2015.

Key informant interviews and secondary data

Interviews with key informants were conducted with officials from MAL, the Zambia National Farmers Union (ZNFU) and with representatives of traditional authorities. Informants were selected based on their expertise on smallholder agriculture as well as interactions with local farmers. Secondary data were collected through a review of government reports, books, journals and websites in order to enhance our understanding of smallholder agriculture in Choma and Zambia.

Definition of terminologies

Maize retained for household consumption**:** The proportion of the maize held back by the farmer and not sold after harvest. This does not include the maize some farmers buy later in the season after their reserves ran out.

Maize sold**:** The proportion of the harvest sold to private buyers or to the FRA.

Household maize requirements**:** The total maize required by farmers to be maize-sufficient until the next harvest season, determined through surveys in which farmers estimated the amount of maize they consumed annually. The annual maize requirement for an individual was referred to as the *per capita* maize requirement.

Crop preference**:** Crops that farmers would rather cultivate at the expense of other crops.

Available fertiliser**:** The amount of fertiliser available to farmers. It included fertiliser provided under FISP as well as supplies bought from local dealers.

Data analyses

Correlation and linear regression analyses were performed to analyze the relationships between maize production and area planted, maize production and maize sold, household size and household maize requirements, rainfall and maize production as well as temperature and maize production among smallholder farmers in Choma. The statistical operations done in SPSS 22 and MINITAB 15 took into account the Durbin-Watson test for independent residuals and autocorrelation which was always in the range 1.5 to 2.5 indicating the data set had no temporal autocorrelation. The probability of maize sufficiency among households in Choma was assessed using a paired *T*-test by pairing the maize retained for household consumption and the annual household maize requirement from 1976 to 2014, taking into account the growing human population in Choma. A Pearson correlation analysis was also used to analyze productivity relationships involving crop and weather data. All the analyses were conducted at a P=0.05 probability level.

Data from the questionnaires were analysed using descriptive statistics and presented as means and percentages. A qualitative analysis was performed in which the responses were isolated into key emerging themes, whereby a high frequency of a particular theme represented a more common phenomenon in comparison with themes of lower frequency. Crop preference was analyzed through descriptive statistics by comparing the percentages of farmers who preferred to plant particular crops. Reasons for farmer choice of crops were assessed.

Results

Demographic characteristics of sample

Most of the respondents were male (66.7 %), and this may have had implications on the cropping systems and the crops grown. For example, while all male-headed households reported they concentrated on maize production, 58 % of them also grew groundnut (which was mostly managed by women). In contrast, 81 % of female-headed households grew groundnuts. Many of the farmers (34.2 %) were in their farming prime (aged 31-40). However the sample also included 19.6 % farmers older than 50 years, who had been engaged in agriculture for over 25 years. Most of the farmers we interviewed were literate. The sample included 38.2 % of respondents who had completed middle basic school while 16.3 % had gone to high school. But none of the interviewed farmers had reached college or university level (Table 1).

Interaction between maize produced, maize sold, maize retained for household consumption, area planted and household maize requirements

About half of the maize produced in Choma over the period 1976-2014 was sold, the remainder being retained for household consumption (Fig. 2a). The amount of maize retained for consumption and the amount sold has been increasing over the study period with a strong positive correlation (r=0.88; P=0.001; R^2=0.777) between maize produced and maize sold among smallholder farmers in Choma, implying that the more maize the farmers produced, the more they sold. At the same time, the amount of maize produced in Choma was dependent on the maize area cultivated (Fig. 2b). The area planted with maize increased over the study period, resulting in a rise in household maize produced. Every additional hectare of maize area planted in Choma resulted in a 1.8 tonne (t) increase in annual maize production in the district. Maize was allocated an average 73.4 % of the available arable land between 1976 and 2014 with a significant correlation between the maize area planted and maize produced (r= 0.578; P=0.001; R^2= 0.334).

Fig 2 Scatter graphs showing **r**elationship between (a) maize produced and maize sold in all of Choma District, 1976 to 2014 (b) maize produced and maize area planted in Choma (c) maize produced and maize retained for household consumption in Choma, 1976 to 2014 and (d) household size and household maize requirements in Choma. Dots represent mean annual values

There was a strong correlation between maize produced and maize retained for household consumption (r=0.725; P=0.001; R^2=0.526) (Fig. 2c). However, there was no significant correlation between maize retained for household consumption and maize sold (r=0.312; P=0.053), implying that the amount of maize required for household consumption did not determine how much maize the farmers would sell or not sell. Family size and household maize requirement were not major factors in determining how much maize was sold; rather, the amount of maize sold was largely determined by the size of the harvest. Choma had a mean household size of 6.4 persons in 2015, ranging from 5.3 in 1976 to 7.4 in 1989, and with no significant correlation with household maize production (r=0.173; F=1.136; P=0.293), implying that the larger labour supply in bigger households did not necessarily translate to higher maize production. However, household maize requirement correlated strongly with household size (r=0.842; P=0.001; R^2=0.709) (Fig. 2d). Each additional person contributed a 185.2 kg increase in annual household maize requirement (Fig. 2d).

Maize retained for household consumption and household maize requirements, and rising human population

Maize retained for household consumption after sales for Choma District ranged from a low of 3102.4 t in 1992 to a high of 60342.6 t in 1981 (Fig. 3). The low amount of maize retained for consumption in 1992 was due to drought in that year, resulting in reduced maize production. Maize insufficiency prompted the donor community to provide relief aid to most Zambian communities. Since the government had withdrawn input and market support to the agriculture sector during this period, many farmers produced less maize. In the 2011/2012 agricultural season, farmers retained 59071.9 t of maize for household consumption; the highest over the last two decades and second highest after 1981. The amount of maize retained for household consumption has been increasing since 2008 but this did not always translate into maize sufficiency. The human population of Choma has undergone a near 3-fold increase from 100451 people in 1976 to 271280 in 2014. Maize retained for household consumption correlated positively with household maize requirement (r=0.525; P=0.001; r^2=0.276). When the annual threshold for household maize requirement was not reached, farmers purchased maize from other farmers when they exhausted their retained maize. Using the *per capita* consumption rate of 185.2 kg/year for the varying household sizes over the period 1976 to 2014, Choma has had only nine years of maize surplus since 1976 (Fig. 3). The black bars in Fig. 3 show the current situation in Choma where the maize retained for household consumption is the difference between the maize produced and the maize sold, resulting in a maize deficit among farmers.

Fig 3 Maize retained for household consumption in Choma, Zambia, for current and possible scenarios of maize sales, 1976 to 2014

If household maize consumption was given precedence before sales and only the excess maize was sold, then only in nine years since 1976 would there have been a maize deficit, with most of the deficit occurring in the 1990s and early 2000s (Fig. 3). This is represented by the grey bars in Fig. 3 where the maize sold is shown as the difference between maize produced and household maize requirement. The household maize requirement would then equal the maize retained for household consumption for all the years in which maize production was higher than the household maize requirement. With the exception of the nine deficit years, farmers would attain maize sufficiency. In order to determine whether the maize retained for household consumption was sufficient for households in Choma, a paired sample *T*-test was conducted, with each year as a measure, to determine whether there was a significance difference between the maize retained for consumption and the household maize requirements. The resulting *T*-statistic was significant (T=-4.365; p=0.001). The household maize requirement was significantly higher than what was actually retained for consumption. When households ran out of the maize retained for consumption, farmers reported they mostly engaged in off-farm income generating activities such as petty trade, casual work or gardening to raise money to purchase maize from other farmers with maize stocks. In severe cases of hunger, relief maize was provided by the government such as in 1992/1993 and 1995/1996 under the Program Against Malnutrition (PAM).

Changes in per capita maize production

The area planted with maize in Choma correlated with increases in human population over the period 1976 to 2014 (Fig. 4). The population growth rate in Choma since 1976 has averaged 2.6 % (ranging from 1.9 % to 3.3 %), 4440.7 persons per year, resulting in a corresponding maize production increase in Choma of 230.8 t/year. Each additional person in Choma has resulted in a 0.1 ha increase in the maize area planted and a 50 kg increase in maize produced. Farmers opened up new lands for maize cultivation at a rate of 445.2 ha/year (Fig. 4). The total area planted for all crops in Choma grew from 22 700 ha in 1976 to 61 067 ha in 2014. Choma's maize production rose from the mid-1970s to the late-1980s (Fig. 4). The most productive year was 1981 with 130572 t of maize produced in Choma. Production decreased in the 1990s but, as indicated earlier, since 2006 maize production has been increasing again. Maize accounted for 89.7 % of the farmers' total household food production over the study period.

Fig 4 Maize area planted, maize produced and human population size in Choma, Zambia, 1976-2014

From our calculations, the *per capita* production of maize for Choma District has decreased at the rate of 7.3 % per annum from 1976 to 2014 (Min=17.7 kg/ person in 1992; Max=1088.3 kg/person in 1981; Mean=317.3 kg/ person) (r=0.382; p= 0.001; R^2=0.146). Three phases of per capita production of maize were identified. There was a phase of high production from 1976 to 1991 with a mean per capita maize production of 450.3 kg/person. This could have been the result of heavy government subsidy support to farmers as well as the lower population. The mean *per capita* production of maize fell to 191.1 kg per person from 1992 to 2009. The early part of this phase coincided with the period of a structural adjustment programme (SAP) when government withdrew most support from the agricultural sector, resulting in higher costs of inputs for farmers. Even when government support resumed in the early 2000s, the levels of subsidies were less than in the 1970s-1990s. The third phase, featuring a renewed increase in *per capita* production from 2010 to 2014 (averaging 346 kg per person), coincided with a period of favourable weather and further increased government support in the agriculture sector, and it occurred despite a larger human population in Choma.

Interaction between maize area planted and available fertilizer

There was a strong correlation between the area planted with maize and the amount of fertilizer used for maize (r=0.758; P=0.001; R^2=0.574). Access to fertilizer was reported to be one of the major limiting factors to increased maize production by smallholder farmers in Choma. Delays in fertilizer distribution to the area, as well as a lack of access to sufficient fertilizer, were commonly mentioned. Farmers complained of receiving fertilizer in December or January instead of October or November when it was required. The amount of FISP fertilizer received was static and did not increase with area planted. Hence farmers had to supplement it with purchased fertilizer.

Rainfall and temperature effects on maize production

Seasonal rainfall in Choma correlated with maize production, but not significantly (r=0.261; F=2.698; P=0.109); neither did the amount of early rainfall occurring during the planting period in November to December (r=0.034; F=0.042; P=0.839). Rainfall during the tasselling and silking period (from February to April) showed a significant relationship with maize production (r=0.456; P=0.004; R^2=0.208). Seasonal temperature, however, did not show a significant relationship with maize production (r=0.137; F=0.705; P=0.406).

Use of income from maize sales

All the farmers interviewed said they retained some of the money received from maize sales to buy farming inputs for the next season. Even farmers that were FISP beneficiaries bought farming inputs for additional production above the 0.5 ha or 1 ha for which subsidised inputs were provided. Other domestic needs such as children's school fees, provision of additional foods not produced by the household, the repair and upgrade of houses, and recreation, required funds which came mainly from maize sales (Table 2). Maize and maize-meal selling prices were at a peak in 2000, 2002 and 2013 (Fig. 5). The maize price represented the price at which the government was buying maize grain from farmers while the maize-meal price was the retail price for processed maize. Maize-meal is Zambia's staple food and its prices have generally been increasing while maize grain prices have been relatively stable since 2009.

Fig 5 Government maize grain buying price and millers' maize-meal selling prices in Zambia, 2000 to 2014

Trends in other crops grown in Choma

After maize, groundnut was the second most cultivated crop over the study period (Min=304 ha in 1979; Max=14114.1 ha in 2010; Mean=4356.2 ha), planted on 10.9 % of the total arable land (Fig. 6a). Land allocated to groundnut cultivation decreased until 1985 when it started increasing again. Sunflower (*Helianthus annuus*) was planted on 5.8 % (Min=101.6 ha in 2007; Max=10516 ha in 1985; Mean=2241.4 ha) of the total arable land. Sunflower production decreased until 1997, when production began to increase. Sorghum, a potential substitute to maize, was found on only 0.6 % of the arable land (Min=8 in 1992; Max=1087 ha in 2006; Mean=242.5 ha). Cotton production was allocated 5.3 % of the total arable land (Min=38 ha in 1977; Max=8144 ha in 2005; Mean=2109.6 ha). Cotton and sorghum production was almost constant over the study period.

Fig 6 Trends in (a) area cultivated and (b) production of less important crops in Choma, 1976 to 2014

Besides maize, groundnut, sunflower, cotton and sweet potato were the most consistently cultivated crops (Fig. 6b), accounting for a combined 9.3 % by weight (Groundnut=2.3 %; Sunflower=1.6 %; Cotton=3.4 %; Sweet potato=2.0 %) of the total produce in the area. Sweet potato increased in production since 1998. Production of other crops remained fairly constant. Most of the sunflower produced (Min=33.89 t in 2007; Max=4414.7 t in 1986: Mean=981.9 t) was sold (72.8 %). Groundnut was largely produced for household consumption (Min=76.8 t in 1978: Max=7685.6 t in 1980: Mean=1403.4 t) with 15.7% of the produce sold. Cotton in Choma was produced entirely for sale (Min=35.3 t in 2012; Max=2939.5 t in 1985; Mean=623.7 t). Production of cotton was variable, peaking around 1986, 2005 and in 2012.

From 1976 to 1997 farmers grew maize, groundnut, sunflower, common bean (*Phaseolus vulgaris*), sorghum, soyabean and cotton. Most of these crops were important for household consumption. Maize and cotton were the crops mostly produced for sale as the government provided markets for maize while private ginneries provided markets for cotton. Cotton was always produced under contract where the cotton company provided inputs to farmers who agreed to sell back to the company upon harvest. In the period 1998 to 2014, farmers also cultivated cowpea (*Vigna unguiculata*), Bambara nut (*Vigna subterranea*) and sweet potato.

Crop preference by farmers in Choma

Farmers in Choma gave priority to the cultivation of maize (100 %) while groundnut and sweet potato were the second and third most preferred crops (60.7 % and 57.1 %, respectively; Fig. 7). Availability of markets for maize was responsible for 92 % of farmers' preference for the crop. The high demand for maize from both the government and the private sector made the crop preferable to over 78 % of the respondents. The cultural value attached to the staple local dish *nshima* (a hard porridge prepared from maize-meal and consumed with relish), made maize the preferred crop to 73.5 % of respondents (Table 3).

Fig 7 Smallholder farmer preference of crops for planting in Choma, Zambia, 2014

Discussion

Maize production in Choma District increased at an annual rate of 230.8 t/year from 1976 to 2014. The human population in Choma dependent on maize as the staple food for consumption also increased nearly three-fold over this period. However, only 50 % of the total maize production in Choma was kept for household consumption, with the rest sold. The annual household maize requirement was significantly higher than the part of the maize harvest kept for household consumption. Hence farmers usually had a maize deficit for home consumption.

Choma recorded a decrease in mean per capita maize production from 450.3 kg/person (during 1976 to 1991) to 191.1 kg/person for 1992 to 2009, and then an increase since 2010 (averaging 346 kg/person). The phase of high per capita production (1976 to 1991) coincided with a period of high investment into the agricultural sector by the Government of Zambia. Large input subsidies and a guarantee of markets with above-market prices (Howard and Mungoma 1996) motivated farmers to increase their production. The establishment of the National Agriculture Marketing Board (NAMBOARD) and later the Zambia Cooperative Federation (ZCF), which bought maize from the farmers locally, made maize production profitable as this provided an effective subsidy on transport costs. These incentives resulted in increased maize production during the phase of high *per capita* production.

The phase of decreased *per capita* maize production (i.e., 1992-2009) occurred while Choma continued to experience large increases in the size of its human population. Although maize production still increased somewhat, *per capita* maize production decreased substantially from the early 1990s to early 2000s when government withdrew agricultural subsidies. After the government resumed the subsidy programme in 2001, fertilizer and seed inputs were only subsidized at 50 % (GRZ 2013b) and the proportion of input costs paid by the farmers remained high. Since 2010, the Government of Zambia increased its proportion of the subsidy on fertilizer to 76 % and to 50 % for seed. Since 2013, fertilizer has been subsidized at 50 % and seed free. These favourable policies have clearly contributed to the increased per capita production of maize that Choma has experienced since 2010. Additionally, Choma has also experienced favourable annual rainfall conditions since 2010 (Max=1010 mm in 2010; Min= 793 mm in 2012; Mean= 881 mm), and others have credited the increase in *per capita* maize production to the improved rainfall (see Sitko et al. 2011). In all three phases of maize production we identified, we calculated higher *per capita* maize production than the household requirement for maize, implying that farmers generally produced enough maize to meet home consumption needs and had a surplus before sales. If farmers would retain sufficient maize for their household maize requirement, they would always have food sufficiency. However, this would have meant less maize for sale, hence, less household income from maize. The lost income could have been replaced by farmers diversifying their livelihoods or their crops. Farmers reported they sold a proportion of their maize in order to sustain household financial requirements such as the need for clothing, farming inputs, school fees and other needs. Allocation of income to non-food related activities implied that even for rural households, food sufficiency was not always the main objective (Swift and Hamilton 2001). Because of the price rises of maize meal from millers after the year 2000 in Zambia, farmers have not been using income from sales of maize to buy maize meal from millers. Locally-bought and locally-ground maize meal was less expensive (US$ 0.15/kg) compared to maize meal from millers (US$ 0.4/ kg).

The recommended planting period for maize in Choma is between 15th and 30th November (CSO 2012). However, as mentioned earlier, FISP inputs were sometimes only provided in December or January. To avoid late planting, farmers said they used money from maize sales to buy inputs in advance. The total maize area planted in Choma underwent an annual increase of 445.2 ha/year over the study period. An important way of increasing agricultural production in Choma has been by extensification (i.e., opening up new land for cropping) rather than intensifying production (increased production per unit area of land). Agriculture intensification is often seen as a key means to achieve food sufficiency and reduce rural poverty (see Suhardiman et al. 2015). Intensifying production is a consequence of increased inputs per unit land area cultivated (Ricker-Gilbert 2014) which involves farmers either needing access to increased agriculture capital or to technological advances in agriculture. As such, increasing the area cultivated in Choma has remained the most important way to raise production. While this method of increasing production may have provided food sufficiency in the past and the short term future, it is not sustainable in the long term. Agricultural extensification involves deforestation, opens up new areas of land for erosion, and when coupled with the increase in human population large areas are eroded (Gregory et al. 2002). Crops grown on such farms still have low productivity and farmers will require yet more land to produce enough to sustain themselves. In contrast, agricultural intensification ensures increased productivity on the same field by improving the soil fertility and land management rather than opening up new lands (Pretty et al. 2011; Droppelmann et al. 2017); an approach more likely to provide sustainable food sufficiency but which requires capital and technological investment to be sustainable.

Less important crops

Compared to our early period (1976 to 1997) when only maize, groundnut, sunflower, common bean, sorghum, soyabean and cotton were grown, the latter period (1998 to 2014) saw several formerly ‘unpopular crops’ such as cowpea, Bambara nut and sweet potato more widely cultivated by farmers in Choma. Very little of the sweet potato was sold as it was used for breakfast by households. Greater crop diversity over the period 1998 to 2014 was mostly driven by emerging markets for some of these products. For example, the World Food Programme’s (WFP) Home Grown School Feeding Programme which involves buying cowpea for rural school children (WFP 2014) has resulted in increased production of cowpea since 1998. Increased demand for sunflower and soyabean by oil manufacturing companies has resulted in the increased production of these crops. The nature of crops grown was also influenced by the gender of the farmer. Groundnut was mostly cultivated by female farmers and was generally considered to be a ‘woman’s crop’ by both males and females. While the fields owned by a household were under the control of a husband (male-headed), wives were also allowed their 'own' fields where they grew crops such as groundnut, common bean and cowpea.

Factors contributing to smallholder farmers’ food insecurity

This study has established that the amount of maize the farmers retain for household consumption after harvest is usually less than their annual maize requirement, contributing to household food insufficiency. However, other factors affect the food sufficiency status of smallholder farmers in Choma.

Firstly, the government policy of subsidizing maize production by providing inputs through FISP has encouraged maize mono-cropping as it makes maize a cheaper crop to produce. While this policy was intended to boost food sufficiency among farmers and provide cheaper maize to feed the politically important urban population in Zambia, it has also led to farmers producing maize on most of their fields (73.4 % of available arable land) at the expense of other crops. The ensuing mono-cropping worked against the principles of crop diversification that the government had also been promoting through its national agriculture policy (NAP) (GRZ 2004). Maize mono-cropping without crop rotation may lead to reduced production over a longer term due to nutrient use without replenishment (Zingore et al. 2011). It could also contribute to farmer vulnerability to crop losses during periods of extreme climatic events (Reynolds et al. 2015). Failure to diversify cropping systems has been at the heart of food insufficiency in many places (Lipton 2006). Crop diversification gives farmers wider human nutritional options and contributes to poverty reduction (Thurlow and Wobst 2006).

Secondly, provision of markets and market incentives such as a transport subsidy to maize depots for maize sellers, coupled with a lack of markets for other crops, has contributed to food insecurity among smallholder farmers in the area by encouraging the marketing of maize at the expense of other crops. This has also contributed to the maize mono-cropping culture as farmers prefer to grow crops for a ready market. FRA has been mandated to buy maize from farmers at above market prices (Govereh 2008). The skewed land use for the different crops is therefore also a response to the availability of markets.

Thirdly, farmer preference for maize relative to other crops has meant farmers cultivated the crop at the expense of crops that may be more agronomical suitable for Choma. For example, both pearl millet (*Pennisetum glaucum*) and sorghum are maize substitutes and are less sensitive to droughts compared to maize (Reynolds et al. 2015; Jukanti et al. 2016) with a higher probability of facilitating food sufficiency by stabilizing food grain production in dry years. However, most of Choma's farmers did not prefer these potential maize substitutes and did not cultivate them (less than 1 % of the available arable land was allocated to their cultivation). Cultural preferences have shaped the farmers' regard for particular crops. Traditionally, *nshima* made out of maize-meal is the staple food for households in Choma. The response given by a farmer engaged in farming for over 30 years summarised the general feelings of smallholder farmers in the area about their preference for maize compared to potential maize substitutes such as pearl millet:

> "Sorghum or pearl millet is not used for food here. People who used to grow these were using it for making a local brew. But with the increase in the availability of opaque beer, farmers no longer grow sorghum and pearl millet."

Fourthly, maize was reported to require more production inputs compared to other crops and this made the crop more expensive to cultivate and manage; the high level of management coming at a cost beyond the capacity of most small scale farmers. A comparison of fertilizer requirements (kg/ha) for selected crops in Choma showed that maize cultivation required more fertilizer than other crops (Table 4). Despite the expense involved in cultivation of maize, the crop is one of the lowest priced on the agricultural output market (ZNFU 2015) and the profitability of maize was reduced by the fairly constant government pricing since 2009 (ZNFU 2015). Failure to meet the costs of management, particularly relating to fertilizer, has resulted in yield and financial losses for farmers and food insecurity.

Conclusion

Smallholder farmers in Choma generally produce enough maize to guarantee their own food sufficiency. However, indiscriminate selling of the harvest due to various incentives for sale has often left them maize insufficient. The *per capita* maize requirement of 185.2 kg/year for human consumption was rarely satisfied by the maize retained for household consumption. Maize production in the region has increased since 1976 due to farmers increasing the overall area cultivated with maize. Annual maize production in Choma District has been increasing at the rate of 230.8 t/year. However, Choma's human population has also been increasing substantially, at an annual rate of

4440.7 persons/year. This means that despite the increased maize production, the *per capita* production of maize in Choma has fallen from 450.3 kg/person/year during the period 1976 to 1991, to 346 kg/person/year during the period 2010 to 2014. The Government of Zambia's provision of production input, market and transport subsidies to maize farmers over these years has promoted a culture of maize mono-cropping and an increasing over-reliance on maize in Choma, as elsewhere in Zambia. Maize production was determined to be more expensive compared to most other crops due to higher costs of inputs and a near static maize price on output markets. The now in-grained farmer preference towards maize at the expense of other crops has exacerbated maize mono-cropping. Improving smallholder food sufficiency in Choma should address the broadening of markets as a major driver of smallholder agriculture. Provision of competitive markets for a wider range of other crops could make them attractive to farmers, improving crop diversification and the disposable income of farm households. This should contribute to household food sufficiency in Choma.

Acknowledgments

The authors thank the STRECC programme of Maastricht University, The Netherlands, for providing funding for this research, and a scholarship to the first author.

Declaration of no conflict of interest

The authors declare that they have no conflict of interest.

References

Berdegué, J., Reardon, T., & Escobar, G. (2001). Rural non-farm employment and incomes in Chile. *World Development, 29*(3), 411-425.

Brown, R.P., Hochman, Z., Bridle, K.L., & Huth, N.I. (2015). Participatory approaches to address climate change: perceived issues affecting the ability of South East Queensland graziers to adapt to future climates. *Agriculture and Human Values, 32*(4), 689-703.

Challinor, A. J., Wheeler, R.T., Osborne, M.T., & Slingo, M.J. (2006). Assessing the vulnerability of crop productivity to climate change thresholds using an integrated crop-climate model. In: Schellnhuber, J, Cramer, W, Nakicenovic, N, Yohe, G and Wigley, T, (eds.), *Avoiding Dangerous Climate Change* (pp. 187-194). Cambridge University Press, UK.

Collier, R., Fellows, J., Adams, S., Semenov, M., & Thomas, B. (2008a). Vulnerability of horticultural crop production to extreme weather events. *Aspects of Applied Biology, 88*, 2-14.

Collier, P., Conway, G., & Venables, T. (2008b). Climate change and Africa. *Oxford Review of Economic Policy, 24*(2), 337-353.

Dessai, S., Adger, W.N., Hulme, M., Köhler, M., Turnpenny, J., & Warren, R. (2003). Defining and experiencing dangerous climate change. Tyndall Center for Climate Change Research. Norwich, UK: University of East Anglia.

Droppelmann, K.J., Snapp, S.S., & Waddington, S.R. (2017). Sustainable intensification options for smallholder maize-based farming systems in sub-Saharan Africa. *Food Security, 9*(1), 133-150.

Eakin, H., Webhe, M., Ávila, C., Torres, S.G., & Bojórquez-Tapia, A.L. (2006). A Comparison of the social vulnerability of grain farmers in Mexico and Argentina. *Working Paper No*. 29. Washington DC, USA: Assessments of Impacts and Adaptations to Climate Change (AIACC).

Ellis, F. (2000). Rural livelihoods and diversity in developing countries. New York, USA: Oxford University Press.

Godfray, H., Charles, J., Beddington, R.J., Crute, R.I., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., & Toulmin, C. (2010). Food Security: The challenge of feeding 9 billion people. *Science, 327*(5967), 812-818.

Govereh, J., Jayne, T.S., & Chapoto, A. (2008). Assessment of alternative maize trade and market policy interventions in Zambia. *Working Paper No. 33*. Lusaka, Zambia: Food Security Research Project (FSRP).

Gregory, P. J., Ingram, J. S. I., Andersson, R., Betts, R. A., Brovkin, V., Chase, T. N., Grace, P. R., Gray, A. J., Hamilton, N., Hardy, T. B., Howden, S. M., Jenkins, A., Meybeck, M., Olsson, M., Ortiz-Monasterio, I., Palm, C. A., Payn, T. W., Rummukainen, M., Schulze, R. E., Thiem, M., Valentin, C. & Wilkinson, M. J. (2002). Environmental consequences of alternative practices for intensifying crop production. *Agriculture, Ecosystems & Environment, 88*(3), 279-290.

Gregory, P. J., Johnson, S.N., Newton, A.C., & Ingram, J.S.I. (2009). Integrating pests and pathogens into the climate change/food security debate. *Journal of Experimental Botany, 60*(10), 2827-2838.

GRZ (2004). National agricultural policy (2004 – 2015). Ministry of Agriculture and Co-operatives. Lusaka, Zambia: Ministry of Agriculture and Co-operatives (MACO).

GRZ (2013a). Farmer input support programme (FISP): Implementation manual 2013/2014 agricultural season. Lusaka, Zambia: Ministry of Agriculture and Livestock.

GRZ (2013b). Ministry of Agriculture and Livestock: End of Year Report 2013. Choma, Zambia: Department of Agriculture.

Hichaambwa, M., & Jayne, T.S. (2014). Poverty reduction potential of increasing smallholder access to land. *Working Paper No. 83*. Lusaka, Zambia: Indaba Agricultural Policy Research Institute (IAPRI).

Howard, J. A., & Mungoma. C. (1996). Zambia’s Stop-and-go Revolution: The Impact of Policies and Organizations on the Development and Spread of Maize Technology. MSU International Development *Working Paper No. 61*. East Lansing, MI, USA: Michigan State University.

Jukanti, A.K., Laxmipathi Gowda, C.L., Rai, K.N., Manga, V.K., & Bhatt, R.K. (2016). Crops that feed the world 11. Pearl Millet (*Pennisetum glaucum* L.): an important source of food security, nutrition and health in the arid and semi-arid tropics. *Food Security, 8*(2), 307-329.

Lipton, M. (2006). Can small farmers survive, prosper, or be the key channel to cut mass poverty? *Journal of Agriculture and Development Economics, 3*(1), 58-85.

Mason, M. N., & Myers, J.R. (2011). The effects of the food reserve agency on maize market prices in Zambia: are there threshold nonlinearities. *Working Paper No. 60*. Lusaka, Zambia: Food Security Research Project (FSRP).

Mason, M. N., Jayne, T.S., & Mofya-Mukuka, R. (2013). A Review of Zambia's Agricultural Input Subsidy Programs-Targeting Impacts and the Way Forward. *Working Paper 77*. Lusaka, Zambia: Indaba Agricultural Policy Research Institute (IAPRI).

McDowell, J. Z., & Hess, J.J. (2012). Accessing adaptation: multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change, 22*(2), 342-352.

Milimo, J. T., Shilito, T., & Brock, T. (2002). The poor of Zambia speak. Who would ever listen to the poor? Lusaka, Zambia: Zambia Social Investment Fund.

Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences, 104*(50), 19680-19685.

Pretty, J., Toulmin, C. & Williams, S. (2011). Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability, 9*(1), 5-24.

Reilly, J. M., & Schimmelpfennig, D. (1999). Agricultural impact assessment, vulnerability, and the scope for adaptation. *Climatic Change, 43*(4), 745-788.

Reynolds, T., Waddington, S.R., Anderson, C.L., Chew, A., True, Z. & Cullen, A. (2015). Environmental impacts and constraints associated with the production of major food crops in Sub-Saharan Africa and South Asia. *Food Security, 7*(4), 795-822.

Ricker-Gilbert, J., Jumbe, C. & Chamberlin, J. (2014). How does population density influence agricultural intensification and productivity? Evidence from Malawi. *Food Policy, 48*, 114-128.

Simatele, M. C. H. (2006). The impacts of structural adjustment on food production in Zambia. *African Economic Research Consortium*, paper no. RP_159.

Sitko, N. J., Chapoto, A., Kabwe, S., Tembo, S., Hichaambwa, M., Lubinda, R., Chiwawa, H., Mataa, M., Heck, S., & Nthani, D. (2011). Technical compendium descriptive agricultural statistics and analysis for Zambia. *Working Paper No. 52*. Lusaka, Zambia: Food Security Research Project.

Smithers, J., & Smit, B. (1997). Agricultural system response to environmental stress. In Ilbery, B., Chiotti, Q., & Richard, T (Eds.), *Agricultural restructuring and sustainability: A geographical perspective*. New York, USA: CAB International.

Suhardiman, D., Giordano, M., Leebouapao, L., & Keovilignavong, O. (2015). Farmers' strategies as building block for rethinking sustainable intensification. *Agriculture and Human Values*, *33*(3), 1-12.

Swift, J., & Hamilton, K. (2001). Household food and livelihood security. In: Devereux, S., Maxwell, S. (Eds.) *Food security in sub-Saharan Africa*. London, UK: ITDG.

Tadross, M., Suarez, P., Lotsch, A., Hachigonta, S., Mdoka, M., Unganai, L., Lucio, F., Kamdonyo, D., & Muchinda, M. (2009). Growing-season rainfall and scenarios of future change in southeast Africa: implications for cultivating maize. *Climate Research, 40* (2-3), 147-161.

The World Bank (2008). World development report 2008. *Agriculture for development*. Washington DC, USA: World Bank.

Thurlow, J., & Wobst, P. (2004). The road to pro-poor growth in Zambia: past lessons and future challenges. *Discussion Paper 16*. Washington, D.C, USA: International Food Policy Research Institute.

WFP (2014). Improving links between smallholder farmers and school feeding programmes. World Food Programme.

Zingore, S., Tittonell, P., Corbeels, M., Van Wijk, M. T., & Giller, K. E. (2011). Managing soil fertility diversity to enhance resource use efficiencies in smallholder farming systems: a case from Murewa District, Zimbabwe. *Nutrient Cycling in Agroecosystems, 90*, 87-103.

ZNFU (2015). Zambia national farmers union commodity prices. *Farm prices*. http://www.farmprices.co.zm/. Accessed 13th August, 2015.

Zulu, B., Jayne, T.S., & Beaver, M. (2006). Smallholder household maize production and marketing behaviours in Zambia. *Working Paper 17*. Lusaka, Zambia: Food Security Research Project.

ZVAC (2008). Multi-sectorial in-depth vulnerability and needs assessment. Lusaka: Zambia Vulnerability Assessment Committee (ZVAC).

Table 1 Demographic characteristics of smallholder farmer respondents (n=319) in Choma District, Zambia

Area	Frequency	Percentage	Education	Frequency	Percentage
Singani	176	55.3	No formal education	13	4.1
Mbabala	85	26.5	Lower basic	38	11.9
Batoka	58	18.3	Middle basic	122	38.2
Gender	*Frequency*	*Percentage*	Upper basic	93	29.2
Male	213	66.7	High school	52	16.3

Female	106	33.3	*Years farming*	*Frequency*	*Percentage*
Age	*Frequency*	*Percentage*	≤ 5	77	24.1
≤ 20	4	1.4	6-10	93	29.2
21-30	56	17.4	11-15	57	17.9
31-40	109	34.2	16-20	36	11.3
41-50	87	27.4	21-25	15	4.7
≥ 51	63	19.6	≥25	41	12.9

Table 2 Use of money from maize sold by smallholder farmers (n=319) in Choma, Zambia

Use of money from maize sales	Percentage
Buying farming inputs e.g. fertilizer, seeds	100
Other foods not produced by households	93
School fees	84
Clothing	83
Repair/upgrade of houses	56
Social and recreational	54
Unplanned expenses e.g. sickness, death	13

Table 3 Reasons for maize preference among farmers (n=319) in Choma

Reasons for maize preference	Percentage
Staple food	100.0
Ready market	92.2
Matures relatively early	80.8
High maize demand from public and private sector	78.5
Cultural value related to *nshima*	73.5
Residues provide food for livestock in dry season	69.9
It's been grown even by our ancestors	49.3

Table 4 Input costs vs. output sales for selected crops grown in Choma, Zambia for the year 2015

Crop	Basal Dressing (kg/ha)	Top Dressing (kg/ha)	Yield Sale Price (USD/t)^
Maize	200-300	200-250	197
Pearl millet	100	80	-
Cassava#	-	-	395
Bean	200-300*	100*	789
Groundnut#	-	-	368

Source (GRZ 2014; ZNFU 2015). Basal fertilizer is (N: P_2O_5: K_20, 10:20:10) while top dressing fertilizer is 46 % N. * = Fertilizer required only in first year of cultivation. # = No fertilizer required during cultivation. ^ = 1 USD≈ZMW 8.3 at the time of data collection

Figures

Fig 1.

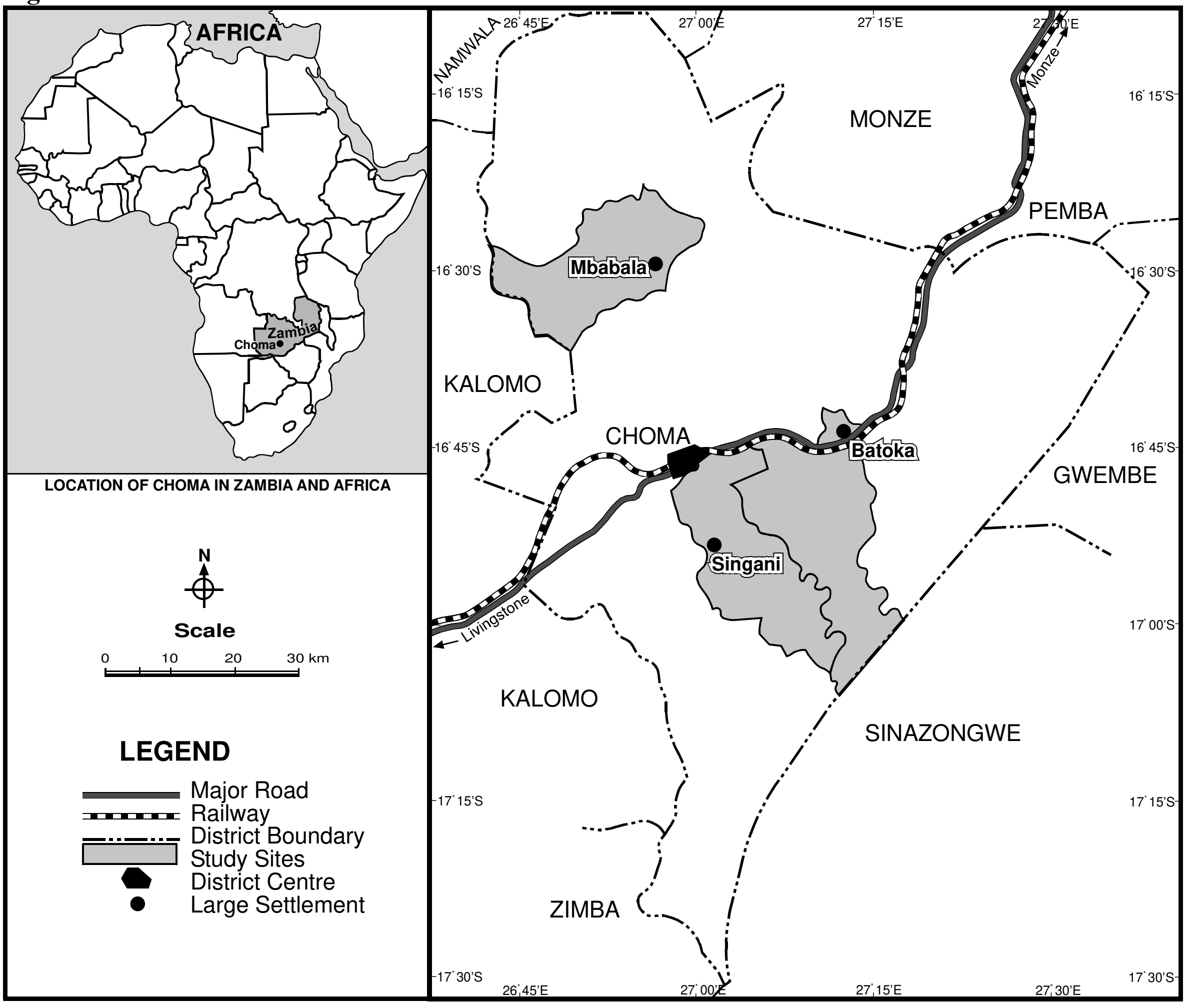
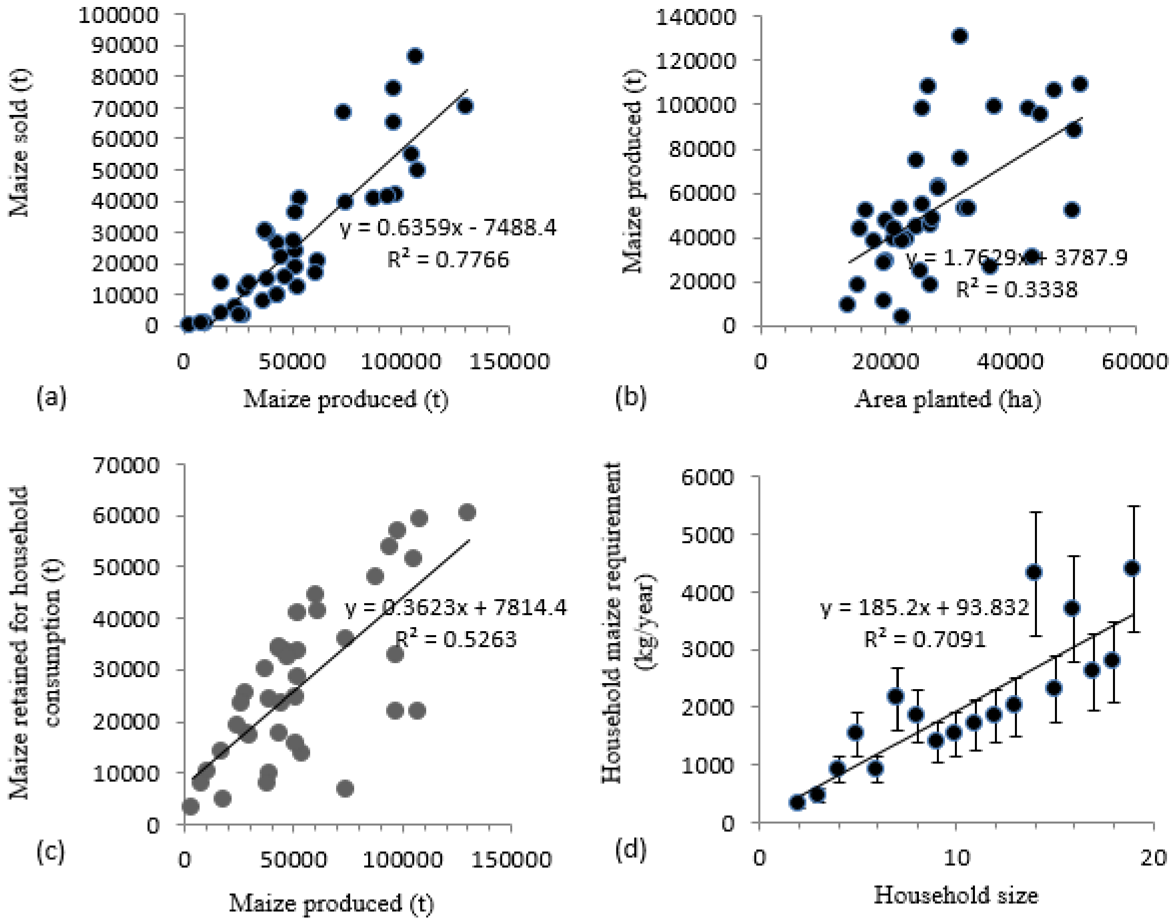
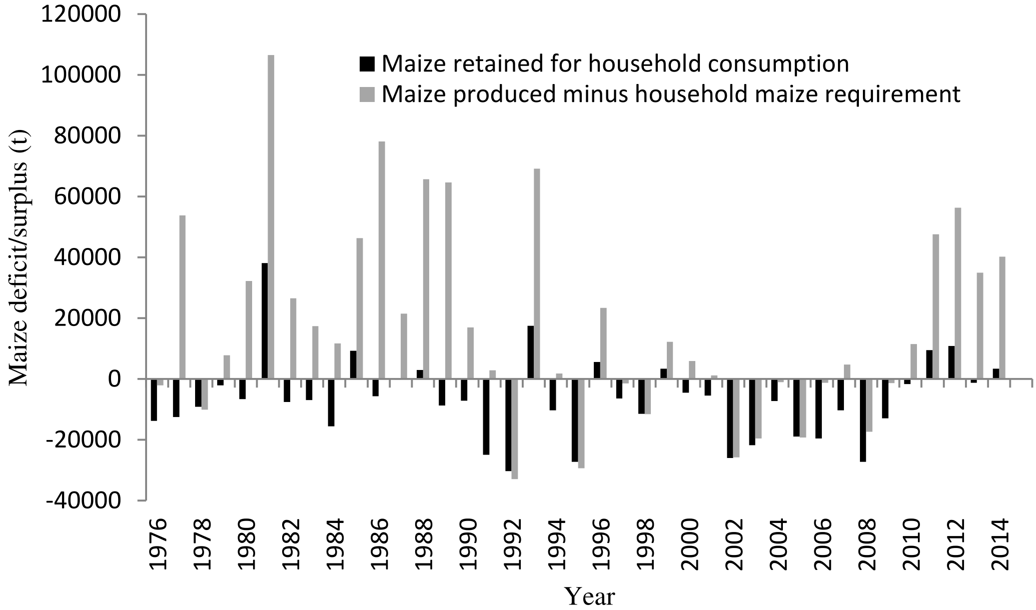


Fig 2.



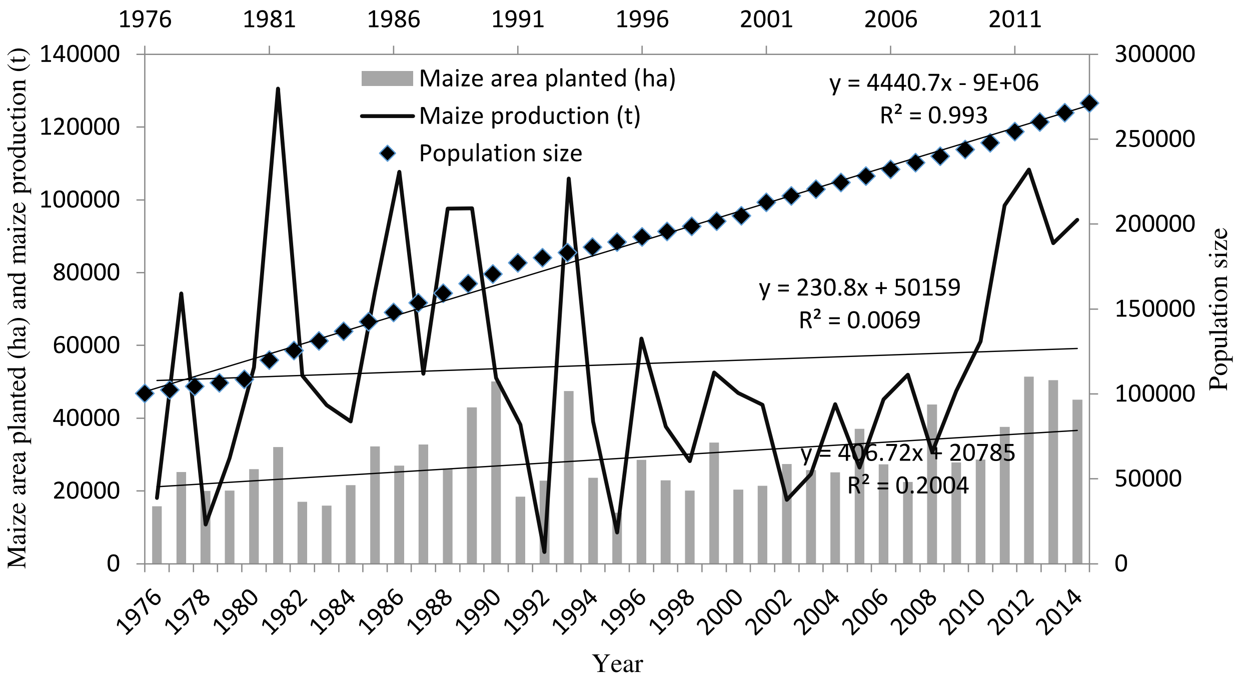
(a)
Maize sold (t)
Maize produced (t)
y = 0.6359x - 7488.4
R² = 0.7766
(b)
Maize produced (t)
Area planted (ha)
y = 1.7629x + 3787.9
R² = 0.3338
(c)
Maize retained for household consumption (t)
Maize produced (t)
y = 0.3623x + 7814.4
R² = 0.5263
(d)
Household maize requirement (kg/year)
Household size
y = 185.2x + 93.832
R² = 0.7091

Fig 3.



Maize retained for household consumption
Maize produced minus household maize requirement
Maize deficit/surplus (t)
120000
100000
80000
60000
40000
20000
0
-20000
-40000
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year

Fig 4.



1976
1981
1986
1991
1996
2001
2006
2011
Maize area planted (ha)
Maize production (t)
Population size
y = 4440.7x - 9E+06
R² = 0.993
y = 230.8x + 50159
R² = 0.0069
y = 406.72x + 20785
R² = 0.2004
Maize area planted (ha) and maize production (t)
140000
120000
100000
80000
60000
40000
20000
0
Population size
300000
250000
200000
150000
100000
50000
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year

Fig 5.

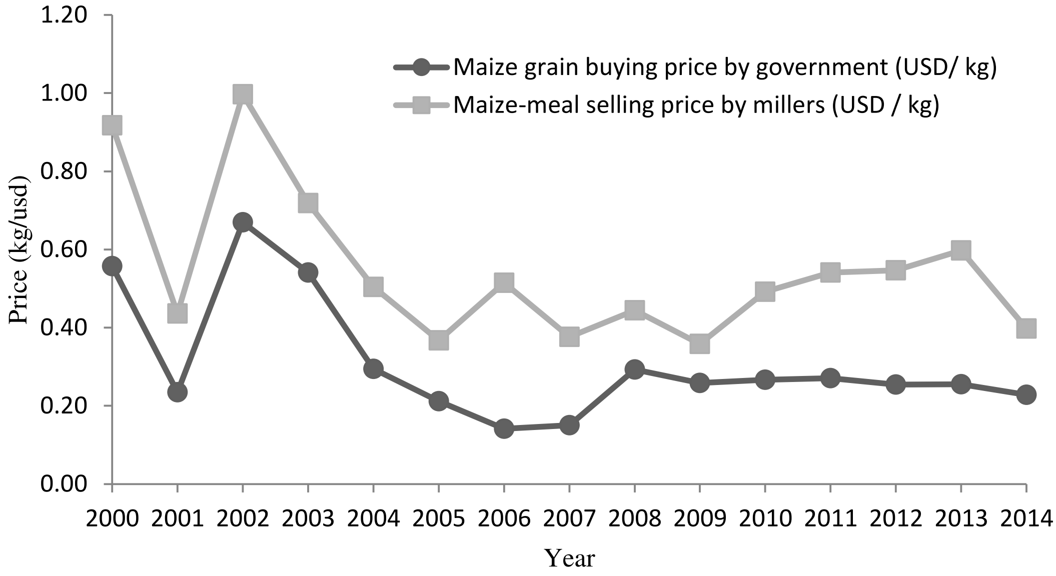
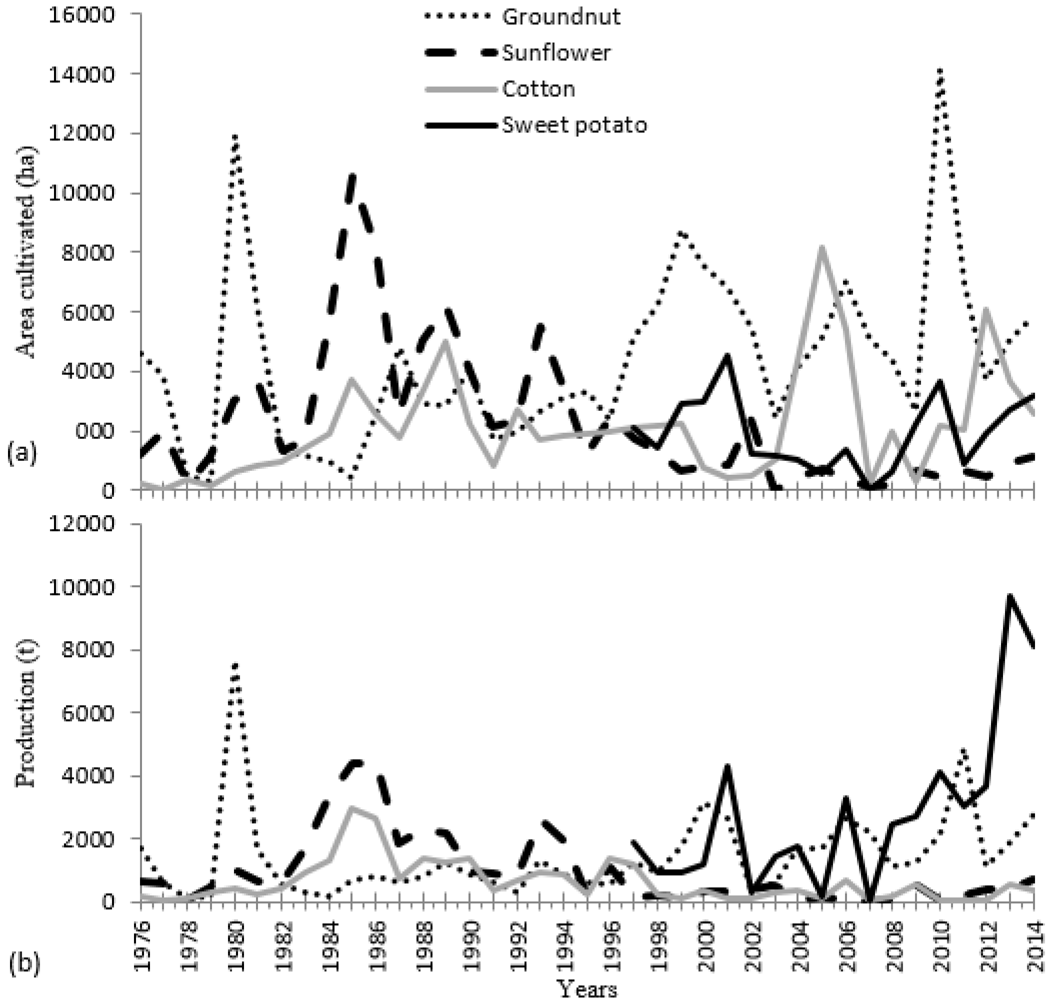
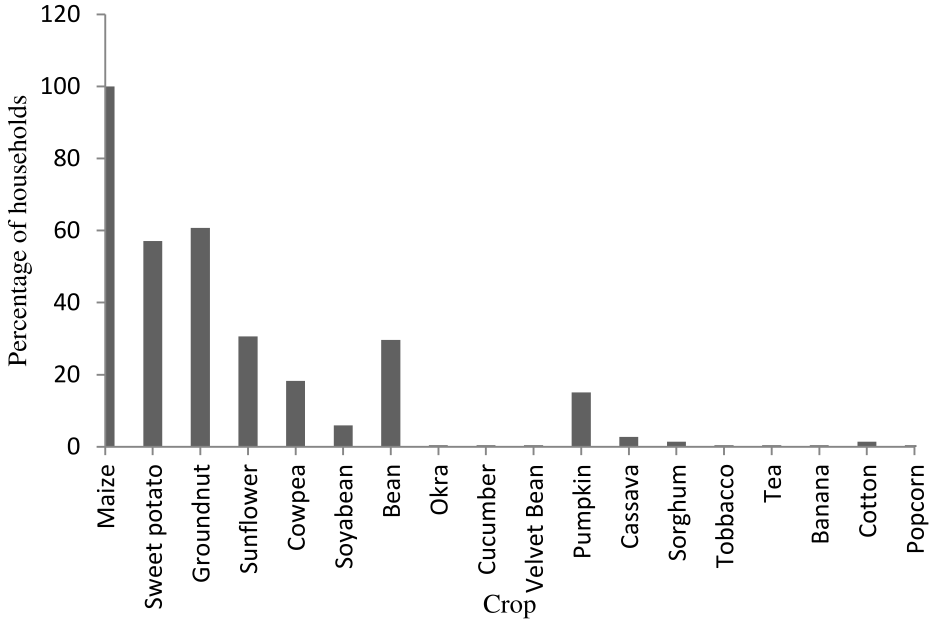

1.20
1.00
0.80
0.60
0.40
0.20
0.00
Price (kg/usd)
Maize grain buying price by government (USD/ kg)
Maize-meal selling price by millers (USD / kg)
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Year

Fig 6.



Groundnut
Sunflower
Cotton
Sweet potato
Area cultivated (ha)
(a)
Production (t)
(b)
Years

Fig 7.



120
100
80
60
40
20
0
Percentage of households
Maize
Sweet potato
Groundnut
Sunflower
Cowpea
Soyabean
Bean
Okra
Cucumber
Velvet Bean
Pumpkin
Cassava
Sorghum
Tobbacco
Tea
Banana
Cotton
Popcorn
Crop

Kabwe Harnadih Mubanga has been a lecturer and researcher at the University of Zambia. He is currently pursuing a PhD in Environment and Society at the University of Pretoria Centre for Environmental Studies (CFES), in South Africa. He holds a BSc in Natural Resources (awarded in 2007) and MSc in Geography (2013) from the University of Zambia. Kabwe's research interests are in the areas of climate change and variability, agriculture and food systems.

Willem Ferguson (Environmental Ecology MSc, PhD; Environmental Management M.Inst. Agrar., PhD) is a lecturer in the Department of Zoology and Entomology at the University of Pretoria, South Africa. His current research interests have focussed on the evolution of communication systems and grassland biodiversity conservation. The research has two components: a) a theoretical component regarding the interaction between behaviour and speciation mechanisms, and b) an applied component on the biology of population fragmentation in the southern African montane grasslands. Willem is also the Director for the Centre for Environmental Studies (CFES) at the University of Pretoria.