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# Women Smallholder Farmers and Sustainable Agricultural Intensification: A Case of Conservation Agriculture in Zambia

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**Abstract.** Smallholder women farmers are engaging in sustainable agriculture intensification by adopting Conservation Agriculture (CA), through programmes implemented by several national and international agencies. Conservation Agriculture is an agricultural system espoused to not only increase crop productivity but to do while enhancing soil health, reducing agro-based environmental degradation, and is ideal for women farmers across Sub-Saharan Africa (SSA). This study examined the effects of CA among smallholder farmers in Southern, Eastern, and Central Zambia. It used questionnaires, household and key informant interviews, observations, field assessments, and desk reviews to collect the data. The results show that CA improved crop yields, and nutrient use efficiency; gave more stable yields during periods of moisture stress, and above normal rainfall; resulted in more diversified crop combinations; and was welcomed by women farmers as it encouraged the production of food legumes. CA adoption was also associated with a reduction in the use of purchased inputs and more use of locally available resources. CA is thus a sustainable intensification agricultural system that could help the many women farmers in Zambia that currently face low crop productivity due to unreliable access to agricultural inputs. The study recommends more recognition of the challenges faced by smallholder women farmers in the design and implementation of CA programmes by the many actors involved in this.

**Keywords:** crop productivity, sustainable agriculture, food security

## 1. Introduction

Africa remains the region with the highest proportion of undernourished people in the population, at 29%, compared with a 17% average for developing countries [1, 2]. Over 70% of the food insecure population in Africa lives in rural areas. Half of them are smallholder farmers who produce over 90% of the continent's food supply [3]. Dependence on agriculture is greatest in Sub Saharan Africa (SSA) where the sector employs 62% of the population (excluding South Africa) and generates around 30% of Gross Domestic Product (GDP) for many countries in the region [4]. Agriculture is therefore important and indicators of rural well being are closely related with its performance. SSA has the lowest agricultural productivity in the world [5]. Its agricultural productivity has remained low and far below its potential. In many cases farmers cannot guarantee food security from their own production due to low production levels and very few smallholder farmers are able to sell some surplus to generate income [6]. Women constitute a large and important segment of smallholder farmers in SSA. They have lower access to productive resources compared to their male counterparts, and thus lower production and productivity. Women smallholder farmers also face challenges in implementing soil and water conservation strategies on their farms, as these require significant investments in terms of time and resources.

Although there is a lot of debate on the causes of the low agricultural productivity among smallholder farmers in SSA, there is a general consensus on the importance of employing sustainable intensification strategies which will not only increase agricultural productivity, but to achieve this while concomitantly

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improving soil health and reducing agro based environmental degradation. Many efforts aimed at increasing smallholder agricultural productivity through intensification of input use, albeit sustainably have been made by several national and international agencies. Many such sustainable agriculture interventions are either gender neutral or merely end at rhetoric when it comes to addressing the challenges of women smallholder farmers in SSA. Due to the diversity in bio-physical; socio-cultural, and economic factors among smallholder farmers in SSA, options available to them for adopting sustainable agriculture intensification differ. What may be relevant and appropriate in one locale may be unsuitable in another. However, such local diversity is rarely reflected in the promotion of sustainable agriculture intensification strategies across the region. The promotion of Conservation Agriculture in Zambia is not an exception.

Conservation Agriculture is an agricultural system espoused to not only increase crop productivity but to do while enhancing soil health, and reducing agro-based environmental degradation. It is defined as a variant of sustainable agriculture that focuses on minimum tillage and strives to achieve high and sustained production levels while conserving the environment [7] or as an agricultural system that aims to produce high crop yields while reducing production costs, maintaining the soil fertility and conserving water [8]. The aim of this study, therefore, was to examine the effects of CA among smallholder farmers in Southern, Eastern, and Central Zambia and to analyse its impact on women smallholder farmers in the studied areas. The rationale was to determine if women smallholder farmers in the study areas were able to capture the benefits of CA and whether they experienced challenges that were unique to their gender. Such information could prove useful to CA programme implementers in their efforts to optimize the benefits women farmers get from their interventions and help them design CA programmes that are more locally appropriate and hence improve their adoption and success levels.

## 2. Materials and Methods

### 2.1. Data Collection

A panel household survey was conducted annually over a period of four consecutive years. The households to be interviewed were randomly selected from lists of farmers under the Conservation Agriculture Programme (CAP) implemented by the Conservation Farming Unit, a unit under the Zambia National Farmers Union. A total of 640 households were interviewed in 2007, 535 in 2008, 486 in 2009, and 440 in 2010. The attrition was due to out-migration, death, and unavailability of respondents during period of the survey. The households were interviewed on all CA related agronomic practices, input use and produce. The agronomic practices investigated were tillage systems, crop rotations, weed control, cover crops, application of manure and mineral fertilizers, crop residue retention, integration of *Faidherbia albida* and cassava into the CA system, etc. Questions on household food security and incomes were also addressed. In addition to the panel survey, semi-structured interviews were conducted with 129 households in the same study areas between April and July 2009. These interviews probed the experiences of practicing CA among smallholders in more detail.

Focus Group Discussions (FGD) were conducted in groups of six to eight discussants, comprising both men and women CA farmers. Discussions focused on issues that had been highlighted in the semi-structured interviews as major challenges and benefits associated with CA. They focused on such issues as weed burden, dry season land preparation, labour use, crop yields, crop residue management, decisions on crop choice, and the role and influence of gender in decision making around CA. The FGD were employed as a triangulation tool to see how the discussants responded to each other's views and whether the same issues were confirmed to be important when group dynamics were at play. Key informant interviews were conducted with agricultural extension officers and lead farmers involved in the promotion of CA in the study areas and researchers working on the development and dissemination of CA technologies in Zambia. Field assessments were conducted to determine actual labour use on the different farming operations by having field assistants observe the households as they worked in their fields. Information collected included how many persons were involved in a particular farm operation, how long they worked per day, the total area worked on at the end of each work day, the farming implements used and the sources of labour. The farming operations monitored were land preparation, planting, manual weeding and harvesting. The assessments were conducted on the two CA tillage systems as well as on the conventional hand hoe and ploughed systems for comparative purposes.

### 2.2. Data Analysis

Statistical analyses were carried out using MINITAB 15 for personal computers (Minitab, 2009). The questionnaire survey data were analyzed using ANOVA, Two-sample T-test and Z-test at a probability level of $p \leq 0.05$ unless otherwise stated. Descriptive statistics such as means, standard deviations and percentages were also used to analyze results from the questionnaire survey and the field assessments. Gross margins were calculated using farm gate prices and labour was costed at prevailing local wage rates.

### 2.3. Description *of Study Areas*

Three provinces are selected for study. These were Southern, Central and Eastern provinces. The study areas are located in Agro-Ecological Regions (AER) I and IIa (Figure 1). AER I is a low rainfall, semi-arid region which receives mean annual rainfall of below 800mm. It has an average growing season of 80-120 days and is at low altitudes ranging between 400 - 900m. AER II is a medium rainfall region and receives between 800-1000mm of rainfall annually. It has a growing season of between 100 and 140 days and is a plateau region with altitudes of between 900 and 1300m [9]. The climate of the study areas is characterized by three distinct seasons; a warm-wet season (Nov-April), a cool-dry season (May-Aug) and a hot-dry season (Sept-Oct). Mean annual temperatures range between 23 and 32 ℃. Dominant soils types in AER I are Haplic Luvisols, Haplic Solonertz and Dystic Leptosols. AER IIa has moderately leached clayey to loamy soils of high agricultural potential. These soils are mainly Haplic Lixisols, Haplic Acrisols and Haplic Luvisols [10].

The majority of the population of the study areas is engaged in smallholder farming and grows crops mainly for home consumption while some sell part of their produce. Major crops grown are maize (*Zea mays*), the country's most important staple crop, cotton (*Gossypium hirsutum*), soya beans (*Glycine max*), cowpeas (*Vigna unguiculata*), groundnuts (*Arachis hypogaea*), sorghum (*Sorghum bicolor*), sweet potatoes (*Ipomea batatas*), cassava (*Manihot esculenta*) and various members of the cucurbit family. Most farming systems include both crop and livestock production [11].

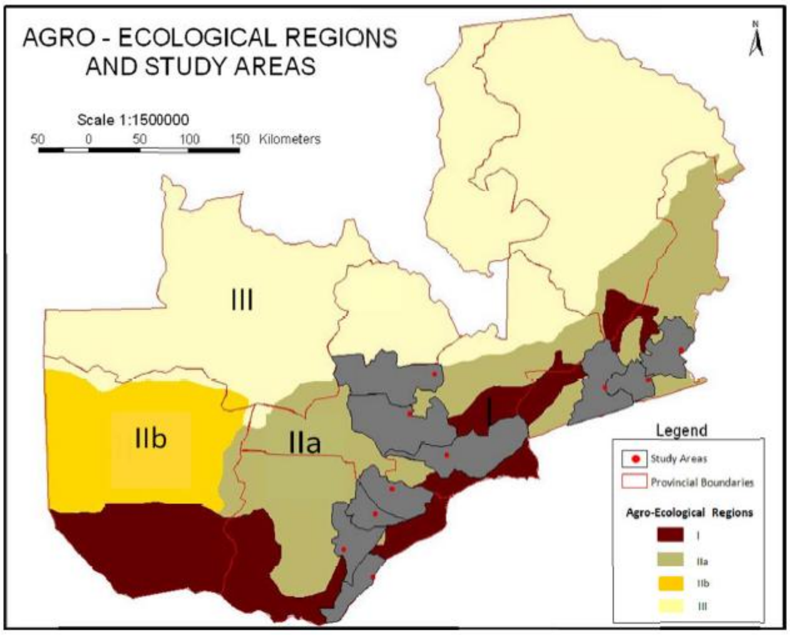


Fig. 1: Map of Zambia showing the study areas

## 3. Results and Discussion

The survey found that between 34 and 39% of the total cultivated area was under minimum tillage while the remaining part was under complete tillage, either ploughing or traditional hand hoe. Minimum tillage is a tillage system under CA. This shows that households were only partially adopting the CA tillage systems. The two CA tillage systems are ripping and planting basins. Ripping involves the making of 15-20cm furrows, which are spaced 90cm apart. The space in between the furrows is covered with crop residues. Planting basins are 30cm x 15cm x 20cm holes dug in the ground, along a row. The planting basins are spaced 70cm apart along a row, and the rows are 90cm apart. The spaces in between the rows are covered with crop residues (Figure 2).


Fig. 2: Conservation Agriculture Tillage Systems used in Zambia

CA promoters advise that ripping and digging of planting basins be performed during the dry season. They contend that, this helps labour constrained households, the most severely affected of whom are women headed households. However, tillage during the dry season seemed to be a big challenge for most households as they preferred to engage themselves in non-farming activities during this period. Most waited until the beginning of the rainy season before starting to till their land, contrary to instructions given by CA promoters. About two-thirds planted their crops late. This was not always caused by late tillage but also by late access to seed and mineral fertilizer. CA promoters espoused the system as especially beneficial for labour constrained household as it entailed the use of labour saving tillage methods.

An average of 34 person-days $ha^{-1}$ for land preparation was reported under manual CA compared to 7.8 person-days $ha^{-1}$ under traction CA. Planting basins or manual CA was reported to be very labour demanding and characterized by drudgery. Ripping or traction CA resulted in significant savings in labour compared to ploughing, the equivalent conventional practice. FGD, key informant interviews and field observations pointed to an increase in weed burden under CA. This problem was exacerbated by the seeming inability of households to weed as frequently and as timely as recommended so as to prevent the formation and dispersal of weed seeds. Allowing weeds to disperse their seeds perpetuates the weed problem. Shortages of labour at weeding time were reported especially for households without access to trained oxen. The high labour demand under manual CA is a major bottleneck considering the severe labour shortage that characterizes smallholder households at critical periods of the farming season, especially those without access to trained oxen. Labour use during planting, weeding and harvesting was similar for the two systems. Weeding using oxen relieves the pressure on manual weeding labour for those households that have access to oxen (Umar et al. 2011).

Crop rotations were practised by over 90% of the households but only on a small portion of the total area cultivated. Larger fields were allocated to maize, the country's most important staple, year after year. Reluctance to plant larger areas with legumes was attributed to poor development of legume markets and lack of access to legume seed.

Use of herbicides remained low although there was an increasing trend from only 1.1% of the respondents using them during the 2006/2007 season to 8.2% during the 2009/2010 season. Incorrect application of herbicides was common as farmers reportedly found the herbicide application instructions too technical and difficult to follow.

CA promoters have also encouraged the use of manure. Survey results revealed that the proportion of farmers that reported applying manure onto their fields increased from 21% during the 2006/2007 season to

47% during the 2009/2010 season while the average quantity of manure applied by the households fluctuated from 5.9 ox-carts during the 2006/2007 season to 2.8, 3.2 and 4.7 ox-carts respectively during the next three seasons.

Households that had adopted CA under CFU were offered cuttings of Cassava (*Manihot esculenta*), a perennial drought resistant crop that performs well even on low fertility soils [12]. The cassava is promoted for food security reasons, an available food source during the seasonal hunger period that characterizes most smallholder households in Zambia [13]. The percentage of households that had planted cassava increased from 3.9% during the 2006/2007 farming season to 30% during the 2009/2010 season. The amount of cassava harvested followed a similar trend with an average of 166.7kg per household in 2006/2007 increasing to 463.3 kg during the 2009/2010 farming season.

Maize yield increases were reported after adoption of CA. Households reported higher yields for maize and groundnuts from their CA fields than from the fields that were tilled in the conventional way. The current study calculated average maize yields of 4.4 and 2.8 tons per hectare for the manual CA and the traction CA respectively. The yields from the conventionally farmed equivalents were 1.7 and 2.4 tons per hectare for the manual and traction systems respectively. The gross margins for manual CA were US$465 but only US$ 7.3 for the manual conventional agriculture system. The trend was similar for the traction systems with ripping giving a gross margin of US$106 while ploughing gave a gross margin of –US$57. Returns to labour were between 3.5 and 5.7 times higher under CA compared to conventional tillage. The higher yields reported under CA systems compared to conventional systems are similar to those reported by Marongwe et al. [6] for Zimbabwe.

Using number of crops as an indicator of biodiversity, results showed a significant increase (p value= 0.014) in the biodiversity as the number of crops that are used in rotation increased from an average of 2.8 during the 2006/2007 farming season to 3.0 during the 2009/2010 farming season. The increase in the number of crops grown is largely attributed to the emphasis on diversified crop rotations, integration of cassava into CA, and the free distribution of sweet potato vines, groundnut and cowpea seeds, and cassava stems. Most of the crops have shown significant increase in the number of households growing them from 2006/2007 to 2009/2010 season (Table 1).

Table 1: Percentage of households by crops grown

| | 2006/2007 | 2009/2010 | Z value |
|---|---|---|---|
| Cassava | 3.9 | 29.3 | 11.08* |
| Cotton | 38.1 | 26.3 | -4.15* |
| Groundnuts | 63.0 | 88.3 | 10.16* |
| Cowpeas | 22.2 | 46.1 | 8.22* |
| Soya beans | 10.8 | 12.3 | 0.81 |
| Other beans | 4.7 | 27.3 | 9.93* |
| sunflower | 15.5 | 23.9 | 3.37* |
| Maize | 97.3 | 97.5 | 1.36 |
| Sweet potatoes | 27.3 | 68.7 | 14.33* |

*significant at $p \leq 0.01$

The increase in the growing of cassava and food legumes arguably increased household food security. Since cassava can remain in the ground for long periods, it is available during the period when food stocks are very low or run out. Growing of food legumes enabled households to diversify their diets and to have some cash incomes after selling some of the legumes. Household food security was conceptualized as having enough food for all household members at all times for the past 12 months.

From 2007/2008 agricultural season, all crops showed an overall increase in production. The decrease in crop production in 2007/2008 was largely due to above normal rains and subsequent floods that were experienced during the season. However, cassava seemed not to be affected as the production increased substantially (p=0.032) during the same season. This shows the benefit and importance of diversified crop rotations and production in reducing vulnerabilities to extreme weather events such as floods.

Table 2: Average household crop production figures (in kg) for 2006/2007-2009/2010 farming seasons

| Crops | 2006/7 | 2007/8 | 2008/9 | 2009/10 |
|---|---|---|---|---|
| Cassava | 169.4(44.5) | 390.9(86.1) | 699(295) | 461(127) |
| Cotton | 756.7(77.3) | 603.2(49.1) | 781.4(78.9) | 1007(106) |
| Maize | 3820(988) | 1828(173) | 2448(166) | 3964(277) |
| Sunflower | 389.4(71.9) | 232.7(17.9) | 443(61) | 313.4(37.6) |
| Sweet potatoes | 470.3(43.3) | 373(42) | 627.4(61.9) | 609.1(52.2) |
| Cowpeas | 129.4(12.6) | 95.4(12.9) | 123.7(13.2) | 132.1(13.9) |
| Groundnuts | 489.6(27.7) | 398.2(24.5) | 604.1(36.4) | 661.4(39) |
| Soya beans | 335.4(56.3) | 388.2(68.1) | 535(129) | 484(100) |

Note: the values in parenthesis are standard errors.

About 80% of households obtained some cash income from crops each farming season. Of those deriving cash income from crops, results showed steady and significant increases ($p<0.05$) in the last three seasons (Table 3). About half (52%) of the sampled households reported experiencing food shortages for about four months every year between the 2006/2007 farming season and the 2008/2009 farming season. The hunger period significantly reduced ($p<0.0001$) to 3 months during the 2009/2010 farming season.

Table 3: Crop cash income and months of food shortage.

| Farming season | Mean cash income (USD) | Mean months of food shortage |
|---|---|---|
| 2006/2007 | $629.5^{a}$ (145.9) | $4.4^{a}$ |
| 2007/2008 | $397.2^{a}$ (39.7) | $4.2^{a}$ |
| 2008/2009 | $459.7^{c}$ (33.2) | $4.1^{a}$ |
| 2009/2010 | $775.3^{d}$ (60.5) | $3.2^{b}$ |

[a] means the same column followed by the same letter were not significantly different at $p\leq 0.05$ probability level
1 USD=ZMK 4,899 (08/09/2010).

Focus Group Discussions, key informant interviews and anecdotal evidence revealed that CA reduced vulnerability to climatic variability. Timely sowing of crops enabled them to survive intra seasonal droughts. Planting basins were reportedly especially proficient at capturing rainfall and storing moisture for longer periods. When dug to correct depths which enabled the breaking of hard plough or hoe pans, basins resulted in improved water infiltration. Thielfelder and Wall [13] posited that the retention of crop residues on the surface protects the soil against climatic impacts and serves as an additional source of nutrients for both soil fauna and flora. Higher water infiltration rates and greater soil moisture capacity on CA fields compared to conventional agricultural systems have been reported elsewhere (Kassim et al. 2009). This difference translated into higher maize grain yields in seasons when there was marked moisture stress [6]. Longer term soil organic matter accumulation, improved water harvesting through a better pore system and reduced surface run-off lead to more stable yields [14] and reduced the risk of crop failure [15].

## 4. Conclusion

Smallholder Zambian women farmers are engaging in sustainable agriculture intensification via their practice of conservation agriculture. The study reported evidence of reduced vulnerability to climatic variability for smallholders dependent on rain fed agriculture. Increases were reported in crop productivity and crop diversity from conservation agriculture, as well as improvements in household food security. Effects on household labour demands were variable, and depended on what tillage and weeding implements were employed. There was a common argument by promoters of conservation agriculture that the system was good for women smallholder farmers that had very limited access to purchased agricultural inputs. The study concludes that although there is potential for sustainable agricultural intensification, structural bottlenecks which hinder Zambian women smallholder farmers from optimizing the benefits from conservation agriculture will need to be recognized and addressed before the practice of conservation agriculture can be sustained in the long term.

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