African Population and Health Research Center

# Gender and Conservation Agriculture in Sub-Saharan Africa: A Synthesis of Evidence


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**Authors**

Frederick M. Wekesah, MSc., Ushie BA, Ph.D., Martin Bangha, Ph.D., Chimaraoke O. Izugbara, Ph.D..

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# 1 Executive Summary

**Conservation agriculture (CA) involves the practice of concurrent minimum tillage, permanent soil cover using crop residue, and crop rotation. Evidence indicates that CA increases agricultural productivity, reduces farming labor requirements, and improves soil quality.**

While CA is practiced in several African contexts, little is known about its interaction with gender. This review synthesized knowledge on the interplay of gender and CA in some parts of Sub-Saharan Africa. The available evidence on gender and CA showed mixed results. Women farmers adopted CA less and disadopted it more, compared to men, due largely to gendered barriers, including lack of access to land, machinery, inputs, extension services and credit facilities. CA increased women's incomes, labor involvement, household food security. CA also increased women's risk for land and crop dispossession by men when CA made farming lucrative. It also increased workloads, employment opportunities and health risks for women.

CA positively altered gender relations, boosting women's participation in agricultural decision-making at the household level. Deliberately enlisting women as beneficiaries, working with men to advance their understanding of women's needs in agriculture and offering agricultural inputs directly to women are some strategies that enhanced women's participation in CA. Gaps in current research on gender and CA include: the long-term impact of CA on gender relations, incomes for men and women, and women's empowerment, the sustainability of strategies for supporting women's participation in CA, and the dynamics of women's access to local farmland markets in relation to their involvement in CA.

# 2 List of Acronyms and Abbreviations

**CAADP** - Comprehensive Africa Agriculture Development Program

**CF** - Conservation Farming

**CSA** – Climate-Smart Agriculture

**CT** – Conventional Tillage

**NRM** - Natural Resource Management

**PB** – Permanent Bed

**PT** - Plain Tillage

**SAPs** - Sustainable Agricultural Practices

**SSA** – Sub-Saharan Africa

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# 5 Introduction

Conservation agriculture (CA) is defined by the Food and Agriculture Organization (FAO) as a crop farming practice characterized by simultaneous implementation of the three principles of: minimal tillage and soil disturbance; minimum 30% permanent soil cover using crop residue and mulches; and crop rotation and intercropping with three or more types of crops *(Brown, Llewellyn, & Nuberg, 2017)*.

In sub-Saharan Africa (SSA), a partially modified practice of CA is more common. Smallholder farmers tend to adopt only one or two of the three principles *(Kunzekweguta, Rich, & Lyne, 2017)*. Some of the factors that affect the adoption and practice of CA by farmers include: costs related to transitioning from conventional agriculture; ability to effect change; perceived change benefits; and prevailing institutional and bio-physical environment *(Brown, Nuberg, & Llewellyn, 2017b; Kunzekweguta, et al., 2017)*. Currently, only 0.3% of farmers in Africa practice CA in ways that meet the FAO specifications and only 0.8%, if the CA principles are applied in any combination and intensity *(Brown, Llewellyn, et al., 2017)*. Overall, the practice of CA is much less common in SSA compared to the Australia, Southeast Asia, Mexico and US *(Brown, Llewellyn, et al., 2017; Pittelkow et al., 2015; Ward, Bell, Droppelmann, & Benton, 2018)*.

CA began in the United States of America (USA) in the 1950s among commercial farmers *(Kassam, Friedrich, Shaxson, & Pretty, 2009; Ward, et al., 2018)*. Three key factors were responsible for the emergence of CA in the US, namely: 1) the need to protect farmers against severe wind erosion through dust storms caused by conventional ploughing during a prolonged drought period in 1930s (also referred to as the "US dustbowl") *(Brown, Llewellyn, et al., 2017; Lal, 2009; Palm, Blanco-Canqui, DeClerck, Gatere, & Grace, 2014)*; 2) the discovery of herbicides in the 1940 and 1950 *(Brown, Llewellyn, et al., 2017; Lal, 2009; Palm, et al., 2014)*; and 3) the need to curb rising costs of fuel and labor in crop production *(Brown, Llewellyn, et al., 2017)*. Over time, the popularity of CA in the US grew due to increased viability of crop farming as an enterprise, availability of low-cost inputs and equipment, farmer involvement in co- innovation, and the USA government's adoption of policies that promoted CA *(Brown, Llewellyn, et al., 2017)*. From the US, CA spread to South America, particularly Brazil, among large-scale farmers, and later to small-scale farmers in the 1990s *(Baudron, Corbeels, Monicat, & Giller, 2009; Brown, Llewellyn, et al., 2017)*. Currently, efforts have focused on expanding CA among smallholder farmers in SSA and South Asia *(Palm, et al., 2014; Pittelkow, et al., 2015)*.

Multiple benefits are associated with CA. It is climate-smart, it promotes sustainable agricultural production and aids communities to cope with the vagaries of climate change such as reduced rainfall *(Beuchelt and Badstue, 2013)*. CA also enhances soil fertility *(Baudron, et al., 2009; Makate, Makate, & Mango, 2017; Nyanga, Johnsen, & Kalinda, 2012; Palm, et al., 2014; Ward, et al., 2018)* and reduces soil erosion *(Baudron, et al., 2009; Johansen, Haque, Bell, Thierfelder, & Esdaile, 2012; Makate, et al., 2017; Palm, et al., 2014; Pittelkow, et al., 2015; Ward, et al., 2018)*. It is associated with increased water infiltration and retention, enabling efficient use of the available

water for crop production *(Baudron, et al., 2009; Makate, et al., 2017; Palm, et al., 2014; Pittelkow, et al., 2015; Ward, et al., 2018).* CA curbs siltation and recharges aquifers (*Giller, Witter, Corbeels, & Tittonell, 2009)*, and there is evidence that it contributes to carbon sequestration and reduction of greenhouse gas emissions *(Govaerts* et al., 2009; Palm, et al., 2014).* In the long run, CA improves household welfare by increasing agricultural yields and household income and food security *(Baudron, et al., 2009; Kassam, et al., 2009; Makate, et al., 2017; Nkala, Mango, & Zikhali, 2011; Nyanga, et al., 2012; Palm, et al., 2014; Pittelkow, et al., 2015; Ward, et al., 2018)*, reducing crop production costs *(Baudron, et al., 2009; Nkala, et al., 2011; Ward, et al., 2018)*, bringing down farming labor demands when planting is mechanized and herbicides used for weed control *(Johansen, et al., 2012; Kassam, et al., 2009)*, and enabling early land preparation *(Farnworth et al., 2016)* and timely planting *(Kassam, et al., 2009; Ward, et al., 2018).* While the Comprehensive Africa Agriculture Development Program (CAADP) identifies CA as a primary strategy for achieving the region's objectives on food security and soil and water conservation *(Whitfield et al., 2015)*, its adoption remains far from optimal.

This systematic review provides up-to-date knowledge on the state of CA in Africa, focusing largely on its interplay with gender. As a critical social construct, gender has far-reaching implications for agricultural activities in SSA. Gender dynamics affect and are affected by agricultural tasks, practices, functions and roles, and shape relationships and outcomes in the context of farming. Gender remains one of the most important social institutions and factors in African development. Currently, much of the existing research and evidence on CA and gender in the region is fragmented, fails to provide a consolidated perspective of key issues and lessons, and remains largely irrelevant to the knowledge needs of funders, decision-makers, and key agricultural groups in SSA *(Giller, et al., 2009)*. Learning can be generated from an understanding of CA as a site for gendered outcomes. More importantly, the varying social, economic, and environmental impacts of CA in relation to gender need to be understood *(Farnworth, et al., 2016)*.

# 6 Research Questions

The key research questions addressed in this review are:

1. What are the characteristics of farmers likely to adopt CA in SSA?
2. What are the gendered impacts of CA in SSA?
3. What are the impacts of farmers' gender on the environmental effects of CA in SSA?
4. What barriers and challenges are faced by women in CA in SSA?
5. What practical strategies have been used to facilitate women's participation in CA in SSA?

# 7 Methods

This review adopts the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach to literature search and selection. The flow diagram on the search strategy and the selection process is shown in **Figure 1**. The review was restricted to peer-reviewed articles published between 2000 and February 2018. The term 'CA' was formally adopted by the FAO in early 21st century, around the same time the Millennium Development Goals (MDGs) were ratified, which aimed, *inter alia*, to: 1) eradicate extreme poverty and hunger; 2) promote gender equality and women empowerment; and 3) ensure environmental sustainability.

Articles were identified from electronic databases such as Web of Science, African Journal Online (AJOL), Science Direct, Taylor and Francis, Springer and EBSCO Greenfile using "gender AND conservation agriculture AND Sub-Saharan Africa" as primary search terms and key words. Synonyms used for "gender" were "gender mainstreaming", "gender integration", "gender relations", "gender inclusion" and "women". Additional search for "conservation agriculture" was conducted using the terms: "conservation farming", "minimum tillage", "climate smart farming", "permanent soil cover", "crop rotation" and "intercropping." Articles reporting original research, were written in English, and had an abstract or executive summary were included in the initial short-list. Case reports, editorials, and letters to the editor were excluded. Literature search was conducted between mid-December 2017 and mid-February 2018.

A total of 3,775 studies were initially identified; 3,745 from the online search and 30, from manual searches of the reference lists of articles curated from the online search. After ridding the 3775 articles of duplicates, 1154 papers remained. Further screening of these articles showed that 1090 did not address the questions under review. Full texts of 64 of the remaining titles/abstracts were obtained. Following a critical review, a further 39 full texts were excluded because they did not address the research questions, or because they focused primarily on technological aspects of CA. A total of 25 articles were included in the final review, most of which focused on Zambia and Zimbabwe. The research questions guided data extraction and qualitative synthesis of the findings.

# Findings

# 8 Findings

The review is organized according to the following themes: a) the interpretation of the term gender in the reviewed papers; b) farmer-characteristics and CA adoption; c) gendered impacts of CA; d) gender and the environmental effects of CA; e) barriers and challenges faced by women in CA; and f) strategies to facilitate women's participation in CA.

**1. Interpretation of the term "Gender"**

As shown in Table 1, gender was interpreted in two key ways in the papers we reviewed. In the first place, gender was viewed as the socially constructed roles, responsibilities and power relations among men and women in relation to agricultural activities studies *(Beuchelt and Badstue, 2013; C. Farnworth and Colverson, 2015; Hove and Gweme, 2018; Kahimba, Mutabazi, Tumbo, Masuki, & Mbungu, 2014; Kristjanson et al., 2017; Murray, Gebremedhin, Brychkova, & Spillane, 2016; Nyanga, et al., 2012a)*. However, gender was also conflated with the biological sex of farmers (that is male or female) *(Baudron, et al., 2009; Brown, Nuberg, & Llewellyn, 2017a; Giller, et al., 2009; Makate, et al., 2017; Mazvimavi and Twomlow, 2009; Ndiritu, Kassie, & Shiferaw, 2014; Nyanga, et al., 2012a; Teklewold, Kassie, & Shiferaw, 2013; Teklewold, Kassie, Shiferaw, & Köhlin, 2013; Yahaya, Pokharel, Alidu, & Yamoah, 2018)*.

Table 1: *Interpretation of the term gender in source articles*

| **Description** | | **Articles** |
|---|---|---|
| 1. Gender as the socially constructed roles, responsibilities and relationships among men and women in the context of CA | | Beuchelt et al., 2013; Nyanga et al., 2012; Kahimba et al., 2014; Farnworth et al., 2015; Kristjanson et al., 2017; Hove et al., 2018; Murray et al., 2016. |
| 2. Gender as sex of the farmers | *Comparison of male and female-headed households* | Ng'ombe et al., 2017; Makate et al., 2017; Yahaya et al., 2017; Brown et al., 2017. |
| | *Comparison of men and women farmers generally* | Baudron et al., 2009; Teklewold et al., 2013; Kuzengweguta et al., 2017; Mazvimavi et al., 2009; Giller et al., 2009; Nyanga 2012; Ward et al., 2018. |
| | *Characteristics of farmers likely to adopt CA* | Kassam et al., 2009; Wall et al., 2007; Johansen et al., 2012; Palm et al., 2013. |
| | *Men versus women CA plot owners* | Theriault et al., 2016; Ndiritu et al., 2014. |

The current review included studies that interpreted gender in terms of the socially constructed role of men and women and as biological categories of male and female. Table 1 below highlights the conceptualizations of gender used in the reviewed papers.

### 8.2. Gender and the Adoption of CA

In this review, adoption refers to the uptake and practice of the three principles of CA, namely minimum tillage farming, retention of permanent crop residue cover on farmland and the practice of crop rotation and/or rotational intercropping. Of these three principles, minimum tillage farming, is the least preferred in SSA because it does not resonate with traditional land tillage practices *(Ward, et al., 2018)*. Several factors promote the adoption of CA in SSA. These include access to land and the size of land holding, finances resources and farm inputs. Commercial farmers in SSA were more likely than smallholder farmers to adopt CA due to its benefits in reducing production costs and maximizing profits *(Brown, Nuberg, & Llewellyn, 2017a; Johansen, et al., 2012; Kassam, et al., 2009; Wall, 2007; Ward, et al., 2018)*. Among smallholder farmers in Tanzania and Zimbabwe, access to finances and agricultural inputs increased the likelihood of CA adoption *(Kahimba, Mutabazi, Tumbo, Masuki, & Mbungu, 2014; Mazvimavi and Twomlow, 2009)*.

In Zambia and Zimbabwe, male-headed households were more likely to adopt CA than female-headed households. The former had better access to finances, land and other farming inputs *(Kristjanson et al., 2017; Makate, et al., 2017; Mazvimavi and Twomlow, 2009; Ng'ombe, Kalinda, & Tembo, 2017)*. Further, African households with more women than men were more likely to adopt CA farming *(Ward, et al., 2018)*. For instance, the adoption of CA in Malawi was higher among men who were heads of households with large numbers of women due to the perceived availability of free labor *(Ward, et al., 2018)*. Within male-headed households, intra-household decision-making related to the adoption of CA was complex, sometimes involving women, and at other times excluding them.

Decisions to adopt CA were often made by men in East and Southern Africa *(Beuchelt and Badstue, 2013; Farnworth, et al., 2016; Kahimba, et al., 2014)*, while in Kenya, women managing farm plots were less likely than men to adopt soil-restorative strategies such as minimum tillage *(Ndiritu, Kassie, & Shiferaw, 2014)*.

### 8.3. CA, Gender, Food Security and Incomes

The evidence on CA in relation to incomes and food security for men and women is not consistent. In Zambia, for example, among women CA farmers, early land preparation facilitated timely planting and early crop maturity, resulting in food availability during periods of food scarcity *(Nyanga, et al., 2012)*. Women participating in a CA project in Zimbabwe reported increased grain yields, enhanced household food security, evidenced by the ability to provide three meals a day, greater dietary diversity, and enough food to last until the next harvest season *(Hove and Gweme, 2018)*. However, increased productivity and incomes due to CA could also lead to the disempowerment and dispossession of women. The promise of higher incomes associated with CA encouraged male farmers to dispossess women of land used for subsistence farming and take over the production of traditional women's crops in order to expand their own incomes *(Beuchelt and Badstue, 2013)*.

For instance, in Zambia, groundnuts are a women's plant if grown for subsistence, and men's when grown for commercial purposes *(Nyanga, et al., 2012)*. However, earnings from men's cash crops were not always utilized to directly improve household food security but went into the purchase of agricultural inputs, livestock

medicines and vaccines *(Nyanga, et al., 2012)*. Zambian women's risk of losing their traditional control of farming and trading in pulses to men increased as the latter recorded enhanced yields and incomes from CA *(Nyanga, 2012)*.

The practice of CA created a dilemma for women in that it reduced the time spent on weeding but tended to compromise food security *(Beuchelt and Badstue, 2013)*. For example, the use of herbicides in CA killed off edible weeds traditionally used to supplement household diets such as amaranthus. In Zambia, this loss put pressure on women, who are responsible for household food security, sometimes forcing them to buy alternatives *(Beuchelt and Badstue, 2013; Nyanga, et al., 2012)*.

CA discouraged intercropping of maize with other traditional foods, thus reducing women's ability to guarantee household food variety in Zambia *(Nyanga, et al., 2012)*. In the same country, CA increased food insecurity levels by introducing crops that were not part of local diets, therefore forcing women to spend more time and resources in sourcing alternative food *(Baudron, et al., 2009)*. CA also threatened food security by discouraging the planting of household staples such as groundnuts and tubers, leading some women to disadopt CA for conventional agricultural practices *(Hove and Gweme, 2018)*.

### 8.4. CA, Gender Relations and Household Decision-Making

The adoption of CA transformed intra-household gender relations, decision-making, crop management practices, and increased agency among some women in Zimbabwe *(Hove and Gweme, 2018; Kunzekweguta, et al., 2017)*. In Zaka, Zimbabwe, women reported active involvement in making decisions about which crops to grow, where and when to plant, when to weed, apply fertilizer, and harvest, despite such roles being traditionally a male responsibility *(Hove and Gweme, 2018)*. In the study, women's decision-making capacities reportedly expanded because of engagement in CA. Women heads of households exercised more decision-making powers on plant management than their counterparts in male-headed households *(Hove and Gweme, 2018)*. A study on factors affecting the adoption and intensity of CA practice in Masvingo District, Zimbabwe, found that, in almost half of the households that practiced CA, women were the primary crop managers or co-managers, contrary to the widely-held perception that women farmers in SSA only provide labor and made few management decisions *(Kunzekweguta, et al., 2017)*.

### 8.5. CA and Changes in Gendered Labor Demands

The adoption of CA had both positive and negative impact on men and women farmers' labor demands. The practice of crop residue retention eliminated the need for clearing or pre-tilling land, which in turn reduced the workload of women and children *(Nyanga, et al., 2012)*. Since planting basins were dug predominantly by women, and usually in the dry seasons, CA enabled them to spread the workload over a long period of time and still have their land ready in good time for early planting *(Farnworth, et al., 2016; Hove and Gweme, 2018; Nyanga, et al., 2012)*. A study in Zambia reported that women practicing CA started their land preparations on average 68 days earlier than non-practicing women and 94 days earlier than non-practicing men, thus facilitating timely land preparation and planting of crops *(Farnworth, et al., 2016)*. The same study reported that herbicide use in CA farming freed up women and children's time to engage in other economic activities and to go to school, respectively *(Farnworth, et al., 2016; Nyanga, et al., 2012)*. In addition, herbicide use decreased household need to hire labor *(Beuchelt and Badstue, 2013)*. Use of herbicides in CA also increased incomes and employment

opportunities for men who dominated the herbicide spraying business *(Nyanga, et al., 2012)*. However, increased weed pressure associated with no-till farming practices created employment opportunities for poor men and women in Zambia, who provided weeding services to farmers unable to afford herbicides *(Beuchelt and Badstue, 2013)*.

On the other hand, while CA helped women space their work, CA added complexity to farm work because it required them to dig basins, using hand-held hoes, in the hot, dry season when the soil was hard *(Baudron, et al., 2009; Nyanga, et al., 2012)*. The fact that they had to observe stipulated depths and distances between basins and rows during digging added further complexity *(Beuchelt and Badstue, 2013; Giller, et al., 2009)*. In Zambia for instance, to prepare basins, women used the "chaka" hoe, which weighs 4-5 Kg *(Nyanga, 2012)* and is heavier than other traditional tools *(Nyanga, et al., 2012)*. When digging, they have to raise the hoe above shoulder level and bring it down with enough force to break the soil *(Nyanga, et al., 2012)*. Women described the use of the "chaka" hoe as an arduous task, which wore them out and inhibited their ability to perform other domestic tasks *(Nyanga, et al., 2012)*. Well-off local Zambian male farmers did not often engage in farming activities that required bending over to dig. Only men from poor households helped their spouses in basin preparation *(Nyanga, et al., 2012)*. To ease the task, nearly half of the women who engaged in a CA project in Zaka District, Zimbabwe, tilled their land using an ox-drawn plough and in so doing breached the minimum tillage principle of CA *(Hove and Gweme, 2018)*, effectively disadopting CA.

Further, when land preparation and planting were done using rippers and direct seeders, poor men and women lost employment opportunities as manual tillers and weeders *(Beuchelt and Badstue, 2013)*. Cases of women using the "Magoye" ripper (an animal drawn tool used for land preparation) were reported in Zambia, indicating a shift in the role of land preparation to women even where machinery is used *(Farnworth, et al., 2016)*. Herbicide use in CA also reduced demand for women's, children's and poor men's weeding services, denying them incomes *(Farnworth, et al., 2016; Nyanga, et al., 2012)*. Where farms were fertilized using manure and compost, women and children were also involved in the arduous task of transporting the manure to the farms *(Hove and Gweme, 2018)*. In Ethiopia, the adoption of a package of sustainable agricultural practices (SAPs), of which CA was part, increased women's workload, a clear indication that 'agricultural intensification technology interventions may not be gender neutral' *(Teklewold, Kassie, Shiferaw, & Köhlin, 2013)*.

### 8.6. CA, Gender and Health

Research in Zambia and Zimbabwe has linked CA with increased food and nutritional security for households, women and children due to early maturity of crops, all-year availability of food, and increased yields and food variety resulting from intercropping *(Nyanga, 2012; Nyanga, et al., 2012)*. Nutritional security resulted through the sale of surplus yield to purchase items that farmers did not produce *(Nyanga, 2012)*.

Even so, CA has been linked with health risks for men, women and children. For example, the use of the heavy "chaka" hoe in basin preparation has been associated with back strain and pain among women digging planting basins for extended periods. *(Farnworth, et al., 2016; Nyanga, et al., 2012)*. Ideally, farmers prepare 15,850 basins per hectare under CA *(Farnworth, et al., 2016)*. Long-term use of herbicides such as Atrazine during CA caused soil and surface water contamination *(Beuchelt and Badstue, 2013; Nyanga, et al., 2012)*, resulting in poor health among people and livestock *(Nyanga, et al., 2012)*.

Women and children, because of their traditionally-assigned roles in farming, came into contact with contaminated water bodies in the context of CA more than men,

making them more vulnerable to health complications *(Nyanga, et al., 2012)*. Among men, herbicides used in CA have been linked to low sperm count and breast and prostate cancers, while in women, it caused breast cancer, spontaneous abortions, and other reproductive health complications *(Nyanga, et al., 2012)*. Herbicides also caused birth defects and other severe health complications in fetuses and babies *(Nyanga, et al., 2012)*.

### 8.7. Gender and the Environmental Effects of CA

There is evidence that farmers' gender mediated the environmental effects of CA. In households where there was competing demand for crop residue for use as livestock feed and pasture, fuel, or house construction material, people resorted to environmentally-harmful alternatives such as cutting down trees *(Beuchelt and Badstue, 2013; Palm, et al., 2014)*. Deforestation, to meet the diverse pasture needs of households, was more common among poor women CA *(Beuchelt and Badstue, 2013; Palm, et al., 2014)*.

Since crop rotation is not a common practice among smallholder farmers in SSA, intercropping of cereal and legumes provides an alternative for improving soil health through nitrogen fixation *(Baudron, et al., 2009)*. However, in several African contexts, legumes are considered a subsistence women's crop, while cereals are usually considered a cash crop 'owned' by men *(Beuchelt and Badstue, 2013; Nyanga, 2012)*. In cases where intercropping put women at risk of food insecurity *(Baudron, et al., 2009)* or in danger of being forced to cede their crop to men, they (women) avoided CA altogether, foregoing its soil-replenishing benefits *(Beuchelt and Badstue, 2013)*.

### 8.8. Barriers to CA Unique to Women

Available evidence shows that overall, women's limited decision-making power affected their involvement in CA. Women are generally not involved in household-level decision-making related to CA *(Farnworth, et al., 2016)*. As earlier noted, complexity surrounds decision-making at the household level related to the adoption and practice CA in SSA. Men and women do not always share farming preferences and priorities, or participate equally in decision-making regarding farming activities *(Beuchelt and Badstue, 2013)*. In households headed by men, decision-making on use of productive assets such as agricultural land is reserved for men *(Beuchelt and Badstue, 2013)*.

In Tanzania, this complexity was exemplified by evidence that in one part of the country, Arusha, decisions to adopt minimum tillage and cover-cropping were made by men and women jointly *(Kahimba, et al., 2014)*, while in another part, Dodoma, decisions to adopt planting pits and minimum tillage were made by men alone and those on cover-cropping were made jointly *(Kahimba, et al., 2014)*. The latter situation obtains because men were more likely to make decisions individually if the CA activities were labor-intensive *(Kahimba, et al., 2014)*. Female heads of households exercised more decision-making regarding CA adoption and practice compared to women in households headed by men (Farnworth, et al., 2016; Murray, Gebremedhin, Brychkova, & Spillane, 2016).

The power of men, as household heads, to adopt or dis-adopt CA was demonstrated in a study in Kenya where men who did not favor CA overruled their wives who did *(Brown, Nuberg, et al., 2017a)*. Similar findings were observed in Zambia, where negative attitudes among men towards CA resulted in non-adoption *(Farnworth, et al., 2016; Kunzekweguta, et al., 2017)*. However, when women were involved in decisions regarding CA, the likelihood of adoption was higher *(Kunzekweguta, et al., 2017)*. Acquisition of farming input was also affected by unequal decision-making powers at the household level. In households, where women could not negotiate for

herbicide use, male heads of households did not prioritize the purchase of herbicides, preferring their wives to manually weed the farms *(Farnworth, et al., 2016)*.

The labor-intensive nature of no-till CA, particularly in planting basin preparation and weeding, is another challenge women faced in relation to CA *(Giller, et al., 2009; Johansen, et al., 2012)*. The adoption of CA caused a shift in key land preparation duties from men to women. Basin preparation reduced the need for conventional ploughing which men do in conventional agriculture: women, therefore are the primary bearers of the brunt of the manual labor required in CA (Nyanga, et al., 2012).

A study in Zimbabwe demonstrated that where women had time constraints, they disadopted CA basin preparation in the first year of uptake, practiced CA on small land portions or breached CA principles by ploughing their land to ease basin preparation and save time *(Hove and Gweme, 2018)*. The unavailability or the inability to afford hired labor were also shown to be deterrents to women's ability to practice CA in SSA *(Baudron, et al., 2009; Hove and Gweme, 2018)*. For example, knapsack sprayers for herbicides are heavy for women to carry. Many women farmers therefore hired men for spraying service which increased the cost of crop production *(Farnworth, et al., 2016)*. Women disadopted CA when they perceived its labor inputs to outweigh its yield benefits. In Zaka, Zimbabwe, for instance, CA is derogatorily referred to as "dhiga ufe","dig and die", a commentary on the intensive labor requirements of CA, which did not often match agricultural yields *(Hove and Gweme, 2018)*.

Compared to households headed by men, women-headed households faced more challenges in protecting their crop residues, particularly where plots were unfenced and in areas where communal livestock grazing was practiced *(Baudron, et al., 2009; Hove and Gweme, 2018)*. Women farmers also had more difficulties defending their mulch against theft and use by men or individuals from more powerful households *(Farnworth, et al., 2016)*. When faced with competing needs for scarce crop residue for CA, for example livestock feed, fuel, and construction material, women tended to withdraw the crop residue from farms to meet other (livestock feed, fuel and construction material) needs *(Beuchelt and Badstue, 2013; Farnworth, et al., 2016; Palm, et al., 2014)*. In Zimbabwe, such women did not often have the required financial resources to meet the residue requirements of CA, which affected yields *(Hove and Gweme, 2018)*. There is also evidence from Zimbabwe that crop rotation requirements of CA can pose challenges to women CA farmers *(Hove and Gweme, 2018)*. For instance, because a good maize stock is considered a measure of food security in the country, women CA farmers opted for inter-cropping instead of crop-rotation which enabled them to have maize throughout the year *(Hove and Gweme, 2018)*.

Limited access to farm inputs for CA such as seed, herbicides and farming equipment is another challenge women faced *(Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Giller, et al., 2009; Johansen, et al., 2012)*. Among women with access to land, tenure security was of utmost importance. Women with insecure land tenures avoided CA out of fear that they would lose their land if their yields rose *(Beuchelt and Badstue, 2013; Kahimba, et al., 2014)*. Women farmers had less knowledge of how to use herbicides *(Beuchelt and Badstue, 2013; Farnworth, et al., 2016)*. Women had lower access to credit facilities, relevant farming information and social capital *(Deressa, et al., 2009; Farnworth, et al., 2016; Makate, et al., 2017)*. Limited contact with extension services is a further barrier women faced in relation to CA *(Farnworth, et al., 2016; Makate, et al., 2017)*. Research in Zambia and Zimbabwe showed that men were more likely than women to be reached by CA extension services providers *(Ng'ombe, et al., 2017)* due to low education/ literacy levels among women and lack of access to land. Other factors include cultural restrictions on interactions between men and women and the cultural relegation of women to non- public spaces *(Beuchelt and Badstue, 2013)*. However, when they were

reached and invited for training workshops on CA, women heads of households attended agricultural training events more than men *(Yahaya, Pokharel, Alidu, & Yamoah, 2018)*.

### 8.9. Strategies to Facilitate Women's Participation in CA

Targeted farm input support for women and training for men are some of the effective strategies that have been used to promote women's adoption and practice of CA. Research in Zimbabwe shows that deliberately recruiting both men and women project beneficiaries in CA interventions and channeling CA inputs to households through women increased access to production resources and willingness to experiment with CA *(Hove and Gweme, 2018)*. The same study showed that formation of women agricultural groups that offer labor services to members increased women's adoption of CA *(Hove and Gweme, 2018)*. Through such groups, women developed operation regulations on punctuality, reciprocity and fair workload distribution in relation to CA among themselves *(Hove and Gweme, 2018)*. In Zambia, workshops on CA targeted at men, as the key owners and decision-makers on land, motivated them to permit women to plant pulses in their (men's) farms as cover crops and in so doing enabled women to engage in CA *(Nyanga, 2012)*.

### 8.10. Additional Search and Review

An expanded search and review was conducted focusing specifically on the Democratic Republic of Congo (DRC) and Ethiopia after we found very little information in scientific literature on the two countries based on the aforementioned review process. In this expanded focus, findings on conservation agriculture without the strict requirement that they report on the interplay between gender and CA were considered. Peer-reviewed articles as well as gray literature were included in the review. Findings were mostly on the effect of CA on run-off, soil loss and yield/crop productivity. The use of locally/culturally acceptable and modified land preparation approaches and implements and innovation on lighter and low-cost implements for CA are also reported. Factors that affect the adoption of CA, apart from gender, included household endowments and access to information, land ownership, age of the household head, and availability of household labor, the latter being the case because labor requirements for CA differ from that of CT. The findings from this additional review are summarized in Table 2.

# Discussion

# 9 Discussion

There is a paucity of evidence on the interaction between gender and CA in SSA. The bulk of existing literature is based on data from few countries, predominantly from Southern Africa, and specifically Zambia and Zimbabwe.

There is also little consistency in the interpretation of gender in available studies on CA in Africa. A few papers conceptualized gender in terms of the socially-constructed roles of men and women. The majority merely defined gender in terms of sexual categories of male and female. This distinction is key in understanding of the interplay between gender and CA in SSA. The available research shows that CA is more likely to be adopted by well-to-do male smallholder farmers than poor smallholder farmers, who are also often women. Most women CA farmers in Sub-Saharan Africa face barriers such as lack of machinery and inputs *(Grabowski and Kerr, 2014; Johansen, et al., 2012);* unavailability *(Brown, Nuberg, et al., 2017a)* or lack of knowledge of where to get them from *(Nyanga, et al., 2012)*; low or non-existent extension service provision *(Brown, Llewellyn, et al., 2017; Yahaya, et al., 2018)*; limited access to credit facilities *(Brown, Llewellyn, et al., 2017; Brown, Nuberg, et al., 2017a; Johansen, et al., 2012; Yahaya, et al., 2018)* and land (since most have to assess it through patrilineal relations) (FAO, 2011) and insecure land tenure *(Farnworth, et al., 2016; Kaumbutho and Kienzle, 2007; Kristjanson, et al., 2017)*. The ability of women to engage in decision-making related to CA is affected by their marital status, access, control and ownership of productive resources, including land, level of awareness of CA, sense of agency and intra-household power relations *(Farnworth, et al., 2016)*.

Women's participation in CA can be facilitated by targeted and beneficiary-driven programs. Deliberately recruiting women as beneficiaries, working with men to improve their understanding of the needs of women in agriculture and providing agricultural inputs directly to women are among strategies that enhance women's participation in CA. Findings also show that CA has the potential to increase household food security, transform gender relations in favor of women, lead to increased incomes for women and enhance women's decision-making capacities. Nevertheless, gains in food security from CA can only be sustained if farmers are encouraged to grow crops that are culturally acceptable rather than new crops that have little resonance with local farming practices *(Baudron, et al., 2009; Nyanga, 2012)*. A couple of studies showed that CA can positively transform gender relations at household levels. Further research is however required to understand the contexts within which this gain is realized and the extent to which women benefit from the transformed relations.

Women's increased incomes accruing from CA farming can be threatened by commercialization of 'their' farm products arising from male take-over of agricultural lands or and crops *(Beuchelt and Badstue, 2013; Doss, 2001; C. Farnworth and Colverson, 2015)*. Limited evidence exists on how farmers' gender influences the environmental impacts of CA. However, there are indications that poor women-headed households practicing CA may resort to environmentally harmful practices to meet the diverse and compounded pasture needs of their households. Long-term herbicide use in CA is linked to cancers among women and low sperm count among men. Herbicides also cause harm to livestock and the environment, which may have more drastic impacts on food security among women-headed households. Non-use of herbicides however means that women must carry out manual weeding, which led to lumbar complications occasioned by the physical strain of using heavy hand-held tools and intense bending.

# Conclusions

# 10 Conclusions

While SSA stands to benefit from CA, little research has explored its interactions with key social institutions such as gender. This review found very little evidence on how gender and CA interact on the continent. The few existing studies on the issue has focused on patterns of adoption of CA by men and women, barriers which face women in relation to CA; gender and decision-making in CA, strategies for promoting women participation in CA, the impact of CA on women's incomes, health, and food security among women-headed households, and impact of CA and gender relations at household levels. These studies are short-term, limited in number and robustness, conducted in a few countries and use cross-sectional data. They, therefore, offer little basis for any reliable conclusions on how gender and CA impact each other in the region. Further, there is a critical lack of focus on gender as a social construct in existing studies on CA in SSA. Several issues also remain unexplored in the literature. For instance, little is known about the long-term impacts of CA for gender relations, incomes for men and women, and women empowerment. We also know little about the sustainability of strategies for supporting women's participation in CA. There is also little research on the connection between women's access to farmland and markets and their involvement in CA.

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# 12 Appendices

Figure 1: Preferred Reporting Items for Systematic Reviews (PRISMA) Flow Diagram on study selection and inclusion

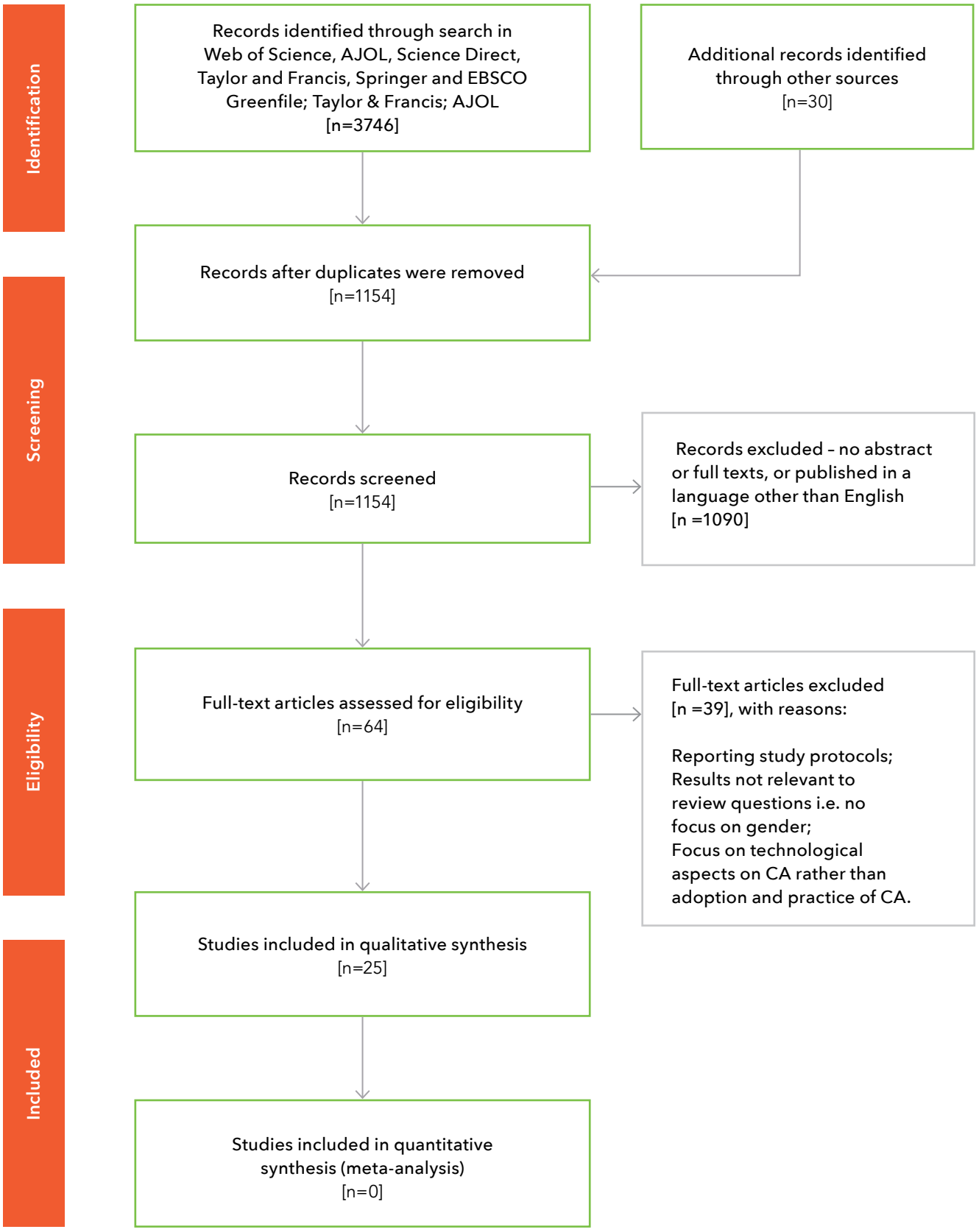

**TABLE 2:**
Salient findings from studies included in the review

| | Authors, Journal, Year | Title of Study | Study Design | Theme(s) |
|---|---|---|---|---|
| 1 | Kunzekweguta M, Rich KM, Lyne MC. *Agrekon*. 2017;56(4):330-46. | Factors affecting adoption and intensity of conservation agriculture techniques applied by smallholders in Masvingo district, Zimbabwe. | A study | Discusses adoption of CA including household characteristics, land endowment, farming techniques, crop production, and access to extension services. |
| 2 | Ward PS, Bell AR, Droppelmann K, Benton TG. *Land Use Policy*. 2018;70:27-37. | Early adoption of conservation agriculture practices: Understanding partial compliance in programs with multiple adoption decisions. | Randomized controlled trial | Focuses on factors that influence CA adoption. Demonstrates that decision-making to adopt CA is complex, stepwise and interrelated. Families with more females (translated as labor availability) were more likely to adopt CA. |
| 3 | Palm C, Blanco-Canqui H, DeClerck F, Gatere L, Grace P. *Agriculture, Ecosystems & Environment*. 2014;187:87-105. | Conservation agriculture and ecosystem services: An overview. | Review | Focuses on the eco-system services that can be provided through application of CA principles and also identifies the type of farmer likely to adopt CA. |
| 4 | Baudron F, Corbeels M, Monicat F, Giller KE. Biodiversity and Conservation. 2009;18(10):2625-44. | Cotton expansion and biodiversity loss in African Savannahs, opportunities and challenges for conservation agriculture: a review paper based on two case studies. | Review | Investigates potential of CA in developing productive and environment-friendly cropping systems, barriers to CA adoption and specifically highlights how CA affects gendered division of labor by increasing women's workloads in weeding. |
| 5 | Ng'ombe JN, Kalinda TH, Tembo G. *Agrekon*. 2017;56(2):205-21. | Does adoption of conservation farming practices result in increased crop revenue? Evidence from Zambia. | Cross-sectional study | Addresses factors that influence adoption of CA principles and the role of financial access to extension services. |
| 6 | Beuchelt TD, Badstue L. *Food Security*. 2013;5(5):709-21. | Gender, nutrition-and climate-smart food production: Opportunities and trade-offs. | Literature review and observational research | Addresses the differential impact on men and women of technologies, access to resources, labor, information and CA technology and the trade-offs in CA adoption such as choosing between herbicide uses and reducing employment opportunity for poor women in weeding. The paper provides a conceptual framework for integrating gender into climate-smart agriculture and in the project cycle. |
| 7 | Makate C, Makate M, Mango N. *African Journal of Science, Technology, Innovation and Development*. 2017;9(3):269-79. | Sustainable agriculture practices and livelihoods in pro-poor smallholder farming systems in southern Africa. | Cross-sectional survey | Focus on determinants of adoption for sustainable agricultural practices and impacts of adoption SAPs of livelihood outcomes. It highlights that female-headed households are less likely to adopt SAPs due to limited access to information, resources, land and requisite equipment. |

| | Authors, Journal, Year | Title of Study | Study Design | Theme(s) |
|---|---|---|---|---|
| 8 | Nyanga PH, Johnsen FH, Kalinda TH. *International Journal of Technology and Development Studies*. 2012;3(1):1-24 | Gendered impacts of conservation agriculture and paradox of herbicide use among smallholder farmers. | Cross-sectional Survey | Analyses the impacts of CA on women's livelihoods by focusing on the pre-tilling, land preparation, planting, weeding and herbicide use. Findings show the effects on long-term use of herbicides on men's and women's health. |
| 9 | Johansen C, Haque M, Bell R, Thierfelder C, Esdaile R. *Field Crops Research*. 2012;132:18-32. | Conservation agriculture for smallholder rain-fed farming: Opportunities and constraints of new mechanized seeding systems. | Review | Documents existing CA equipment and machinery available for use by smallholder farmers. Findings show that CA without herbicide use among smallholder farmers increases women's labor demands. |
| 10 | Giller KE, Witter E, Corbeels M, Tittonell P. *Field Crops Research*. 2009;114(1):23-34. | Conservation agriculture and smallholder farming in Africa: the heretics' view. | Review | Focuses on the trade- offs of practicing CA principles and suitability of CA for smallholder farmers in sub-Saharan Africa. The paper suggests that CA can increase labor demands for women. |
| 11 | Farnworth CR, Baudron F, Andersson JA, Misiko M, Badstue L, Stirling CM. *International Journal of Agricultural Sustainability*. 2016;14(2):142-65. | Gender and conservation agriculture in East and Southern Africa: towards a research agenda. | Review | Addresses gender differentials in decision-making, access to resources and CA implements/inputs, labor, and extension services. |
| 12 | Brown B, Nuberg I, Llewellyn R. *International Journal of Agricultural Sustainability*. 2017;15(4):467-81. | Negative evaluation of conservation agriculture: perspectives from African smallholder farmers. | Cross-sectional study | Assesses reasons farmers decide not to adopt CA such as perceived benefits and feasibility due to resource constraints and institutional factors. Intra-household decision-making processes can determine CA adoption with male heads of household capable of overruling women's decisions. |
| 13 | Mazvimavi K, Twomlow S. *Agricultural Systems*. 2009;101(1-2):20-9. | Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. | Cross-sectional study using mixed methods | Presents factors influencing CA adoption, which include gender, age, farming experience of the farmer, labor availability, access, to extension access, presence of NGOs promoting CF, size of the land, and rainfall region. |
| 14 | Kahimba FC, Mutabazi KD, Tumbo SD, Masuki KF, Mbungu WB. *Natural Resources*. 2014;5 (1):161-176 | Adoption and scaling-up of conservation agriculture in Tanzania: case of Arusha and Dodoma regions. | Mixed methods cross-sectional study | Focuses on the types of farmers likely to adopt CA, gendered decision-making on adoption of CA principles, and factors inhibiting CA adoption in Tanzania. |
| 15 | Hove M, Gweme T. *Journal of Arid Environments*. 2018;149:18-29. | Women's food security and conservation farming in Zaka District-Zimbabwe. | Case study | Evaluates women's efforts to ensure household food security through CA. Challenges women face in CA such as labor demands for basin preparation, health complications, unfavorable cover crop options and lack of resources are also highlighted. CA is said to improve gender relations and women's involvement in decision-making processes regarding CA adoption. |

| | Authors, Journal, Year | Title of Study | Study Design | Theme(s) |
|---|---|---|---|---|
| **16** | Nyanga PH. *Journal of Food Research.* 2012;1(2):120. | Food security, conservation agriculture and pulses: evidence from smallholder farmers in Zambia. | Mixed methods longitudinal/ Panel study | Focuses on pulse production and its impact on food security and women's incomes. Findings demonstrate that CA can improve household food security if the cover crops utilized form part of local diets. CA also has potential for increasing women's incomes. Male farmers interest in "women's crops" once they become lucrative can worsen women's livelihoods. |
| **17** | Murray U, Gebremedhin Z, Brychkova G, Spillane C. *Gender, Technology and Development.* 2016;20(2):117-48. | Smallholder farmers and climate smart agriculture: technology and labor-productivity constraints amongst women smallholders in Malawi. | Mixed methods cross-sectional study | Presents the gendered constraints in adopting CA with a focus on labor demands, decision-making capacities, lack of adequate equipment, production. |
| **18** | Yahaya I, Pokharel KP, Alidu A-F, Yamoah FA. *British Food Journal.* 2018; 120(2):468-482. | Sustainable agricultural intensification practices and rural food security: the case of North Western Ghana. | Cross-sectional study | The study mainly focuses on food security. It highlights that the gender of the household head can affect CA adoption, which male-headed households are more likely to engage in CA and that in certain cases female heads of households are more likely to attend CA training. |
| **19** | Kassam A, Friedrich T, Shaxson F, Pretty J. *International Journal of Agricultural Sustainability*. 2009;7(4):292-320. | The spread of conservation agriculture: justification, sustainability and uptake. | Expert analysis | Focused on the history of CA, application of CA principles, benefits of adopting CA and the types of farmers like to adopt CA. |
| **20** | Wall PC. *Journal of Crop Improvement.* 2007;19(1-2):137-55. | Tailoring conservation agriculture to the needs of small farmers in developing countries: an analysis of issues. | Review | The paper provides insights on what CA is, the benefits and challenges of CA and the factors that affect adoption and practice of CA.<br><br>Types of farmers likely to adopt CA are also identified. |
| **21** | Kristjanson P, Bryan E, Bernier Q, Twyman J, Meinzen-Dick R, Kieran C, et al. *International Journal of Agricultural Sustainability.* 2017;15(5):482-500. | Addressing gender in agricultural research for development in the face of a changing climate: where are we and where should we be going? | Review | The synthesis focuses on gender differences in exposure to climate related shocks, vulnerability and adaptation. It highlights how differential access to resources and information affect women's ability to adapt to climate change. Study emphasizes the importance of conducting intra-household surveys for agricultural research. |
| **22** | Theriault V, Smale M, Haider H. *World Development.* 2017;92:177-91. | How Does Gender Affect Sustainable Intensification of Cereal Production in the West African Sahel? Evidence from Burkina Faso. | Panel study | Assesses gender differentials in adoption of sustainable intensification practices in Burkina Faso from the dimension of Sustainable Intensification Practices. |
| **23** | Ndiritu SW, Kassie M, Shiferaw B. *Food Policy*. 2014;49:117-27. | Are there systematic gender differences in the adoption of sustainable agricultural intensification practices? Evidence from Kenya. | Cross-sectional study | Focus on gender differences in adoption of sustainable intensification practices among male and female plot managers engaged in maize farming. Female plot managers were less likely to practice manure and conservation tillage but there were no differences between male and female farmers in the adoption of maize and legume rotations, maize and legume intercropping and chemical fertilizer use. |

| Authors, Journal, Year | Title of Study | Study Design | Theme(s) |
|---|---|---|---|
| **24** Teklewold, Hailemariam, Menale Kassie, Bekele Shiferaw, and Gunnar Köhlin. *Ecological Economics* 2013;93:85-93. | Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor. | Multinomial endogenous switching regression model based on farm household survey | Conservation tillage increased pesticide application and labor demand, as a means to compensate for reduced tillage while the adoption of a package of sustainable agricultural practices of which CA was one, increased the workload of women, suggesting that agricultural intensification technology interventions may not be gender neutral. |
| **25** Deressa, Temesgen Tadesse, Rashid M. Hassan, Claudia Ringler, Tekie Alemu, and Mahmud Yesuf. *Global Environmental Change* 2009; 19(2): 248-255. | Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. | Cross-sectional household survey data | Determinants of the adoption of climate change strategies by farmers in Ethiopia, which included level of education, gender, age, and wealth of the head of household; access to extension and credit; information on climate, social capital, agro-ecological settings, and temperature, while the main barriers to adopting climate change strategies included lack of information on adaptation methods and financial constraints. |

## TABLE 3:

Publications, including grey literature on other issues other than [gender] and conservation agriculture

| Title of Paper | Focus | Findings |
|---|---|---|
| **Araya T, Cornelis WM, Nyssen J, Govaerts B, Bauer H, Gebreegziabher T, et al.** Effects of conservation agriculture on runoff, soil loss and crop yield under rainfed conditions in Tigray, Northern Ethiopia. *Soil Use and Management*. 2011;27(3):404-14. | Evaluating the effect of CA on soil quality and crop yield whilst reducing runoff and topsoil erosion. | An experiment to evaluate the effect of CA on runoff, soil loss and crop yield revealed that derdero+ (DER+), which consisted of permanent raised beds with a furrow and bed system, retention of 30% of standing crop residues and zero tillage on the top of the bed led to low levels of soil loss and runoff but also lower yields compared to conventional tillage (CT) and terwah (TER) which was similar to CT except for contour furrows that were included at 1.5m intervals. |
| **Araya, Tesfay, Wim M. Cornelis, Jan Nyssen, Bram Govaerts, Fekadu Getnet, Hans Bauer, Kassa Amare, Dirk Raes, Mitiku Haile, and Jozef Deckers.** "Medium-term effects of conservation agriculture based cropping systems for sustainable soil and water management and crop productivity in the Ethiopian highlands." *Field Crops Research*. 2012: 53-62. | Experiment to quantify changes in runoff, soil loss and crop yield due to Conservation agriculture (CA) in the sub-humid May Zegzeg catchment. | As a result of this experiment, soil organic matter was significantly higher in DER+ and TER+ compared to CT. There were positive effects on runoff, soil loss and crop yield in TER+ and DER+, practices that were improvements to CT and that qualify them as CA. |
| **Shiferaw, Bekele, and Stein T. Holden.** "Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: a case study in Andit Tid, North Shewa." *Agricultural Economics*.1998; 2(3):233-247. | Soil erosion and sustainable land use. | The major finding of this study was that where poverty was widespread and appropriate support policies were lacking, population pressure on its own was unable to encourage sustainable land use. |
| **Oicha, Tigist, Wim M. Cornelis, Hubert Verplancke, Jan Nyssen, Bram Govaerts, Mintesinot Behailu, Mitiku Haile, and Jozef Deckers.** "Short-term effects of conservation agriculture on Vertisols under tef (Eragrostis tef (Zucc.) Trotter) in the northern Ethiopian highlands." Soil and | Experiment to evaluate the short-term changes in soil quality of a Vertisol due to the implementation of CA practices and | Permanent bed (PB), and terwah (TERW), modified CA-like practices led to significantly higher soil organic matter, and reduced soil runoff volume by up to 50% and soil loss by up to 86%. |

| Title of Paper | Focus | Findings |
|---|---|---|
| Tillage Research. 2010;2:294-302. | to assess their effect on *soil erosion, and crop yield.* | |
| **Nyssen, Jan, Bram Govaerts, Tesfay Araya, Wim M. Cornelis, Hans Bauer, Mitiku Haile, Ken Sayre, and Jozef Deckers.** "The use of the marasha ard plough for conservation agriculture in Northern Ethiopia." *Agronomy for Sustainable Development*. 2011; 31(2):287-297. | Effect of the use of a slightly modified traditional Marasha, the traditional ox-drawn ard ploughing + glyphosate herbicide on CA. | The decreased runoff (−51%) and soil loss (−81%) allow protection of the downslope areas from flooding, but soil nutrient build-up and soil structure improvement are slow processes, and hence the full benefit of the permanent bed system can only be expected after some years. |
| **Teklewold, Hailemariam, Menale Kassie, and Bekele Shiferaw.** "Adoption of multiple sustainable agricultural practices in rural Ethiopia." *Journal of Agricultural Economics*. 2013; 3:597-623. | Analysis of factors that facilitate or impede adoption of interrelated sustainable agricultural practices in Ethiopia. | Findings showed that adoptions of SAPs were interrelated, and the adoption of SAPs were influenced by among other things a household's trust in government support, credit constraints, spouse education, rainfall and plot level disturbances, household wealth, social capital and networks, labor availability, plot and market access. |
| **Kassie, Menale, Precious Zikhali, Kebede Manjur, and Sue Edwards.** "Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia." In *Natural Resources Forum,* 2009; 33(3):189-198. Oxford, UK: Blackwell Publishing Ltd. | Factors that influenced farmers' decisions to adopt agriculture practices that enhanced agricultural yields including conservation tillage, compost and chemical fertilizer. | Notwithstanding enhanced productivity arising from these sustainable farming practices, their choice and adoption were influenced by household endowments and access to information, age of the household head, availability of household labor (given that the labor requirements differed from technology to technology) and land ownership. |
| **Rockström, Johan, P. Kaumbutho, J. Mwalley, A. W. Nzabi, M. Temesgen, L. Mawenya, J. Barron, J. Mutua, and S. Damgaard-Larsen.** "Conservation farming strategies in East and Southern Africa: yields and rain water productivity from on-farm action research." *Soil and Tillage Research*. 2009; 103(1):23-32. | Experiments comparing conventional (inversion) tillage with CF with and without fertilizer. | Results present increased yields and improved water productivity using conservation farming in semi-arid and dry sub-humid locations in Ethiopia, Kenya, Tanzania and Zambia. There were significantly higher yields for CF+ fertilizer treatments over conventional treatments in most locations and improve soil water/moisture retention. The paper states that 'challenges for the future adoption of CF in Sub-Saharan Africa include how to improve farmer awareness of CF benefits, and how to efficiently incorporate green manure/cover crops and manage weeds'. |
| **Lanckriet, Sil, Tesfay Araya, Wim Cornelis, Els Verfaillie, Jean Poesen, Bram Govaerts, Hans Bauer, Jozef Deckers, Mitiku Haile, and Jan Nyssen.** "Impact of conservation agriculture on catchment runoff and soil loss under changing climate conditions in May Zeg-zeg (Ethiopia)." *Journal of Hydrology*. 2012:336-349. | Assessment of CA in the May Zeg-zeg catchment in the North Ethiopian Highlands as a soil management technique for reducing soil loss and runoff. | When CA was compared to plain tillage (PT), there were significant differences in runoff and soil loss, indicating the important influence of increased surface roughness on water ponding. The paper concludes that CA would be a beneficial alternative for the current plain tillage, as it will increase infiltration and keep runoff coefficients under control. |
| **Bewket, Woldeamlak.** "Soil and water conservation intervention with conventional technologies in northwestern highlands of Ethiopia: Acceptance and adoption by farmers." *Land Use Policy*, no. 2 (2007): 404-416. | Farmers' acceptance and adoption of soil and water conservation (SWC) technologies. | Sustainable adoption and widespread replication of CA was unlikely despite the recorded benefits against soil erosion and for improving land productivity. Farmers were discouraged from adopting the technologies on their farms due to labor shortage, problem of fitness of the technologies to the farmers' requirements and farming system circumstances, and land tenure insecurity. |

| Title of Paper | Focus | Findings |
|---|---|---|
| **Temesgen, Melesse, W. B. Hoogmoed, J. Rockstrom, and H. H. G. Savenije.** "Conservation tillage implements and systems for smallholder farmers in semi-arid Ethiopia." *Soil and Tillage Research* 104, no. 1 (2009): 185-191. | Newer implements developed for use in CA in Ethiopia. | Lighter and low cost implements (Subsoiler, the Tie-ridger, and the Sweep) for use in CA have been developed in Ethiopia, and were judged to be suitable to undertake conservation tillage under smallholder farming systems in the semi-arid regions of Ethiopia. |
| **Pretty JN, Noble AD, Bossio D, Dixon J, Hine RE, Penning de Vries FWT, et al.** Resource-Conserving Agriculture Increases Yields in Developing Countries. *Environmental Science & Technology*. 2006;40(4):1114-9. | Adoption and the impact of CA on yields and household food security. | The study report that some 12,500 households adopted conservation agriculture which resulted in a 60% increase in crop yields in Ethiopia. |
| **Stevenson JR, Serraj R, Cassman KG.** Evaluating conservation agriculture for small-scale farmers in Sub-Saharan Africa and South Asia. *Agriculture, Ecosystems & Environment*. 2014;187:1-10 | Answers to four key questions are sought:<br><br>What is the impact of CA on yields?<br><br>What is the impact of adopting CA on farmers' profits?<br><br>What are the environmental impacts of adopting CA?<br><br>How well does CA fit with wider agricultural, social, economic and political contexts for small-scale farmers? | Yield increases under CA were possible but uncertain given the low average yields that pertain in SSA and South Asia, and yield gains were more likely to be observed after several years. CA was not widely adopted in SSA and South Asia owing to a lack of economic incentive for smallholder farmer: the process of conversion to CA was not profitable over planning horizons of most farmers. Farmers however perceived a benefit from CA adoption in regions that were prone to erratic rainfall, findings that suggest a potential risk mitigation role of CA. |
| **Schut M, van Asten P, Okafor C, Hicintuka C, Mapatano S, Nabahungu NL, Kagabo D, Muchunguzi P, Njukwe E, Dontsop-Nguezet PM, Sartas M.** Sustainable intensification of agricultural systems in the Central African Highlands: The need for institutional innovation. *Agricultural Systems*. 2016;145:165-76. | Analysis of the constraints and opportunities for sustainable in the Central Africa Highlands, and possible solutions. | This paper analyses constraints and opportunities for sustainable in the Central Africa Highlands and finds that they are of economic and institutional nature. Constraints were caused by the absence, or poor functioning of institutions such as policies and markets, limited capabilities and financial resources, and ineffective interaction and collaboration between stakeholders. |
| **Ragasa C, Kinwa-Muzinga A, Ulimwengu J:** Gender assessment of the agricultural sector in the Democratic Republic of the Congo in Washington DC: *International Food Policy Research Institute*; 2012. | Compilation of existing empirical evidence to highlight the gender gaps in access to resources and opportunities in the agriculture and food sector in the DRC. | There exists an overall lack of explicit attention to gender issues and the inclusion of women in agricultural development. Authors report that attention to women in agriculture in the DRC remains a minor or new focus of many donor programs. Findings show that until recently, few donor interventions in the agricultural sector in the country have been designed to augment women's opportunities or to overcome gender-related constraints to their participation. |