ORIGINAL ARTICLE

The State of Conservation Agriculture Practices in Jimma and Illu-Ababora Zones of Oromia Region, Ethiopia

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ABSTRACT

Conservation agriculture (CA) practices were assessed in six districts of Jimma and Illu-Ababora Zones in Oromia region of Ethiopia in 2017. A multi-stage sampling procedure was followed to select districts, sub-districts and households. Sample districts were identified purposefully based on agricultural and environmental conservation practices, and stratified into three different agro-ecologies based on elevation. Two sub-districts were randomly picked in each district from two different agro-ecologies, and sample households randomly chosen. Quantitative and qualitative data were collected through structured household interviews, key informant interviews (KIIs), and focus group discussions (FGDs). The results showed that farmers exercise different types of CA practices. Rotating crops, aimed at enhancing soil fertility restoration and minimizing pest and disease build-up, was a relatively common practice recorded in 36.3% (n=2075) of the plots or by 59% (n=412) of the total households. However, this practice has come waning because of declining landholdings. Consequently, it is common to find plots consecutively planted to the same crop suggesting unsustainable farming system in the study areas. Reduced tillage, crop residue retention and intercropping were reported in 6%, 10% and 6.5% (n=2074) of the farmers' plots, respectively. However, from contemporary CA perspective the current level of adoption is low, and is limited to one or a few components. Land and oxen shortage, crop-livestock production tradeoff, low crop biomass, and weeds and insect pests, inadequate promotion by the agricultural extension advisory services, and farmers' obsession towards repetitive tillage are likely to contribute to the lower adoption. Hence, improving biomass availability, diversifying sources of livestock feed and controlled grazing, and introducing alternative energy sources for cooking are suggested. Besides, awareness creation and building the capacity of Extension Officers and farmers, revisiting the extension message on tillage frequency, and promoting CA in a stepwise process through options by context approach are recommended.

Keywords: biomass, conservation, rotation, intercropping, tillage

INTRODUCTION

Located in the tropical rain forest areas where the country's surviving forest land is found, Jimma and Illu-Ababora Zones can be regarded as High Conservation Value Areas (HCVAs) for their high biological, ecological, social or cultural values. These highly productive ecosystems house a rich plant and biodiversity including wild forest coffee, several spices, and other plant and animal species. The Yayu biosphere reserve is also lodged in the Illu-Ababora Zone. Nonetheless, these areas are seriously undermined by land degradation as seen in districts like Limu Seka and Omo Nada where some 28% of their areas fall under very high erosion susceptibility class, > 50 MT $ha^{-1}yr^{-1}$ (Beshir Keddi and Awdenegest Moges, 2015). These areas, therefore, need to be appropriately managed to maintain and enhance their high values.

While it is a widely valued practice for crop production, tillage results in soil and land degradation, reduced soil organic matter and soil structural breakdown, leading to decreased soil biological activity and water infiltration, as well as increased water runoff and soil erosion (Wall *et al*. 2013). Contrary to this fact, in Ethiopia, conventional wisdom in soil tillage is working the soil repetitively to bring it to a fine tilth, and a farmer doing more of this is seen as a workhorse while a farmer failing to achieve a fine seedbed is often considered indolent. This has resulted in soil compaction, limited water infiltration, soil erosion, and soil moisture loss and thus degraded soil quality (Melesse Temesgen, 2007).

To sustain agricultural production and realize the country's economic development objectives of present and future generation, Ethiopia needs to make a shift from the current paradigm of agriculture focusing mainly on productivity enhancement to an agricultural development trajectory constituting environmental sustainability as its core component like use of conservation agriculture (CA) practices which is perhaps one of a no alternative of the future. There is an abundant literature with success reports that CA ensures a more stable and economically favorable yield (Knowler and Bradshaw, 2007; Rusinamhodzi *et al*., 2011), reduces erosion, improves soil moisture, saves energy, reduce pests and diseases, improves soil organic matter and fertility. By doing so, CA addresses land degradation, air quality, climate change, biodiversity and water quality (Dumanski *et al*. 2006).

Traditional CA elements have of course been and are part and parcel of agricultural practices of Ethiopian farmers. In some western parts of Ethiopia, dibbling (no-till) has been in use for a long time in the tradition of indigenous communities. Even in the intensively cultivated highlands, CA practices like crop rotation and mixed cropping and even reduced tillage practices are commonplace. It is common to find oil crops like Niger-seed and linseed and several pulse crops planted under low tillage intensities. Crops like lupin are often grown tilled just on a single pass or sometimes untilled (Fentahun, Unpublished). In its contemporary sense, research and promotion of different CA components has also been started quite long ago in the country. However, CA technology in its entirety has been introduced to the country in 1998 by Sasakawa Global 2000 in collaboration with Makobu Enterprises PLC and government agriculture departments.

Like in other parts of the country traditional CA practices are expected to be in people's traditions in Jimma and Illu-Ababora areas. Moreover, the government agricultural extension system and NGOs teach about sustainable land and forest management, and CA practices in these areas. Nonetheless, CA practices are affected by several factors like heterogeneity of growing environment and farming systems, biomass availability, population pressure, land size, and market access (Kindie *et al*. 2014). Therefore, an in-depth understanding of the local systems and idiosyncrasies and the underlying enabling and inhibiting factors is vital to design location-specific CA practices. This study was therefore designed to understand the existing knowledge and practices of CA, intensity of use and factors that accelerate or hamper CA practices in high conservation value areas of Jimma and Illu-Ababora Zones of Oromia region.

MATERIALS AND METHODS

Characteristics of the study areas

Jimma and Illu-Ababora Zones in Oromia Regional State of Ethiopia are characterized by a humid tropical climate with annual rainfall ranging from 1200-2000 mm and a temperature ranging 25-30°C (Berhanu Megerssa and Getachew Weldemichael, 2014). The landscape is so heterogeneous characterized by mountains, hills, dissected plateaus, plains, and valleys. Remnants of dense natural forests housing a variety of indigenous tree species exist in these areas and provide timber, fuelwood, construction material and medicine, habitat for wildlife and other ecosystem services. The dominant land use types include agricultural land, grazing land, forest land, wetlands and settlement areas. Two major forms of land tenure exist, private and communal forest land. Private land (with only user rights entitled) is allocated for both food production and environmental services. Communal forestland is managed collectively primarily for environmental services while it also supports household livelihood through a local land tenure arrangement referred to as "*Kobbo*". Under this arrangement, while managed collectively, forest land is entitled to individuals to utilize it for non- timber forest products (NTFPs), like coffee and spice production, beekeeping, etc. A mixed crop-livestock based agriculture is the most significant source of livelihood. Livestock production and fattening, crop production, coffee production, timber, and NTFPs are the major source of income for the households. Coffee is grown in the forest, farm, and homesteads. Maize, teff, and sorghum dominate the annual crops. Enset (false banana) is cultivated in the homesteads often intercropped with coffee. Pulses are cultivated as break crops to replenish soil fertility. About 92% of the households are engaged in livestock production where open grazing fields, crop field aftermaths and residues form the major source of feed for livestock.

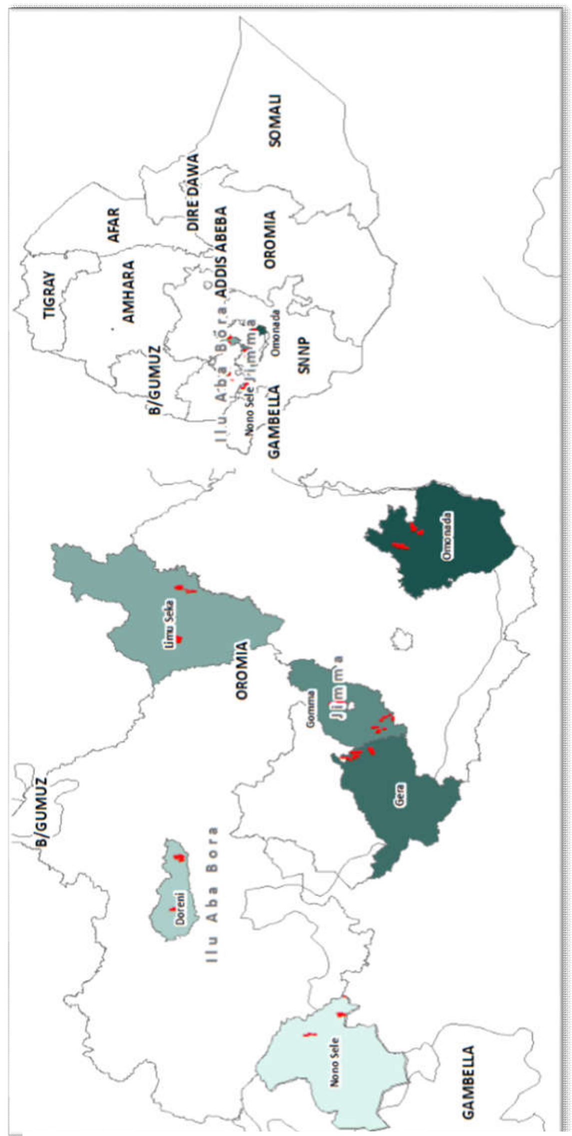


Figure 1. Map of the study areas

Sampling and data collection

The study was conducted in Jimma and Illu-Ababora Zones of Oromia region in western Ethiopia in 2017. The survey covered 6 districts: Nono Sele and Doreni (Illu-Ababora Zone), and Gera, Goma, Limu Seka and Omo Nada (Jimma Zone), Figure 1. A multi-stage sampling procedure was followed to select sample districts, sub-districts and households. Districts were identified by a purposeful sampling technique on the basis of agricultural and environmental conservation practices, and stratified into three different agro-ecologies based on elevation: high, mid and low, and two sub-districts randomly picked in each district. Sample households were randomly chosen from each sub-district based on the minimum proportional ratio of 1.5 and 2.0 for female- and youth-headed households, respectively. On average, 35 households (except Nono Sele district) were selected from the 12 sample sub-districts, which amounts to 412 households, of which female, youth[1] and male-headed households constituted 16.6%, 21.1%, and 67.4%, respectively.

Both quantitative and qualitative data were collected. The quantitative household data was collected by administering structured interviews using a pre-tested questionnaire by trained and experienced enumerators who are conversant with the local farming and social systems. Qualitative data was generated by arranging sub-districts level focused group discussions (FDGs) and key informant interviews (KIIs) at different administrative levels, and transcribed verbatim and analyzed thematically and substantiated and triangulated with the results of the quantitative survey. The sub-districts level survey focused on capturing the general agricultural profile including the status and performance of crop production and natural resource management activities. At household level data were collected on existing agricultural practices, land management, soil and water conservation practices, socioeconomic status, access to agricultural extension services, credit and marketing, and major constraints. The geo-referenced data were collected using an ICT tool - Survey 123 and exported to SPSS for statistical analyses.

RESULTS AND DISCUSSION

The present study revealed that farmers in Jimma and Illu-Ababora areas practice one or more components of CA practices. Government and non-governmental development organizations provide farmers with extension services on improved agricultural and conservation practices. Nonetheless, agricultural extension trainings and messages are dominated by crop production and protection, soil and water conservation and livestock production as reported by 60.2%, 39.3% and 38.1% of the households across the study areas. Extension messages on CA practices are rather scanty. Only 5.3% of the sample households reported as they received training on minimum tillage, 17.5% on crop rotation, 4.4% on intercropping, and 6.8% on crop residue retention (Figure 2). Therefore, CA activities practiced in the area are believed to have emanated more from farmers' own time-honored indigenous knowledge and experiences as a response to environmental and socio-economic dynamics, and to a lesser extent from the learnings introduced by the agricultural extension advisory services.

Nonetheless, the intensity of CA use is low and is limited to one or two components at a time than the full CA packages. This is consistent with many reports that when CA is introduced to an area the prevailing practice is adopting individual components (Kindie Tesfaye, 2017) and seldom have all three principles been part of the systems applied and reported (Wall *et al.*, 2013). But the fact is that the full benefits of CA are achieved when all components are properly practiced.

This is supported by the findings of Wondwossen *et. al.* (2008) who reported crop yield increase and a decline of the amount of labor per unit of crop yield as more components of conservation agriculture are adopted. Details of the individual components of CA practices in the study area are discussed below.

Minimum physical soil disturbance

Minimum tillage represents an important economic appeal to farmers in terms of reducing production costs, particularly expenditure on labor, seeds and other yield-improving inputs (Dumanski *et al.*, 2006; FAO, 2016) and a general pattern of yield enhancement while lowering production costs. Controlling the effects of other inputs, farm, and plot characteristics, maize productivity was reported higher by 0.44 t ha^{-1} for plots with minimum tillage package compared to their counterfactuals (CIMMYT/ACIAR, 2017). A yield advantage of 13-29% and additional benefits of Birr 7.25 for each additional one Birr was also calculated in the west Gojjam Zone of Ethiopia on using reduced tillage combined with herbicides (FAO, 2016). Minimum tillage also decreased average male and female labor respectively by 14.4 and 8.2 person-days per ha and a decrease in draft power use for land preparation by 13.2 pair of oxen-days per hectare (Moti *et. al*. 2016). Especially, resource-poor households who do not have draught power benefit from minimum tillage as this practice enable them to manage their land instead of renting- and sharing-out (Asresie Hassen *et al*. 2015).

[1] Based on AU Commission's Africa Youth Chapter definition of youth that refers for every person (both female and male) between the age of 15 and 35 years

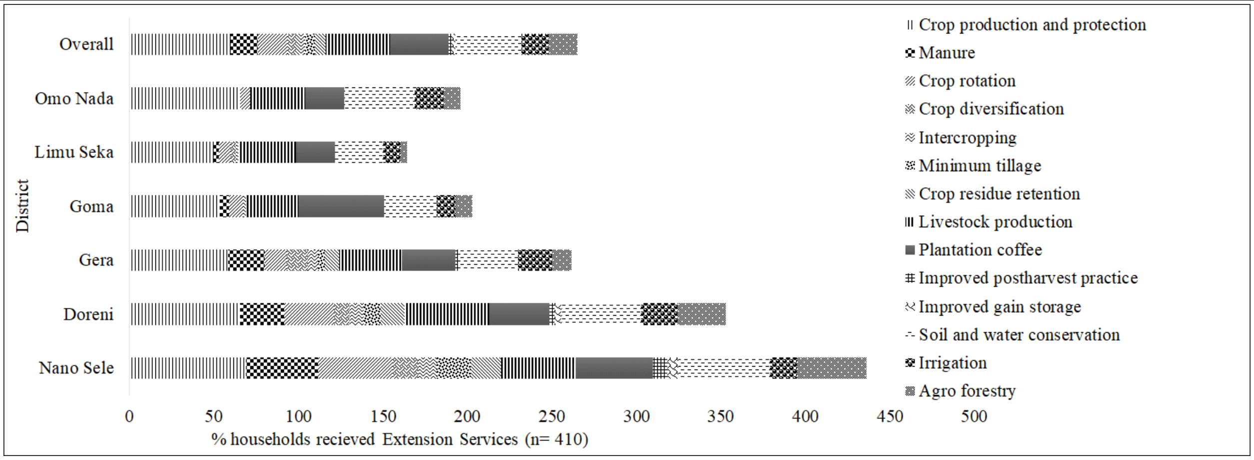


Figure 2. Proportion of households receiving agricultural extension services (n=410)

In the study areas, reduced tillage was recorded only on 6% (n= 2074) of the farmers' plots (Figure 3). Despite very low, this can however be taken as a good start given the current situation where the national agricultural extension advisory service is in favor of higher tillage intensities.

While it is obvious that CA practices like minimum tillage contribute to long-term and sustainable production benefits, farmers' adoption decisions typically rest on the immediate benefits such as short-term productivity (Giller *et al.*, 2009). Several authors reported negative or neutral outcomes in practicing minimum soil disturbance in the early years of adoption. SG2000-Ethiopia reported that in its first year of demonstration, yields in CA plots were not different from plots under conventional tillage (FAO, 2016). Likewise, six years of zero-tillage together with herbicide application resulted in no or marginal yield improvement in teff, wheat, and lentil crops (Erkossa *et. al.*, 2006). Tigist Oicha *et al.* (2010) reported a significantly lower tef yield, biomass, and height in vertisol areas of Tigray under conservation tillage on permanent beds. Thus, the low level of minimum tillage practice in the study areas can partly be explained by depressed productivity in the early years. Besides, according to Kinde *et al.* (2014) areas with >1500 rainfall combined with 3-50% slope and heavy and light clay soil is marginally suitable for CA. Therefore, the high rainfall in the Jimma and Illu-Ababora Zones might have encouraged high weed infestation making it difficult to practice minimum soil disturbance because of the higher labour demand for weeding in the absence of herbicides that are often inaccessible or costly to farmers. Furthermore, as the major source of draught power, oxen ownership is likely to affect crop production in Ethiopia. In the study areas, in districts where a lower number of households are in possession of oxen, minimum tillage practices tend to be better (Table 1). This is well demonstrated by the Nano Sele and Doreni districts where a significant number of households had reported to have no oxen but minimum tillage was practiced well (Figure 3). This suggests that oxen shortage might have been one of the drivers for working the soil at minimum tillage intensities. Moreover, oxen ownership significantly varies by the type of household where male-headed households (66.4%) own more oxen than female-headed households (41.0%) suggesting that minimum tillage intervention would likely be better adopted by women-headed households (Table 1).

Generally, to improve the adoption of minimum tillage practices different actions are required on multiple fronts. Especially, to overcome depressed yield that might arise after practicing minimal tillage alone without mulch, incentive schemes that could potentially compensate yield losses and production risks should be put in place (Abro *et al.*, 2018). IFAD (2017) suggested use of low-cost and eco-friendly biofertilizers for enhancing crop yield while reducing the use of chemical fertilizers. Also, judicious use of chemical fertilizers may need to be considered to enhance crop productivity and organic residue availability. Microdosing and/or balanced application and precision placement of fertilizers, facilitated by the rip-lines or basins, can contribute to more efficient use of fertilizers, and thereby for adaption to climate change through highly efficient use of water and earlier harvest (Dumanski *et al.* 2006; IFAD, 2017).

In the study areas, the adoption of improved inputs is generally low. Only 31.7% of households use improved seeds, and only 43% of plots receive fertilizers. Consequently, for the insufficient utilization of improved inputs together with low CA practices, crop productivity appears to be low (1.6 MT ha^{-1}) in these geographies. Unless the low crop productivity problem is tackled timely it could tempt farmers to encroach forests and protected areas that causes a further forest degradation.

Most importantly, the mindset of farmers that see repetitive cross-plowing, as many as 12 passes in some areas, as an essential activity to bring the soil to a fine tilth, and a notion which is also largely shared by the agricultural extension advisory services, had undoubtedly influence on reduced tillage practices adoption. This suggests that before setting any modern CA practices promotion effort in motion in the study areas and elsewhere in the country, the agricultural extension message on redundant tillage operations needs to change towards conservation tillage and farmers get convinced about it.

Maintaining permanent soil cover

Ensuring permanent soil cover by using either cover crops or crop residue retention is one of the major actions anchored in CA pillars to decrease run-off, soil loss, improving infiltration and increasing soil organic matter. In the Jimma and Illu-Ababora Zones, crop residue retention practice was reported only in 10% (n=2074) of the sample farmers' plots. According to Melese Temesgen (2017), areas of highest CA potential in Ethiopia are those with high mulch availability, high soil organic matter content and high temperatures. When SG2000 introduced CA for the first time in the South Achefer district of Amhara Region of Ethiopia in 1990, of all CA components maize crop residue retention had the lower adoption because of competing multi-purpose use for the residues (Moti Jaleta, *et.al* 2016). Compared to Jimma Zone, the districts in Illu-Ababora Zone (Nano Sele and Doreni) generally tend to show a better crop residue retention which can be ascribed to better biomass availability in the highlands (Figure 3 & 4). Nonetheless, only 6.4% of the plots were reported to have retained the recommended 30% and above crop residue on the soil in 2016 crop season.

In the study districts, 92% (n=412) of sample households possess livestock (Table 1). The major sources of feed for livestock in the dry season are crop field aftermaths and residues on which all sorts of animals are set free for roaming. Despite intense government efforts to bring free grazing to a halt, stray animals remain a major problem in rural areas which affects not only crop residue retention in farms but also compacts the soil and induces erosion. Besides, the major source of household energy in the study areas is biomass. It is not therefore surprising to find a lower level of residue retention practices where there is no adequate biomass, and farmers put crop residues into competing uses: such as livestock feed, fuelwood and roof thatch that tempts them to leave crop residues and stubbles on the field. Insect pest build-up including the recently introduced fall armyworm in unclean fields might have also discouraged retaining crop residues.

Generally, increasing biomass availability through different measures like enhancing crop productivity, increasing forage availability, introducing ration feeds, and zero/controlled grazing, and improving access to cooking stoves would help to tackle residue retention problems. Besides, creating an agro-ecology that provides adequate non-crop residues such as thatch grass, encouraging farmers to use leguminous crops residues for feed and setting aside cereal crops residues for soil mulch, and introduction of dual-purpose crop species and varieties providing higher grain yield and biomass could help reducing competition for crop residue and improve retention (SAA/SG2000, 2019). It is also important that appropriate CA equipment and alternative weed and insect pest control measures are put in place.

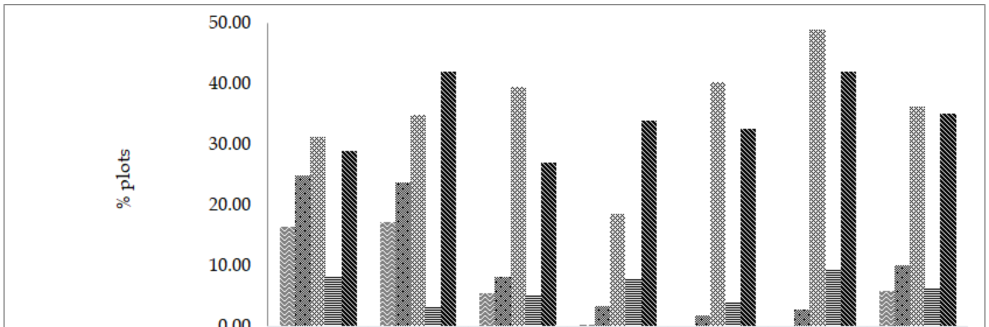
Crop diversification practices

One of the pillars of CA is promoting a healthy living soil through crop rotations and associations (crop sequences, relay cropping, and mixed crops), cover crops, IPM, controlling off-site pollution, and enhancing biodiversity (Dumanski *et al.* 2006). Rotating crops increases microbial diversity and reduce the risk of pests and disease outbreaks (Leake, 2003 cited by Hobbs *et al*. 2008) which also enables reducing requirements for pesticides and herbicides. In the study areas, as shown in Figure 3 a relatively common CA practice is the rotation of annual crops which is reported on 36.3% of the plots (n=2075) or by about 59% (n=412) of the households aimed to enhance soil fertility restoration and minimize pest and disease build-up. In terms of agro-ecology, the lowlands tend to have better rotation practices (Figure 4). Cereals (maize, teff, sorghum, and barley) are rotated with pulse, vegetable, and spice crops. Considering all recorded annual and perennial crop species together in the landscape, coffee ranks first by occupying 52% of the farm plots followed by maize (15%) and teff (5.3%) in 2017 (Figure 5). However, when only annual crops considered, maize dominates the farming system by occurring in 42.8% of the plots followed by teff (15%) in 2017. Likewise, faba bean (pulse), Niger seed (oilseed), garlic (vegetable), banana (fruit) and ginger (spice) were found frequent species in their respective groups (data not shown).

Based on the total 36 species recorded in the study areas, the Shannon diversity index was calculated at 1.87 which is about 52.8% of the maximum possible value that would have been obtained had all species occurred at an equal frequency (3.58) suggesting a moderate level of diversity. On districts basis, the Shannon diversity index ranged from 1.57 at Goma to 1.93 at Gera making the two districts relatively less and more diverse, respectively.

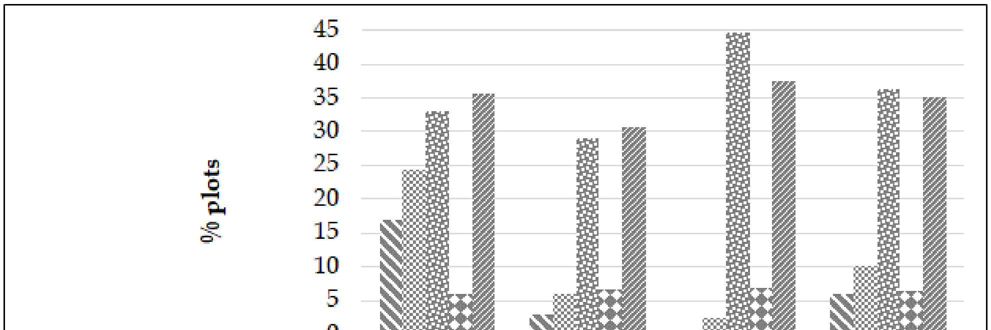
Nevertheless, continuous cropping of the same crop year after year is common place in the study areas. For instance, 35%, 40% and 42% of the plots that were put under maize in 2017 (n=135) were planted straight to maize in the preceding years of 2016, 2015 and 2014, respectively. Similarly, 41%, 29% and 32% of the plots under teff in 2017 (n=73) were planted to the same teff crop in the preceding three years in that order. Some 41% of the 2017 sorghum plots (n= 42) were planted to sorghum in 2016, and 41% and 36% to maize in 2015 and 2014, respectively (Figure 6a-c). This shows that legumes are not widely used in crop rotations in the study areas suggesting unsustainable farming practices.

CA in small-scale mixed farming systems crucially depends on the underlying biophysical and socioeconomic factors that influence the farming system, and the performance and adoption of CA systems (Kinde *et al.,* 2014). In the study areas, declining landholdings due to the rising population, low crop productivity and thus low biomass and shrinkage of grazing lands have most likely contributed to the low level of crop rotation and CA practices in general.



	Nano Sele	Doreni	Gera	Goma	Limu Seka	Omo Nada	All samples
Minimum tillage	16.54	17.33	5.56	0.29	0.00	0.00	6.03
Crop residue retention	25.00	23.86	8.33	3.50	1.93	2.86	10.13
Crop Rotation	31.25	34.94	39.51	18.66	40.38	49.05	36.29
Intercropping	8.46	3.41	5.25	7.87	4.12	9.52	6.46
Soil & water conservation	29.04	42.05	27.16	34.11	32.69	42.14	35.08

Figure 3. Plot level adoption of selected conservation agriculture practices by district



	Highland	Mid Altitude	Lowland	All samples
Minimum tillage	16.94	2.92	0.00	6.03
Crop residue retention	24.43	5.92	2.39	10.13
Crop Rotation	33.10	29.08	44.72	36.29
Intercropping	5.93	6.56	6.82	6.46
Soil & water conservation	35.54	30.64	37.42	35.08

Figure 4. Plot level adoption of selected conservation agriculture practices by altitude

This is shown in Goma district which for its lowest landholding per capita, that shrunk from 2.5 ha in the 1990s (Legesse *et al.*,1992) to the present 1.25 ha per household, recorded the lowest crop rotation practice (18.6%). Besides, poorly developed seed and output market systems of the pulse crops and low level of pulse consumption in the household diet can contribute to the low level of crop rotation practice by farmers. This suggests the need for context-specific strategies for CA promotion based on agroecology, cropping systems and the existing level of crop-livestock interactions.

Intercropping practice was reported on 6.5% (n=2075) of the farmers' plots (ranging from 3.4% at Doreni to 9.5% at Omo Nada) suggesting that mixed cropping is better practiced in the lower than higher altitudes (Figures 3 & 4). On the other hand, some 53.6% of the sample farmers' plots were under agroforestry system (Table 2). The agroforestry practice provides the opportunity to introduce CA with trees, which improves the uptake of CA practices through the provision of diverse utilities like provision of fodder, fuel, construction materials, agricultural implements, biomass, nutrients, fencing, and fruits, among other products and services (Mutua *et al*., 2014). Undoubtedly, coffee shade trees helped enhancing agroforestry practices in the study areas. Maize being a dominant crop amenable for intercropping in the study areas, proven practices of maize- bean intercropping elsewhere in the country could be promoted in these areas to improve CA practices.

Table 1. Percent households raising livestock and ox ownership

District	% Households involved in livestock production	Livestock Size (TLU)	Proportion of Ox ownership by household type			
			Female	Male	Youth	All Samples
Nano Sele	89.3	4.4	30	60.6	33.3	48.3
Doreni	90.0	4.1	50	54	50	52.9
Gera	92.9	4.2	38.5	51.2	63.6	50.7
Goma	88.7	2.7	17.6	55.9	23.1	39.1
Limu Seka	94.3	4.6	50	84.4	57.9	75.8
Omo Nada	97.1	5.2	76.9	88.4	83.3	85.3
All District	92.0	4.2	41	66.4	51.2	59.2

Other complementary conservation practices

Experiences in sub-Saharan Africa highlight the importance of supplementary practices that have come to be called "CA+". These include management of soil fertility, weed, livestock, and mechanization (IFAD, 2017) that, together with the three CA principles, reinforce sustainable agriculture. In the study areas, government and non-governmental organizations support conservation-based livelihoods. The Ministry of Agriculture is the major service provider which its extension service focuses more on sustainable intensification of agriculture that includes coffee production and CA where more than 75% of the sampled respondents reported receiving this service. Besides, NGOs and other development projects provide environmental conservation advisory services on forest and protected area management in the study areas. Therefore, complementary practices that can be seen under the extended concept of CA such as soil and water conservation activities and natural resources management are practiced in the study areas. The widely practiced activities are agroforestry (53.6%), cut-off drains (52.1%) and terraces (51%), Table 2. Coffee shade-based scattered trees in the area are good practices seen from an agroforestry perspective. Besides, soil and water conservation activities are practiced in some 35% (n= 2074) of the farm plots with no significant difference by altitudinal categories (Figures 3 & 4). Generally, looking at the inadequate adoption of the full packages of CA in time and space, as suggested by Thiombiano and Meshack (2009), the promotion and development of CA in the study areas require a step-by-step approach with adequate flexibility at the outset to capture the needs, expectations, and capabilities of resource-poor smallholder farmers.

Summary

In the Jimma and Illu-Ababora Zones, farmers exercise different CA practices that include crop rotation, intercropping, minimum tillage, crop residue management, agroforestry, and various soil and water conservation activities. Nonetheless, the current level of CA adoption is generally low and focused only on a few components. Shortage of resources (such as crop and grazing land, and oxen), crop-livestock production tradeoff, low crop yield and biomass, weed and insect pest infestation, etc. appear to be redoubtable challenges contributing to the low level of CA practices adoption. Also, inadequate promotion of CA by agricultural extension advisory services, and most importantly farmers' preoccupation towards repetitive tillage which is backed by the incumbent agricultural extension system adds to the problem. Depressed yields in the early years, as reported elsewhere, are also likely to affect CA adoption in the study areas. Designing agro-ecology that improves biomass availability like the introduction of dual-purpose crop species for high biomass and grain yield, diversifying livestock feed sources, introducing alternative household energy sources such as improved cooking stoves are some of the plausible actions that should be taken to improve CA ramification. Free-roaming of livestock both during crop growing season and after harvest needs to be put to a halt. Besides, the largely monotonous cereal crop growing pattern needs to be broken through the introduction and growing of more leguminous crops in the farming system in sequences, cover crops or polycultures to create a more diversified farming system.

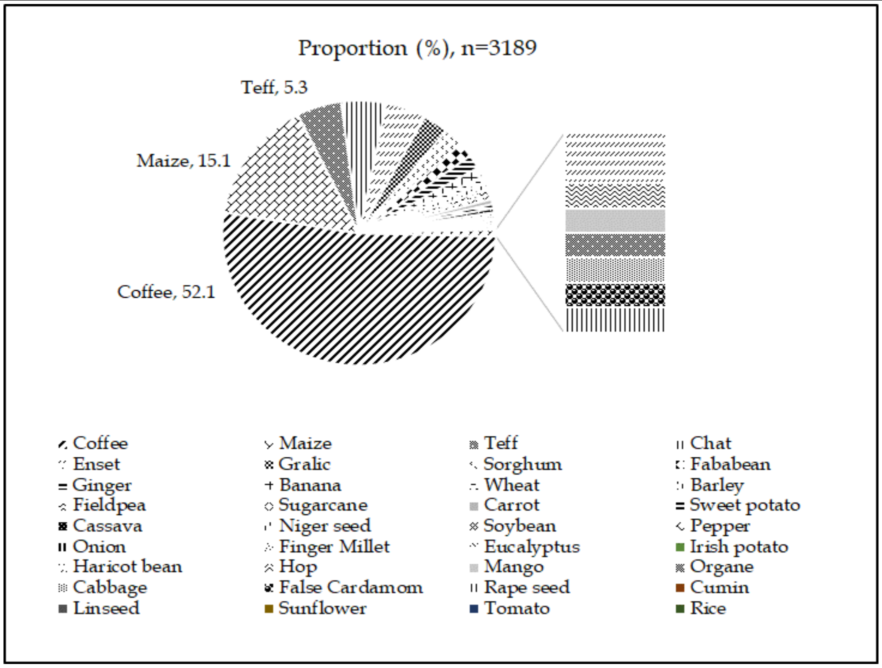
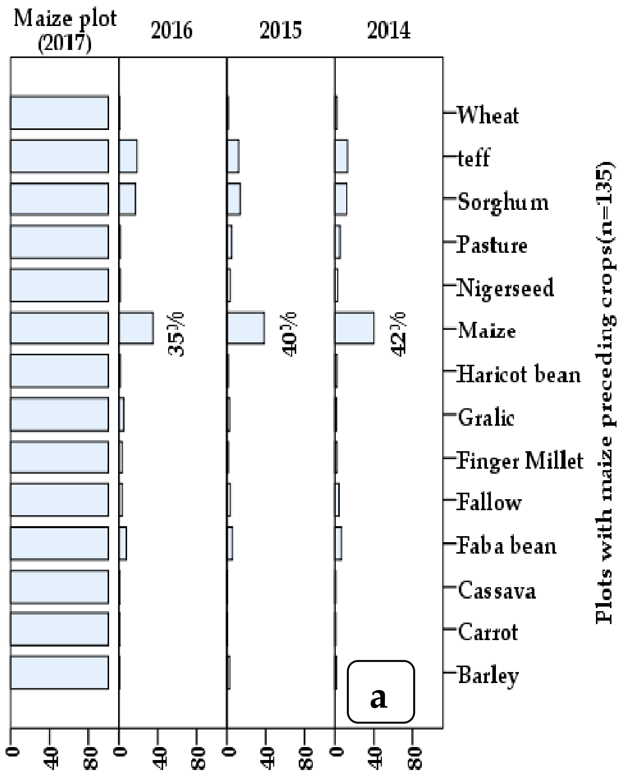
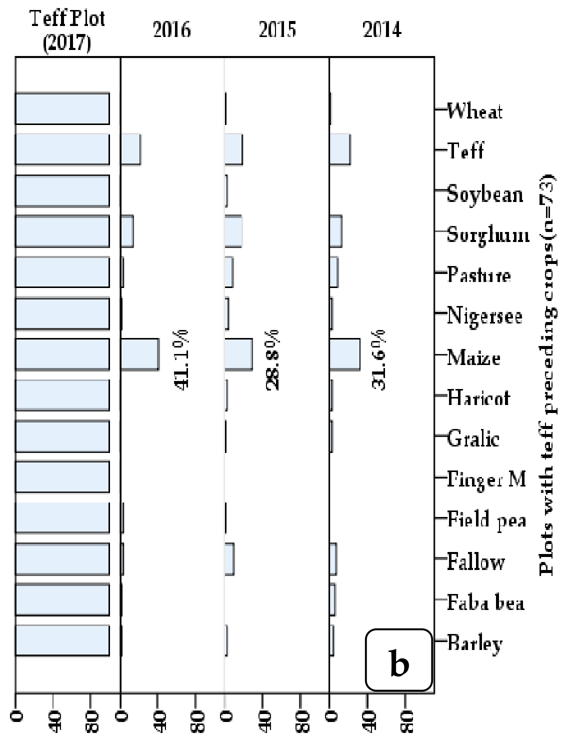


Figure 5: Frequency of plots under different crop species in 2017 (n=3189)

Table 2. Proportion of plots applying land and water management practices

Land and water management practice	District						
	Nano Sele	Doreni	Gera	Goma	Limu Seka	Omo Nada	All Samples
Terraces	60.8	54.1	39.8	34.2	50.8	61	51
Gulley controlling	2.5	0.7	2.3	0	0	0	0.7
Hillside contour terrace with tree planting	11.4	18.9	5.7	5.1	11	16.9	12.5
Cutoff drains	38	45.3	54.5	69.2	59.3	46.9	52.1
Mulching	0	0.7	0	1.7	0	0	0.4
Grass strips	1.3	6.1	10.2	1.7	1.7	3.4	4
Agroforestry	41.1	65.8	42.8	60.3	63.6	46.8	53.6





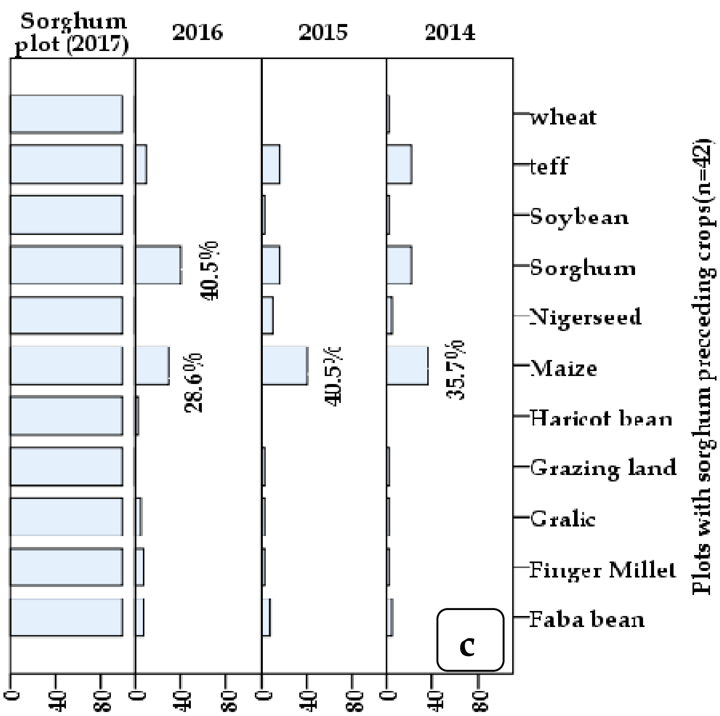


Figure 6: Reference crop (2017) and plots under other crops in the preceding years (2016-14) (A= maize; B= teff; C= sorghum)

Appropriate CA equipment and alternative weed and insect pest control measures need also to be introduced. It is also important that farmers are aware of possible limitations of CA at the outset and given appropriate solutions lest expectations are raised too high and lead to an early dis-adoption. Building on farmers' indigenous practices, it would also be wise to promote CA in a stepwise process starting with easy entry point practices matching with and affordable to the small-scale farmers' settings, capacities, and capabilities. Most importantly, before any attempt to set CA in motion in the study areas, however, the national extension messages on tillage operations need to be revisited and changed. Extension Officers and farmers need to be taught about CA practices and overall sustainable agriculture practices.

In the decades ahead, under the influence of climate change, agriculture in Ethiopia will have to sustainably produce more food from declining agricultural landholding through efficient input usage and with minimal impact on the environment, and reduce food loss and waste to meet the needs of the present and the future generations. As such, if fully adopted, CA practices would serve as a basis for sustainable agricultural production. On the other hand, while the study locations are high conservation value areas housing the country's remaining few natural resources treasures, they are in the state of speedy conversion into agricultural lands. A crucial lesson that has to be learned, from the centuries-old traditional conventional agriculture practice in many other parts of the country that culminated in a highly denuded landscape to the point of no return, is that the cost of degradation prevention is much cheaper than recuperating once the precious resources are gone. In this regard, adopting agroecology based CA practices can ensure sustainable agriculture in the study areas. Especially, wedding farmers local CA practices and sustainable intensification (SI) interventions by the government into what is dubbed agro-ecological intensification would provide an opportunity to practice CA along with judicious use of improved inputs guided by precision farming techniques. This would enable enhancing productivity while conserving the environment and natural resources. It helps to keep balance among agricultural, economic and environmental objectives, and ultimately leads to transformation of the food systems and sustainable use of natural resources. To evolve towards CA and agroecological approaches, building on coffee- and coffee shade-based agroforestry as an entry point, farm tree integration needs to be strengthened for erosion control, to conserve and enhance biodiversity, and to promote soil carbon sequestration.

CONCLUSION

Challenged by several factors, conservation agriculture practice is low in the Jimma and Illu-Ababora Zones. In addition to constraints related to farmers' resource endowments and farming systems, farmers' obsession towards conventional tillage and inadequate promotion by the agricultural extension services contributed to the unsatisfactory CA practices. It is therefore important that these constraints are solved and favorable environment created before any attempt to introduce modern CA practices in these areas. As part of the transition to CA approaches, contemporary CA pillars need to be introduced in a step-by-step process building on the existing indigenous knowledge and practices. In addition, for effective CA innovations "options by context" approach that takes into account heterogeneity of soil and climate conditions, agroecosystems, and socio-economic circumstances, should be promoted.

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