Sasakawa Africa Association

ADOPTION OF CONSERVATION AGRICULTURE PRACTICES AND ITS DETERMINANTS:

The Case of Five Previous Intervention Woredas of Sasakawa Africa Association

Study team: **Getachew Minas, Fikadu Chala**
Editors: **Dr. Fentahun Mengistu, Ethiopia Tadesse**
Design by **SAA Communication Team**

Financed by **Sasakawa Africa Association (SAA)**

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Abbreviations

CA	Conservation Agriculture
Ha	Hectare
HH	Household
ISFM	Integrated Soil Fertility Management
SAA	Sasakawa Africa Association
SIA	Sustainable Intensification of Agriculture

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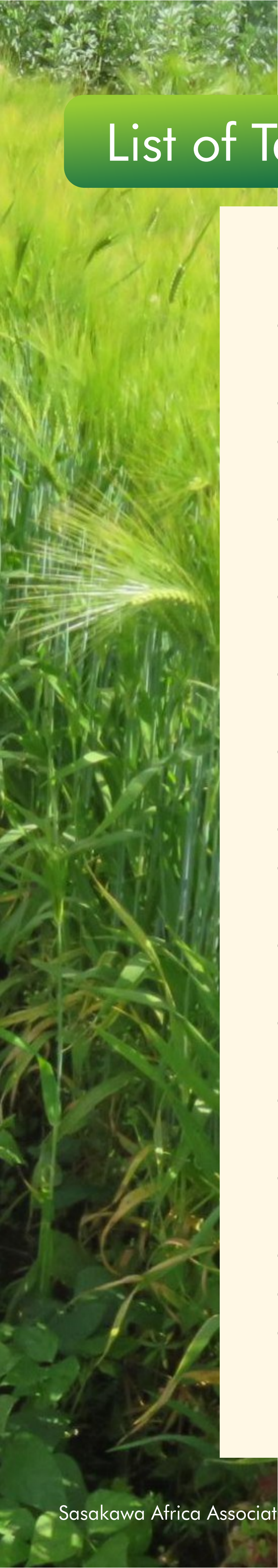

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1. Introduction

The agricultural sector in Ethiopia has recorded a remarkable growth over the last decade, averaging 6.4 percent per year between 2001 and 2017 (NPC, 2018). The agricultural output more than doubled, driven in part by area expansion, but more importantly by significant yield increases. However, this growth is expected to have come at a cost of natural resource degradation and loss of biodiversity. In addition, the growing population and changing climate are putting a strain on the natural resource base of the food, water, and energy production for the rural as well as urban population.

As a result, the natural resource base has been deteriorating over time, which amplifies exposure to substantial environmental and climate risks that affect food and water security, energy, and human health, among others. For example, there is an increasing conversion of forestlands to agriculture, at an annual forest depletion rate of over 1 percent due largely to demand for wood fuel and agricultural land [2]. Soil nutrition depletion has increased over time in the highlands because of serious soil erosion amounting average loss of ranging from 8.3 to 16.1 tons per hectare per year, and in severe cases up to more than 25 tons per hectare per year in areas with high population and long cultivation history [3].

Inappropriate land use, frequent tillage with poor soil management, inadequate organic matter supply, removal of crop biomass and mono-cropping have all contributed to soil degradation. Nationally, 40 percent of crop and pasture land has already been degraded with another 20 percent under degradation processes [4]. This puts the Ethiopian soils at risk to support the ever-increasing human and livestock population if the conventional land management practices continue to be used. Despite a massive land management and natural resource conservation efforts are underway by government and development partners to address the problem, this could not reverse the situation to a desired level. To respond to both the natural resources degradation and demand for food, feed, fiber, and energy with the rising population, the country needs to adopt sustainable and regenerative agricultural practices so as to increase production and productivity without depleting the production capacity of the land.

Conservation Agriculture (CA) has been considered as one of the possible sustainable agriculture trajectories. It is an approach of managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. To this end, three interlinked CA principles; viz., no or minimum mechanical soil disturbance, permanent soil cover with crop residues and live mulches, and crop sequences and associations, applicable to all agricultural landscapes and land uses applied with locally tailored improved management practices are considered as the key road to increased system productivity, resilience and sustainability [5].

The soil quality improvements are around enhancement of soil organic carbon (SOC), water infiltration capacity, water holding capacity and microbial activities, and thereby arresting incline in total factor productivity of applied inputs. Its contribution was indicated in build-up of effective nutrient recycling and enhancement of nutrient use efficiency by creating conducive rhizosphere for soil micro-flora and fauna [6].

In addition to reducing the evaporation losses and non-point pollution of water bodies, CA contributed to reducing vulnerability against impacts of climate change on crop production and mitigation by reducing emissions and improving carbon sequestration in soils [7].

Zero or minimum mechanical disturbance of soils is aimed to minimize processes that contribute to degradation such as erosion, compaction, aggregate breakdown, loss of organic matter, leaching of nutrients and others [8]. A suit of practices including direct sowing/broadcasting of crop seeds, direct placing of planting material in the soil or minimum soil disturbance from cultivation or farm traffic needs to be applied. In fact, the use of zero tillage without appropriate residue retention and suitable rotations is reported to be even more harmful to agro ecosystem productivity and resource quality than a continuation of conventional practices [9].

Ethiopian agriculture today is characterized by insufficient and inefficient input use, water insensitivity, inappropriate agrochemical use, exploitative (energy dissipating, low nutrient cycling), practices encouraging high tillage frequency, mono-cropping, and high crop-livestock tradeoffs, and is highly vulnerable to the effects of climate change. If the country continues to operate under the current agricultural model, it may jeopardize its ability to produce food for current and future generations.

Hence, in the face of a deteriorating environment, which is the foundation of food production, dwindling natural resources, concern for human and environmental safety, and an increasing climate emergency, the country must pursue a sustainable food production trajectory which is a compelling route towards food production to feed the growing population while trailing practices courteous of the environment by redesigning farms in line with principles and practices of sustainable and regenerative agriculture. Sustainable agriculture must achieve economic, social, and environmental goals all at the same time. This has been well articulated by the United Nations Sustainable Development Goals (SDGs), which provide a comprehensive framework to assist decision makers and governments in balancing social, economic, and environmental challenges up to 2030 [10].

The Sasakawa Africa Association (SAA), which has been working in Ethiopia since 1993 to support the country's agricultural production and productivity enhancement efforts by promoting innovations and building the capacity of farmers and extension agents (EAs), dedicated it's time to promote Conservation Agriculture (CA) practices in different parts of the country since a decade before.

This study, therefore, was conducted to assess the adoption of Conservation Agriculture (CA) practices and its determinants in the areas where SAA was promoting CA practices. In addition, it was intended to identify the challenges encountered by the smallhoder farmers to apply CA practices on their own farm plots.

2. Objectives of the Study

I. To assess the adoption rate of Conservation Agriculture (CA) practices in the areas where SAA was promoting it.
II. To identify the determinants that influenced the farmers most to adopt Conservation Agriculture practices in the areas where SAA was promoting.
III. To identify the challenges and potential opportunities to adopt Conservation Agriculture Practices by smallholder farmers.

2.1 Scope and Area Coverage

The assessment sought to investigate the current farming practices implemented by the farming communities in light of the three Conservation Agriculture principles (Minimum tillage, mulching, and

crop rotation or crop diversification). The survey was conducted in 16 Kebeles across five Woredas in the Oromia and Amhara regions, where SAA had previously introduced CA. Six field technicians/enumerators conducted the survey after receiving a day long training and participating in a day long pre-testing of the assessment tools.

3. Methodology

3.1 Sample Size and Sampling Technique

Individual household surveys and Focus Group Discussions (FGD) with groups of 8 to 12 persons which were composed of young and elderly people, men and women were participated in the discussion. Individual households were chosen using a simple random sampling method, and a total of 400 smallholder farmers were interviewed with the help of Computer-Assisted Personal Interviews (CAPI). A two-stage sampling technique was used to select household respondents. First, community stratification approach was used with the participation and consultation of the community members and EAs by identifying SAA's CA intervention and non-intervention kebeles. Second, for individual interviews, sample respondents were drawn randomly from the selected kebeles.

Table 1: Number of sampled households by household type and kebele

Region	Woreda	Kebele	Household type		
			Non-CA Adopter	CA-Adopter	Total
Amhara	Bure	Wadra Gindiba	22	3	25
		Shakwa	23	2	25
		Alefa	23	2	25
		Jib Gedel	10	15	25
	Dangla	Gult	23	2	25
		Abadira	24	1	25
	Mecha	Angut	24	1	25
		Bachima	25	0	25
Oromia	Bako Tibe	Dembi Dima	23	2	25
		Seden Kite	25	0	25
		Terkanfeta Gibe	23	2	25
		Tulu Sengota	24	1	25
	Sibu Sire	Lelisa	15	10	25
		Bikila	22	3	25
		Cheri	23	2	25
		Felamo Yubdo	19	6	25
Total			348	52	400

Source: CA impact Survey, 2021

3.2 Data Collection and Analysis

For data collection, both structured and semi-structured questionnaires were designed and used to extract both qualitative and quantitative data from the different sources. Individual household surveys, Focus Group Discussion (FGD), and Key Informant Interviews (KII) were used to collect primary data. Five experienced enumerators were hired to collect the data from individual households after receiving a day long training on the assessment tools and CAPI operating system. The SAA M&E officer supervised the survey on a daily basis to ensure the quality and reliability of the data. Concurrently, the FGD sessions were facilitated by the experienced person hired by SAA.

Data quality management began while at the field, when the supervisor and enumerators randomly checked the data collected to ensure completeness, consistency, and plausibility. The information was gathered electronically via handheld devices created by the Census and Survey Processing System (CSPro) e-data collection tool development software. The data gathered through open-ended questions was cleaned, and frequency distributions and descriptive statistics were used to check for outliers as well as consistency and plausibility of the data entered. Before analysis, the data were cross-checked against the questionnaire.

Statistical Package for Social Science Studies (SPSS) data analysis software was used to analyze the data. In addition, Excel and Pivot Table analysis and visualization tools were used for graphical presentations of the results. Descriptive statistics and tabular presentations are also used for presenting the findings. A logistic regression analysis was employed to identify the determinant variable which influence farmers most to be adopter of the Conservation Agriculture (CA) practices as part of climate change adaptation measures. The farmers' participation in conservation agriculture is dependent variable which takes a value of 1 if the farmer was found with CA adopter and 0, otherwise. The basic model of the logit estimation (Gujarati, 2004) is described as follows:

$$\text{Odd Y} = \frac{p(Y=1)}{(1-p(Y=1))} \quad \ldots\ldots (1)$$

The binary logistic regression model is specified as follows (Equation (2)): The logit (Y) is given by the natural log of Odds;

$$\ln \frac{p(Y=1)}{(1-p(Y=1))} = \text{Log Odds} = \text{Logit (Y)} \quad \ldots\ldots (2)$$

This can be expanded as

$$P\ (Y=1) = \frac{1}{1+e^{-(b_0+b_1 x1i + \cdots + b_k x_{ki})}} \quad \ldots\ldots (3)$$

$$= \frac{e^{(b_0+b_1 x_{1i} + \cdots + b_k x_{ki})}}{1+e^{-(b_0+b_1 x_{1i} + \cdots + b_k x_{ki})}} \quad \ldots\ldots (4)$$

$$P\ (1\text{-}p(y=1)) = \frac{1}{1+e^{(b_0+b_1 x_{1i} + \cdots + b_k x_{ki})}} \quad \ldots\ldots (5)$$

By dividing (4) by (5) we get

$$\frac{p(Y=1)}{1-P(Y=1)} = e^{(b_0+b_1 x_{1i} + \cdots + b_k x_{ki})} \quad \ldots\ldots (6)$$

Where P is the probability that a household is participating in a Conservation Agriculture (CA) practices and 1-P is the probability that household is non participating in a CA practices and e is the exponential constant. The two computing models commonly used in the adoption studies are the probity and logit models. But the results obtained from the two models are very similar since the normal and logistic distributions from which the models are derived [11]. As a result, only the logit model is used even if both models could be employed for comparison purpose. Before estimating the model, test of multicollinearity was done among the hypothesized explanatory variables. Multicollinearity problem arises when at least one of the independent variables is a linear combination of the others [11]. The variance inflation factors (VIF) is also used to inspect the level of multicollinearity between the independent variables. If VIF is between 5 and 10, then collinearity is suspected, and if the value is reached to 10 and beyond, then high collinearity is existed.

The dependent variable, farmers' participation in conservation agriculture has a dichotomous nature which takes 1 if the farmer adopted CA practices and 0, otherwise. The probability of participation in conservation agriculture practices dependent on several socio-economic characteristics of the farmer. The explanatory variables used in the model include age of the household head, sex of the household head, education level of the household head, access to CA training, family size, land holding size, annual income of the household, ownership of oxen in TLU, ownership of total TLU, and. Therefore, the logistic regression model for this analysis is expressed with the following form:

$$\text{Logit (Adopter)} = \ln\left(\frac{p}{1-p}\right) = \alpha + b_1 Age + b_2\ Sex + b_3\ Education\ Level\ + b_4\ Access\ to\ CA\ training + b_5\ Family\ size + b_6\ Land\ holding\ size + b_7\ Annual\ income + b_8\ oxen\ TLU + b_9\ Total\ TLU.$$

Age is a continuous variable used as a proxy indicator for the adoption of CA.

It was hypothesized to be positively influencing the smallholder farmers to adopt CA practices with the assumption that the older was the farmers' age, the greater the greater the farmer to have knowledge and experience on the different agronomic practices, which eventually increased the likelihood of the farmer to apply CA practices. Gender was measured as a categorical variable (dummy) coded 1 if the respondent was male and 0, otherwise. The probability of CA adoption was expected to be higher among male smallholder farmers as they had more exposure to training and extension service than their female counter parts. Education level of the household head was a categorical variable which had four categorical groups. It was expected to have a positive relationship with the dependent variable, “CA adoption”, with which the greater the education level of the farmer took 1 if the farmer had training opportunity in CA agricultural practices, and 0, otherwise. It was expected to have positive relationship with the dependent variable, because the more the farmer trained, the greater the person had knowledge on the new practices to translated to practices.

Family size is a continuous variable which considered economically active members of the household as a determinant factor of CA adoption. The larger the family size with economically active members had a greater probability to adopt CA practices as they had more labour force to accomplish the different CA agronomic practices. Land holding size was expected to have a posetive relationship with the dependent variable, as the greater the farm size, the higher the number of labor force required to manage the farm land, and hence, farmers adopt minimum tillage agronomic practice that requires low number of labour force. Annual income of the household was a continuous variable calculated by the sum of all sources of household income. It was expected to influence the farmer positively to adopt CA practices. Number of oxen in TLU had been expected to have a negative influence to the farmers to adopt CA practices as the greater the number of oxen owned by the household, the greater the likelihood of the farmer to increase tillage frequencies. Total TLU ownership was also a continuous variable which was expected to have positive relationship with the dependent variable.

4. Results and discussion

4.1 Household Demographic Characteristics

This section presents the households demographic characteristics in terms of age, sex, family size and education level of the household head.

4.1.1 Sex and marital status of the household head

Majority of the respondents (96.3%) were male headed households in all survey woredas. Again, the vast majority of the sampled households were monogamous (95%) with a proportion of 85% in Bako Tibe and 95% in Sibu Sire Woreda, while in the other woredas 100% monogamous in their marital status, Table 2.

Table 2: Proportion of household head desegregated by Sex and marital status

		Bure	Dangla	Mecha	Bako Tibe	Sibu Sire	Total
Sex of the household head	Female	2	2	0	6	6	4
	Male	98	98	100	94	94	96
Marital status of the household head	Single	0	0	0	3	1	1
	Monogamous	100	100	100	85	95	95
	Polygamous	0	0	0	6	3	2
	Widower/widow	0	0	0	5	0	1
	Separated	0	0	0	1	1	1
	Divorced	0	0	0	0	0	0
	Total	100	100	100	100	100	100

Source: CA impact Survey, 2021

4.1.2 Age and family size of the households

The mean age of the overall respondents was 44, with the lowest mean age of 41 in Sibu Sire and 48 years in bure woreda. The average family size of all respondents was found to be 6, which is higher than the national average, 4.9 members in rural Ethiopia [12]. In all sampled woredas household size recorded above the national average with the highest being in Bako Tibe (6.7), followed by Mecha with (6.3), whereas Bure had the lowest family size (5.5) of all survey areas.

Dependency ratios were calculated based on the economic inactive household members with the age of below 15 and above 64 years. The average dependency ratio of all respondents was 45.3%, which is lower than the national average (76.8%). Dependency ratios were highest in Bako Tibe (51%) and lowest in Sibu Sire (41.2%) (Table 5). This would correlate with household size where the largest households expected to have either more dependent children or more elderly members.

Table 3: Mean age, household size and dependency ratio

	Woreda					
	Bure	Dangla	Mecha	Bako Tibe	Sibu Sire	Total
Mean age of the household head	48	43	45	42	41	44
Average household size	5.5	6.2	6.3	6.7	5.7	6
Dependency ratio	42.2	46.8	46.7	51	41.2	45.3

Source: CA impact Survey, 2021

4.1.3 Education level of the household head

Access to information through training and formal education is expected to enhance farmers' innovation capacity by creating effective demand for the adaptation and adoption of sustainable agricultural practices. Out of the total sample respondents, 75% attended some level of literacy either in formal or non-formal education. About 14% of the sample population had religious education while 61% of the population attended a formal education ranging from primary to tertiary level. Overall, the proportion of illiteracy is high in the Non-CA Adopters compared to the CA adopter farmers, which is 26.1% Vs 17.3% in proportion. The proportion of respondents above high school education level was also higher in the CA adopters (5.8%) compared to the non-adopters, which was accounted for 3.7%.

Table 4: Education level of the household head disaggregated by woreda

	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total		Overall
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	
Illiterate	32.1	22.7	34	0	38.8	0	17.9	0	17.7	19	26.1	17.	25
Adult education	24.4	22.7	17	33.	40.8	0	3.2	0	0	4.8	14.4	13.	14.3
Primary	35.9	50	42.6	66.	16.3	100	60	100	58.2	38.	45.7	51.	47.5
Secondary Education	7.7	4.5	6.4	0	4.1	0	12.6	0	15.2	23. 8	10.1	11. 5	10.3
Vocational	0	0	0	0	0	0	6.3	0	3.8	14.	2.6	5.8	3
Tertiary	0	0	0	0	0	0	0	0	5.1	0	1.1	0	1

Source: CA impact Survey, 2021

4.2 Household Socio-Economic Characteristics

4.2.1 Land use

The land use consists of agricultural land, settlement areas, home gardens, grazing land and wetlands. On average, farmers dedicated 1.62 ha of land for producing annual crops, whereas for livestock grazing and forest production they allocated 0.16 and 0.14 ha of land, respectively. The highest size of cultivated land per household was found in Sibu Sire Woreda followed by Bako Tibe and Bure Woredas, which accounted for 2.24 ha, 1.44 ha, and 1.44 ha, in that order, (Table 6). Overall, the average landholding size of the CA adopter farmers was found 2.35 ha of land while the non-adopters possessed 2 ha of land, on the average. The CA adopter farmers had relatively larger farm size with both in land ownership and rented-in scenarios. The largest landholding size of the CA adopters was found in Bako Tibe (3.28 ha) followed by Mecha and Sibu Sire woredas with an average landholding size of 3 ha and 2.96 ha, respectively. Whereas the smallest landholding size was recorded in Bure and Dangla Woredas with 1.61 ha and 1.8 ha, respectively, Table 7.

Table 5: Average land size in ha dedicated by the households for different purpose

	Woreda					
	Bure	Dangla	Mecha	Bako Tibe	Sibu Sire	Total
Own land (ha)	1.01	1.49	1.5	1.32	2.24	1.52
Rented-in land(ha)	0.61	0.51	0.49	0.41	0.59	0.53
Cultivated land(ha)	1.44	1.27	1.33	1.44	2.24	1.62
Grazing land(ha)	0.03	0.25	0.07	0.14	0.32	0.16
Forest land(ha)	0.04	0.38	0.44	0.03	0.1	0.14
Fallow land(ha)	0.01	0	0.01	0.01	0.05	0.02
Homestead(ha)	0.1	0.1	0.14	0.11	0.12	0.11

Source: CA impact Survey, 2021

Table 6: Average owned rented-in and total land size in ha by household type

	Non-adopter			Adopter		
	Own land	Rented-in land	Total land	Own land	Rented-in land	Total land
Bure	0.99	0.63	1.62	1.07	0.55	1.61
Dangla	1.51	0.55	2.06	1.21	0.58	1.80
Mecha	1.49	0.47	1.96	1.75	1.25	3.00
Bako Tibe	1.23	0.42	1.65	3.08	0.20	3.28
Sibu Sire	2.22	0.58	2.80	2.34	0.62	2.96
Total	1.48	0.53	2.00	1.80	0.56	2.35

Source: CA impact Survey, 2021

4.3 Conservation Agriculture (CA) Practices

4.3.1 Access to CA training

Access to training is the major factor for creating awareness and to change the mindset of the farmers so that to increase the adoption of the new technologies and agronomic practices. In this regard, farmers had access to training on CA practices despite the proportion varies from place to place, and between adopter and non-adopter farmers. Different development actors including governmental and non-governmental organizations on top of Sasakawa Africa Association have been providing the awareness raising training at different point in time for the past decade. Consequently, the assessment result showed that overall, 69.2% of the adopters and 50.3% of the non-adopter farmers had access to training on minimum tillage agronomic practices and their benefits. Moreover, 55.8% and 88.5% of the adopters had access to training on mulching and crop rotation agronomic practices, whereas only 18.1% and 71.3% of the non-adopters had access to training for it, respectively. In most of the assessment areas, capacity building training was not given to the farmers on cover cropping agricultural practices, and thus, only 30% and 10% of the adopter and non-adopter farmers had access to training on it across all

assessment woredas. Relatively, CA adopter farmers had better access to training on most of the CA practices in Mecha and Bure Woredas, Table 12.

Table 7: Proportion of farmers who had access to training on CA practices

	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
Minimum/zero tillage	57.7	59.1	38.3	90.0	57.1	99.0	40.0	80.0	58.2	71.4	50.3	69.2
Mulching	43.6	77.3	6.4	0.0	18.4	0.0	4.2	0.0	16.5	57.1	18.1	55.8
Crop rotation	88.5	95.5	68.1	66.7	85.7	100.0	50.5	80.0	72.2	85.7	71.3	88.5
Intercropping	79.5	95.5	44.7	33.3	30.6	0.0	47.4	80.0	50.6	52.4	52.6	71.2
Cover cropping	16.7	36.4	6.4	0.0	8.2	100.0	3.2	0.0	17.7	33.3	10.6	30.8
Crop residue	66.7	90.9	36.2	66.7	44.9	100.0	57.9	80.0	74.7	95.2	58.9	90.4

Source: CA impact Survey, 2021

4.3.2 Farmers' knowledge on different CA practices

For adults, training is an effective way to increase the cognition of new concepts [13]. Technical training is the most effective way to help farmers adopt new technologies after comparing measurements of the acquisition of new technology by farmers [14].

The involvement of farmer in-field training could significantly improve their technical understanding and practical abilities [15]. For adopting CA practice by smallholder farmers, in addition to Sasakawa Africa Association, other governmental and non-governmental organizations have been providing the awareness raising and knowledge enhancement trainings to the farmers in different point in time. This is therefore, the was oriented to know the level of farmers knowledge on the different CA practices. Accordingly, the result of the assessment revealed that 75% of the adopters and 68.4% of non-adopter farmers across all woredas had good knowledge on the concept and technical implementation of minimum tillage agricultural practice. Crop rotation was also very well-known by the farmers, which 94.2% of the adopters and 85.3% of the non-adopter farmers described very well both the technical

implementation and the use of crop rotation for enhancing the soil fertility as well as crop productivity. However, the concept and benefits of mulching and cover cropping agronomic practices were ailing to be known by most of the farmers. Thus, only 32.7% of the adopter farmers and about 11% of the non-adopters had knowhow on the concepts and benefits of cover cropping agricultural practice; similarly, 17% of the non-adopter farmers had knowhow on the concept of mulching, Table 12.

Table 8: Proportion of farmers who had conceptual knowhow about the different CA practices.

	Woreda											
	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
Minimum/zero tillage	56.4	59.1	76.6	100.0	89.8	100.0	63.2	100.0	68.4	81.0	68.4	75.0
Mulching	34.6	77.3	10.6	0.0	20.4	0.0	4.2	0.0	16.5	52.4	17.0	53.8
Crop rotation	94.9	100.0	95.7	100.0	93.9	100.0	71.6	100.0	81.0	85.7	85.3	94.2
Intercropping	79.5	100.0	53.2	33.3	26.5	0.0	49.5	80.0	58.2	57.1	55.5	75.0
Cover cropping	15.4	36.4	6.4	33.3	8.2	100.0	3.2	0.0	20.3	33.3	10.9	32.7
Crop residue	64.1	90.9	44.7	66.7	46.9	100.0	61.1	100.0	79.7	90.5	61.8	90.4

Source: CA impact Survey, 2021

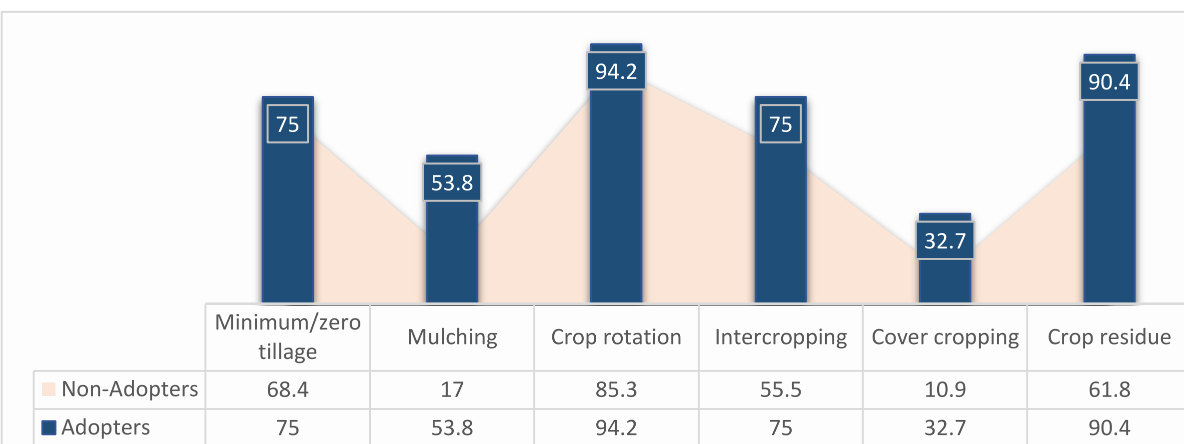


Figure 1: Proportion of farmers who had conceptual knowhow on CA agricultural practices

4.3.3 Adoption rate of CA by smallholder farmers

Table 14 depicts the adoption of CA agronomic practices by the smallholder farmers in the areas where this assessment was conducted. In this analysis, adoption of CA practice is considered if the farmer applied a particular CA practice on one or more of the production plots. Overall, Conservation Agriculture practices (minimum tillage, mulching and crop rotation/diversity) were adopted by only 13% of the sample households, on the average. Minimum tillage was practiced by 10% of the farmers while intercropping and crop rotation was adopted by 6.7% and 16.1% of the farmers, respectively.

The proportion of farmers who adopted minimum tillage farming practice was found good in Dangla and Bako Tibe woredas compared to the other assessment areas. According to the FGD discussions of the farmers, minimum tillage highly associated with weed infestation problem so that it required labor-intensive weed management efforts compared to conventional tillage practices. And thus, the adopter farmers applied herbicides such as glyphosate and roundup before starting land preparation as part of a solution for controlling the weed.

The type of CA practice that was hardly applied by the farmers was found to be mulching, which was adopted by only 2.2% of the farmers in the assessment areas. Mulching material is very scarce resources, and has a trade-off business between crop production and livestock feed, and thus farmers gave priority for livestock feed than mulching the farm land. In Addition, farmers are highly skeptical to leave residue on the farm plots as they believed that such practices were the cause for stalk borer infestation. Of all CA practices, relatively agro-forestry was adopted by a modest proportion of the farmers, which was 20.3% of the sample population, on the average. Perennial crops such as mango and coffee plantation were common in Bako Tibe and Sibu Sire in the annual crop production farm lands.

Table 9: Adoption of CA practices disaggregated by woreda

CA Practice		Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Minimum Tillage	No	475	97.7	120	78.9	151	86.3	296	84.8	363	91.0	1405	90.0
	Yes	11	2.3	32	21.1	24	13.7	53	15.2	36	9.0	156	10.0
Mulching	No	470	96.7	152	100.0	175	100.0	349	100.0	380	95.2	1526	97.8
	Yes	16	3.3	0	0.0	0	0.0	0	0.0	19	4.8	35	2.2
Intercropping	No	429	88.3	147	96.7	174	99.4	332	95.1	374	93.7	1456	93.3
	Yes	57	11.7	5	3.3	1	0.6	17	4.9	25	6.3	105	6.7
Rotation	No	348	71.6	125	82.2	174	99.4	329	94.3	333	83.5	1309	83.9
	Yes	138	28.4	27	17.8	1	0.6	20	5.7	66	16.5	252	16.1
Agro-forestry	No	404	83.1	127	83.6	167	95.4	269	77.1	277	69.4	1244	79.7
	Yes	82	16.9	25	16.4	8	4.6	80	22.9	122	30.6	317	20.3
Total	No	87	87	87	87	87	87	87	87	87	87	87	87
	Yes	13	13	13	13	13	13	13	13	13	13	13	13

Source: CA impact Survey, 2021

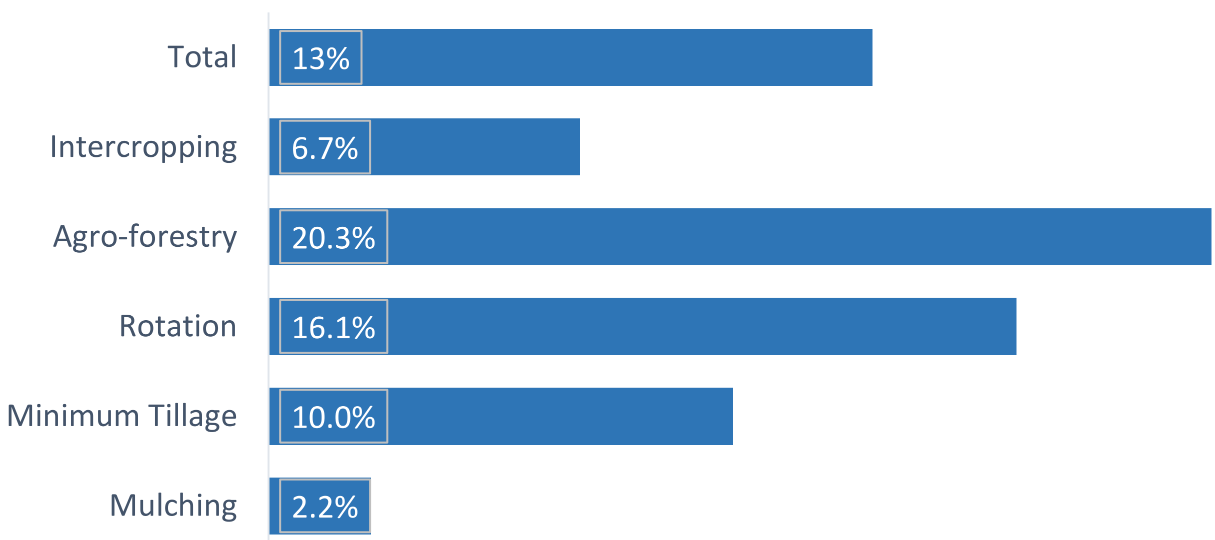


Figure 2: Adoption rate of CA practices by smallhoder farmers

4.4 Natural Resources Management Practices

Well-managed natural resources generate flows of benefits that provide the basis for maintaining and improving livelihoods, improve the quality of life, and contribute to sustainable growth. However, the combined effects of population growth, higher levels of economic activity per capita, and mismanagement are putting increasing pressure on the natural resource base. It also directly threatens the long-term growth of agricultural productivity, food security, and the quality of life, particularly in developing countries [16]. In this regard, the state of NRM activities was investigated in the areas where this assessment was conducted. In the study woredas, community-based soil and water conservation activities have been carried out in a mass mobilization of people every year during the agricultural slack time. In addition, sampled respondents to some extent implemented different soil and water conservation activities and agroforestry practices on their own lands (Table 17).

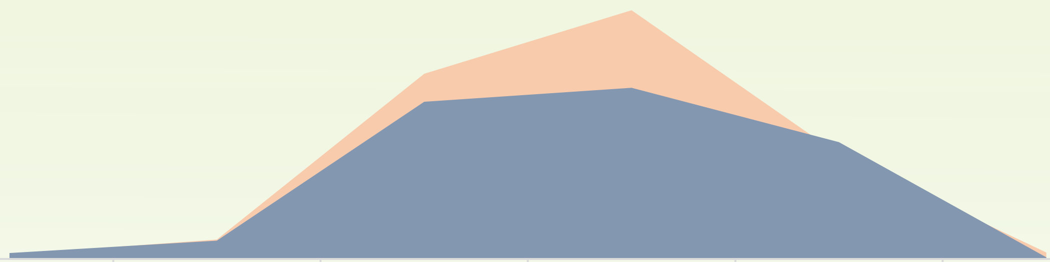
In this instance, of all sample respondents about 42% of the adopters and 32% of the non-adopter farmers constructed terraces for gully treatment on their farm lands.

The adopter farmers in Mecha, Dangela and Bure Woredas were found in a good proportion of the farmers who did terraces as part of gully treatment on their own farm lands with about 90%, 87.5% and 57% of the respondents, in that order. Overall, 34.4% and 29.2% of the adopter and non-adopter farmers constructed soil bunds, while only about 1% of the respondents in both groups constructed stone bunds. Similarly, biological NRM practices were found hardly adopted by the farmers in the areas where this assessment was conducted. Evidently, only 12% and 3.6% of the farmers in all areas have applied tree plantation and strip grass on bunds as part of a biological soil and water conservation mechanism. Tree plantation on boundaries were relatively done by a good proportion of the farming communities, which was adopted by about 19% of the farmers across all woredas.

Table 10: Proportion of CA Adopters and non-adopters who applied NRM practices

	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
Terraces	46.9	56.8	25.7	87.5	31.4	90	18.5	0	31.3	35.8	31.8	46.2
Soil bunds	32.2	41.5	44.4	37.5	37.3	0	24.3	45	19.1	25.3	29.2	34.4
Stone bunds	1.4	1.7	1.4	0	0.6	0	1.5	0	0.3	0	1.1	0.8
Trees on bunds	0.5	1.7	0	0	0	0	0	0	0.7	1.1	0.3	1.2
Trees on boundaries	18.5	14.4	29.2	0	17.8	0	18.8	35	27.3	25.3	21.7	19.4
Grass strips	4.6	5.9	7.6	0	5.3	0	1.8	0	0.7	2.1	3.4	3.6

Source: CA impact Survey, 2021



	Stone bunds	Grass strips	Soil bunds	Terraces	Trees on boundaries	Trees on bunds
Adopter	0.8	3.6	34.4	46.2	19.4	1.2
Non-adopter	1.1	3.4	29.2	31.8	21.7	0.3

Figure 3: Adoption rate of different NRM practices

4.5 Livestock production

Some literatures argued that the higher Tropical livestock (TLU) ownership has a positive relationship to the adoption of Conservation Agriculture practices while others debated as it has negative relationship. Animal ownership reduces the risks associated with adopting new practices such as crop rotation. There was, therefore, a positive relationship between the number of livestock and adoption [17] argued that livestock are a source of income and assets indicating the wealth status of the household, and it affects the adoption of soil and water conservation practices positively. In this assessment, the number of TLU ownership of the smallholder farmers was analyzed in comparison of the two groups: CA adopters and non- adopter farmers. TLU is commonly taken to be an animal of 250 kg live weights (Storck et al. 1991), TLU conversion factors that used in this study which is presented in Appendix Table 4. Generally, livestock was the second most important source of income for all households in the assessment areas.

However, the average number of Tropical Livestock Unit (TLU) owned by the households is different from place to place and between adopter and non-adopter farmers. Overall, the CA adopter farmers possessed 5.67 Tropical Livestock Unit (TLU) whereas the non-adopters had 5.72, on the average. Of all types of livestock, cow and oxen had the greatest share to the total TLU number. The highest number of TLU was owned by the adopter farmers in Bako Tibe Woreda with TLU number of 11.38, on the average. The number of cows and oxen have contributed for the high TLU ownership by the smallholder

households. To the contrary, the smallest number of TLU was owned by the adopter farmers in Bure Woreda, which was, on the average 3.93, Table 9. In terms of oxen ownership, overall, the non-adopter farmers had a greater number of TLU with an average number of 2.15 whereas the adopters had a TLU of 1.69, on the average. This indicated that the non-CA adopters had a greater number of oxen than the CA adopter farmers, which implies that the adopting of CA agronomic practices associated with shortage of draught animals.

Table 11: Number of TLU ownership by CA adopters and non-adopters by woredas

	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
COW	1.09	1.05	2.47	3.67	2.18	2.00	2.20	4.20	1.76	2.52	1.89	2.12
Oxen	2.03	1.50	2.34	2.00	2.35	2.00	2.32	3.20	1.82	1.48	2.15	1.69
Heifer	0.45	0.48	0.94	1.50	0.60	2.25	1.11	2.55	0.80	0.79	0.80	0.89
Calves	0.16	0.13	0.34	0.33	0.33	0.00	0.34	0.40	0.30	0.30	0.29	0.23
Small ruminant	0.12	0.13	0.25	0.54	0.12	0.18	0.03	0.12	0.05	0.05	0.10	0.12
Donkey	0.14	0.11	0.10	0.00	0.03	0.00	0.17	0.14	0.18	0.10	0.13	0.10
Horse/mule	0.16	0.50	0.61	1.47	0.54	0.00	0.28	0.66	0.18	0.26	0.31	0.47
Poultry	0.05	0.04	0.10	0.11	0.11	0.00	0.05	0.11	0.05	0.04	0.06	0.05
TLU	4.19	3.93	7.15	9.62	6.25	6.43	6.48	11.38	5.13	5.54	5.72	5.67

Source: CA impact Survey, 2021

4.6 Crop productivity and average land size of major crops

Crop production was the key farming activity adopted by the farmers for household food as well as source of income. Crop production had the biggest share of the total farming land of the smallholder farmers, and maize and tef were found to be the major crops grown by the farmers in three Woredas. Despite wheat was found the third major crop for the three woredas (Bure, Mecha and Sibu Serie), it was totally nor grown in the remaining two assessment woredas (Dangela and Bako Tibe). Of the total cultivated land, 40.9% was dedicated for maize production with an average size of 0.54 ha cultivated by each of the smallholder farmers while teff and wheat had a share of 13.4% and 7.1% of the cultivated land, in that order. Pulse crops such as soyabean and faba bean are also cultivated in some of the assessment areas a rotation crops for restoring the plant nutrients in the soil. In addition, coffee is an important cash crop especially in Bako Tibe and Sibu Serie Woredas, Oromia region. The overall productivity of maize was found to be 43. 3 quintal/hectare but it was 36.74 quintal/hectare for the CA adopter farmers and 43.93 quintal/hectare for the non-adopter farmers. Both the lowest and the highest average productivity of maize was reported by the adopter farmers in Sibu Serie and Mecha Woredas with 34.3 and 69.33 quintal/ha, respectively. Similarly, the lowest average productivity of wheat was found in Sibu Serie Woreda with 12 quintal per hectare while the highest was reported in Mecha Woreda with 36 quintal per hectare of land. The average productivity of wheat was found slightly lower with the CA adopter farmers than the non-adopters, but it is not statistically significant, Table 11. This is because, the CA adopter farmers not applied the three CA principles at a time (minimum tillage, soil cover/mulching, and crop diversity), rather they tried to minimize only the tillage frequency with no additional soil fertility management practices. Compost preparation and application, cover cropping, green manuring and/or lime application where poorly adopted by the farmers in most of the assessment areas.

Table 12: Average land size covered by the three major crops in different woredas

Crop Type	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total				Overall	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter		Adopter			
	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	%	Ha	%	Ha	%
Tef	0.30	0.25	0.24	0.25	0.33	0.13	0.33	0.50	0.52	0.46	0.39	13.0	0.37	15.4	0.38	13.4
Maize	0.39	0.45	0.50	0.53	0.47	0.75	0.50	0.82	0.72	0.72	0.53	43.5	0.66	27.5	0.54	40.9
Wheat	0.37	0.27			0.62	0.50			0.19	0.25	0.41	6.5	0.28	10.1	0.38	7.1

Source: CA impact Survey, 2021

Table 13: Average land size covered by the three major crops in different woredas

	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total		Overall
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	
Tef	11.83	12.67	7.92	2.00	7.27	14.40	10.02	9.50	5.98	5.82	8.67	9.04	8.74
Maize	49.43	35.77	40.75	36.00	44.07	69.33	46.28	49.43	36.94	34.13	43.93	36.74	43.17
Wheat	30.54	30.43			32.73	36.00			12.00	15.00	30.54	29.42	30.29

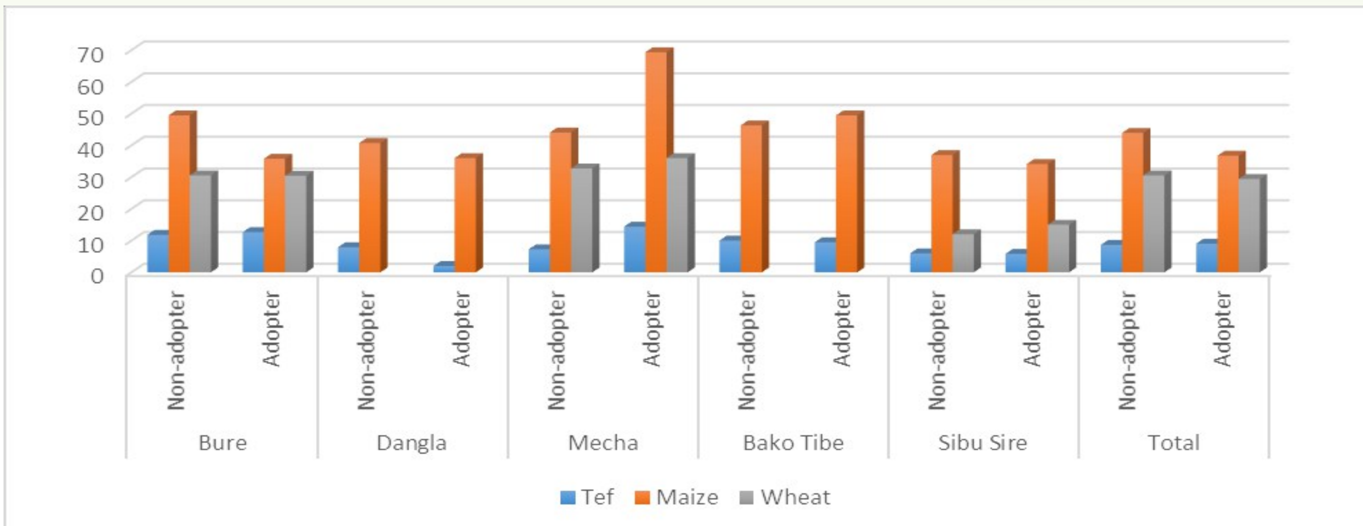


Figure 4: Productivity of major crops

4.7 Household income

Table 10 depicts the annual income of the farmers from different income sources. The average annual income of the CA adopters was found to be 56,500 Birr whereas the non-adopter farmers had 48,114 Birr. According to the result of the survey, crop sales was found the first source of income for smallholder farmers, which accounted for 54% and 57% of the total income of the for adopter and non-adopter farmers, respectively. Livestock was found the second major source of income for the non-adopter farmers which had a share of 21% of the household income. Whereas, for the adopter farmers it was perennial crops which brought the household income next to annual crop sales with a share of 19% of the total household income. The independent t-test result showed that statistically there is no significant difference between the average income of the CA adopter and non-adopter farmers with 0.05 significance level, Table 11.

Table 14: Average household income from different income source per year in Birr

Income source	Bure		Dangla		Bako Tibe		Sibu Sire		Mecha		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
Annual Crops	35618	25945	16089	26000	25195	38600	26901	33102	31483	61400	27574	30738
Perennial crops	4942	9280	368	0	2718	11000	4979	10905	13757	80500	4967	10936
Livestock	8383	11436	16159	48333	5768	2280	4785	2033	23458	24000	10025	9129
Trees/timbers	163	614	4383	0	784	0	220	438	3816	0	1430	437
Salary	26	155	638	0	478	0	1858	971	1245	5000	819	554
Casual labor	109	727	855	0	1356	0	471	1129	306	0	660	763
Off-farm income	399	682	840	10000	45	0	1506	690	539	0	633	1144
Non-farm income	701	455	3017	0	678	3000	1949	3938	306	0	1235	2071
Other income	500	923	481	0	657	1600	1416	457	657	0	770	729
Average	50841	50216	42831	84333	37678	56480	44086	53664	75567	170900	48114	56500

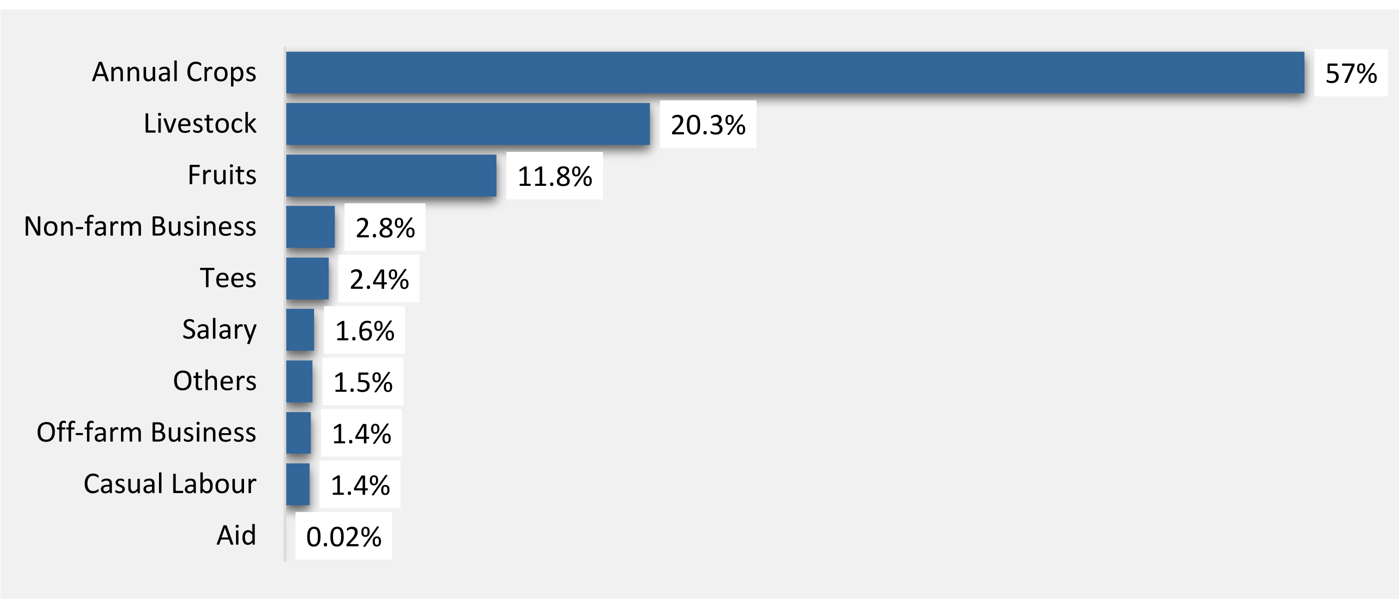


Figure 5: Share of household income from different income sources

The independent sample t-test analysis

A two-tailed independent t-tests at 5% significance level were carried out for continuous variables to test the mean value among the two groups (CA adopter and non-adopter farmers) whether or not a significance difference. Overall, six continuous independent variables were included in to the test statistics. Table 15 depicts the independent t-test analysis result of the continuous explanatory variables. The result revealed that Family Size and ownership of Oxen in TLU significantly differentiated the adopter and non-adopter group of farmers at 5% significance level. This indicated that there was significant difference between CA adopters and non- adopter farmers in their Family Size and number of Oxen ownership. The t- value for both of the two independent variables were found with negative coefficient. The remaining five variables (Age, Land holding size, Total income, Total TLU and number of Oxen TLU) were found with no significant difference between the mean vale of the two groups (CA adopter and non-adopter farmers).

Table 15: Independent sample t- test analysis table

Household type		N	Mean	Std. Deviation	t-value	p-value
Age	Adopter	52	43.62	12.825	-0.009	0.992
	Non-adopter	348	43.63	11.857		
Family Size	Adopter	52	5.52	2.397	-2.036	0.042***
	Non-adopter	348	6.12	1.920		
Land holding in ha	Adopter	52	4.6425	2.95879	0.528	0.598
	Non-adopter	348	4.2208	5.63682		
Total Income	Adopter	52	56500.23	42696.94	1.191	0.234
	Non-adopter	348	48113.86	48010.95		
Total_TLU	Adopter	52	5.6724	4.95524	-0.080	0.936
	Non-adopter	348	5.7177	3.61614		
TLU_OX	Adopter	52	1.6923	1.29158	-2.171	0.031***
	Non-adopter	348	2.1466	1.42389		

Note: *** significant at 5% significance level

Econometric Analysis

Table 16 presents the results of the binary logistic regression model which is used to determine the factors that significantly influence the adoption of Conservation Agricultural practices. The Hosmer-Lemeshow test was performed to test the goodness of fit, and the model was found with a good fit, confirming that the model fitted well (HL=4.346, p= .825). The model was tested for multicollinearity, and hence, the tolerance result of all explanatory variables was found to be > .5 and that of the variance inflation factors (VIF) were below 5, which indicated that multicollinearity was not suspected in the model (Hair et al., 2011). Overall, the explanatory variables were accurately explained with a rate of 85.8%.

Overall, the result of the model revealed that Access to CA trainings, number of Oxen in TLU, and Total TLU ownership were found statistically significant at 5% significance level in influencing the behavior of the smallholder farmers to adopt CA practices. In addition, Family size was found to be significant at 10% significance level. Annual income was found to be neither negatively nor positively related with CA adoption.

In this study CA adoption was found significantly influenced by access to CA training by the smallhoder farmers. Those who had access to CA trainings as part of extension service had a greater likelihood of adopting the CA practices by a factor 6.421 (odds ratio= 6.421) with a significance level of P= 0.000. This is because, access to training would enhance the awareness of the farmers which increased the confidence of the farmers to translated the new knowledge in to practice.

Ownership of Oxen in TLU was found with a negative relationship with the adoption of CA practices, and the ownership of an additional ox by the farmer would reduce the likelihood of adopting CA practices by a factor of .487, which is significant at 5% significance level with P= 0.001. As oxen is a useful tool for cultivating land, the lack of oxen ownership by the smallholder farmers would encourage to adopt CA practices compared those who had sufficient number of oxen.

Total TLU, on the contrary had a positive relationship with CA adoption. Farmers who had a greater number of TLU were found to be adopters of the CA practices compared with those who had less TLU. In this assessment, Total TLU ownership significantly influenced farmers to adopt CA practices by a factor 1.172 (odds ratio = 1.172) with a significant level P=0.013. This may be associated with the increasing access of animal manure which improved the soil fertility significantly and eventually would help to reduce tillage frequency and chemical use for production purpose.

Age of the household head was found to have a positive relation with the adoption of CA practices, which informed us as increasing age of the farmers the likelihood of adopting the

CA practices by the farmer is also increased. However, in this assessment it was not found to be statistically significant. Sex of the household head postulated to be a negative relation with adoption of CA practices, but not statistically significant. This is because, female headed households adopted the CA practice compared with their male counterparts. Female headed households usually either widowed or divorced in our country context and had limited active labour force and draught animals so that they inclined to adopt CA practices. Education level of the household head was found with negatively related with CA adoption though it was not significant. Total land size ownership had positive relation with CA adoption by the farmers, because as the land size owned by the farmers increased, it is difficult for them to do intensive tillage which required an increased human and animal labor. Farmers may also face limitation of financial resources to purchase chemical fertilizer for all of the farming plots to apply the recommended rate of chemical fertilizer, rather they would prefer to adopt CA practices.

Table 16: Binary logistic regression estimation model

Explanatory Variables	B	S.E.	Wald	Sig.	Exp(B)	VIF
Age of the household head	0.010	0.015	0.444	0.505	1.010	1.275
Sex of the household head	-0.509	1.081	0.222	0.638	0.601	1.054
Education Level of HH head						
Primary Education	-0.744	0.780	0.910	0.340	0.475	1.271
Secondary Education	-0.307	0.739	0.173	0.678	0.735	1.271
Tertiary Education	-0.328	0.813	0.162	0.687	0.721	1.271
Access to CA trainings	1.860***	0.346	28.837	0.000	6.421	1.018
Family Size	-0.146**	0.087	2.806	0.094	0.864	1.171
Total land size	0.019	0.025	0.610	0.435	1.019	1.050
Total Income	0.000	0.000	2.503	0.114	1.000	1.166
TLU_OX	-0.699***	0.203	11.876	0.001	0.497	1.496
Total_TLU	0.159***	0.064	6.107	0.013	1.172	2.811
Constant	-0.730	0.911	0.643	0.423	0.482	

*a*** = significant at 5% confidence interval*
*b*** = significant at 10% confidence interval*

4.8 Food security and living standard of households

Smallholder farmers using the CA minimum tillage practice of planting basins have reported an increase in crop yield [18]. This will enhance the income of farmers as well as the food security status of the households as it improves the food availability. The contribution of CA adoption on food security is also evident through increased number of meals per day,

increased per capita maize consumption and availability of food throughout the year among adopters [19].

This assessment also tried to investigate whether there is a food security differences between adopter and non-adopter farmers with certain proxy indicators. As a result, the comparative analysis revealed that overall, there is no difference between adopters and non-adopter farmers in terms of households' status in covering annual household consumption with own production. However, in Bako Tibe woreda the adopter farmers had more production to cover their annual household food consumption (100%) than that of the non-adopter framers which had reported only 89.5% of the respondents could cover the household annual food consumption with own production. In contrary, the adopter farmers in Sibu Serie woreda had less production to cover the annual household food demand compared to the non-adopter farmers represented by 85.7% of the adopters and 94.9% of the non-adopter farmers could cover their annual household food demand with own production. About 5% of the adopters in Sibu Sire, and 3.2% and 2% of the non-adopter farmers in Bako Tibe and Mecha woredas were under food aid program support some time now or in the previous years. There is also no significant difference between adopter and non-adopter farmers with related to household dowelling type with which 98.1% of the adopters and 98.6% of the non-adopter farmers had Iron sheet roof constructed with wooden wall houses.

Table 17: Food security status of households disaggregated by woreda and type of households

	Bure		Dangla		Mecha		Bako Tibe		Sibu Sire		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
HHs with enough production for annual consumption	100	100	95.7	100	93.9	100	89.5	100	94.9	85.7	94.5	94.2
HHs under food aid supports	0	0	0	0	2	0	3.2	0	0	4.8	0.9	1.9
HHs with all school age children are in schooling	89.7	90.9	93.6	100	81.6	100	81.1	100	69.6	76.2	82.2	86.5
HHs with grass roof & wooden wall doweling	0	0	0	0	0	0	2.1	0	3.8	4.8	1.4	1.9
HHs with Iron sheet roof & wooden wall doweling	100	100	100	100	100	100	97.9	100	96.2	95.2	98.6	98.1

Conclusions & Recommendations

- The analysis reveals notable variation in cultivated land size across woredas, with Sibu Sire exhibiting the highest average. Farmers practicing Conservation Agriculture (CA) consistently hold larger land areas than non-adopters, both through ownership and rental arrangements. This disparity highlights the potential of CA adoption to enhance land access and utilization, suggesting that targeted support for CA practices could play a pivotal role in improving agricultural productivity, fostering investment, and advancing sustainable land management strategies.

- Training access is key to CA adoption, with adopters-especially in Mecha and Bure-benefiting from greater exposure. Support from actors like Sasakawa Africa Association has helped, but gaps remain, notably in cover cropping, highlighting the need for more inclusive capacity-building.

- Training is essential for improving adult cognition and promoting adoption of agricultural innovations. Field-based support from groups like Sasakawa Africa Association has boosted understanding of CA practices. Farmers show strong knowledge of minimum tillage and crop rotation, indicating past training success. Yet, gaps persist in mulching and cover cropping, especially among non-adopters. These gaps hinder full adoption and impact of CA technologies. More targeted, inclusive training is needed to ensure comprehensive farmer uptake.

- Despite its benefits, CA adoption remains low, with only 13% of households practicing its components. Minimum tillage and crop rotation show modest uptake, especially in Dangla and Bako Tibe. Mulching is least adopted due to livestock feed needs and pest concerns. Agroforestry, through crops like mango and coffee, is gaining traction in Bako Tibe and Sibu Sire. These patterns reflect varied adoption influenced by local priorities and constraints. Tailored interventions are needed to address resource gaps and farmer perceptions for wider CA uptake.

- Natural resource management is vital for resilient livelihoods and sustainable agriculture. Community-based conservation efforts are active, but individual adoption remains uneven. Physical measures like terraces and soil bunds are moderately practiced in Mecha, Dangela, and Bure. Biological practices such as tree planting and strip grass are still limited. This reflects gaps in awareness, resources, and technical support. Scaling up NRM requires targeted training, resource access, and behavior change strategies.

- Livestock ownership influences CA adoption, but the relationship is complex. While TLU levels are similar across groups, non-adopters slightly lead in overall ownership. Oxen ownership is notably higher among non-adopters, hinting at

reliance on conventional tillage. CA adopters may use fewer draught animals due to minimum tillage practices. This shift suggests CA can suit farmers with limited access to oxen. Effective promotion of CA should consider local livestock dynamics and land preparation needs.

- Crop production, led by maize and teff, dominates smallholder farming across the assessment woredas. Despite its promise, CA adoption has not consistently improved yields, with adopters in Sibu Serie reporting lower maize productivity. This gap stems from partial CA implementation, mainly reduced tillage without key soil fertility practices. Neglecting mulching, composting, and crop diversification has limited CA's effectiveness. Integrated training that emphasizes the full CA package is essential for meaningful impact. Boosting farmer skills in soil management and tailoring agronomic support to local contexts will enhance productivity and resilience.

- CA adopters reported slightly higher annual incomes, mainly from crop and perennial production. Both groups relied on crop sales, but non-adopters leaned more on livestock for income. Adopters showed more diversified income streams, reflecting potential benefits of CA. However, statistical analysis found no significant income difference between the groups. This points to limited financial impact of CA without full practice adoption and market access. Strengthening complementary practices and linking farmers to markets is key to unlocking CA's income potential.

- The t-test analysis showed significant differences only in Family Size and Oxen ownership between CA adopters and non-adopters. Negative t-values indicate that adopters generally have smaller families and fewer oxen. Other variables like Age, Land size, Income, and Total TLU showed no significant variation. This suggests that CA adoption is influenced by specific household traits rather than broad socioeconomic factors. Understanding these nuances can help tailor interventions to support diverse farmer profiles.

- The logistic regression confirmed a strong model fit, with no multicollinearity concerns. Access to CA training was the most significant predictor, increasing adoption odds by over sixfold. Total TLU ownership also positively influenced adoption, likely due to access to organic inputs. In contrast, oxen ownership had a negative effect, aligning with CA's reduced reliance on draught power. Family size showed marginal significance, while other demographic factors were statistically insignificant. These results emphasize that knowledge access and resource availability drive CA adoption more than household demographics.

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Appendix

Appendix Table 1: Details of the sample size

Region	Woreda	Kebele	Household type					
			Non-adopter		Adopter		Total	
			N	%	N	%	N	%
Amhara	Bure	Wadra	22	88	3	12	25	100
		Shakwa	23	92	2	8	25	100
		Alefa	23	92	2	8	25	100
		Jib Gedel	10	40	15	60	25	100
		Sub-Total	78	78	22	22	100	100
	Dangla	Gult	23	92	2	8	25	100
		Abadira	24	96	1	4	25	100
		Sub-Total	47	94	3	6	50	100
	Mecha	Angut	24	96	1	4	25	100
		Bachima	25	100	0	0	25	100
		Sub-Total	49	98	1	2	50	100
Oromia	Bako Tibe	Dembi Dima	23	92	2	8	25	100
		Seden Kite	25	100	0	0	25	100
		Terkanfeta	23	92	2	8	25	100
		Tulu	24	96	1	4	25	100
		Sub-Total	95	95	5	5	100	100
	Sibu Sire	Lelisa	15	60	10	40	25	100
		Bikila	22	88	3	12	25	100
		Cheri	23	92	2	8	25	100
		Felamo	19	76	6	24	25	100
		Sub-Total	79	79	21	21	100	100
	Grand Total		348	87	52	13	400	100

Appendix Table 2: Average income in Birr

	Woreda											
	Bure		Dangla		Bako Tibe		Sibu Sire		Mecha		Total	
	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter	Non-adopter	Adopter
Sale of crops	37543	28540	16438	26000	27512	38600	28719	33102	37626	61400	29801	31967
Sale of livestock and	18683	14800	20527	48333	11658	5700	11117	7117	28736	24000	18076	16369

livestock products												
Sale of fruits, vegetables and coffee	14278	11342	2883		17213	13750	14049	45800	39651	80500	18585	20309
Sale of trees/timbers	3175	6750	20600		6773		5800	3067	20778		13449	4540
Salaried employment and/ or pensions	2000	1700	15000		7567		29352	20400	12200	5000	15008	7200
casual labor	2125	3200	13400		6779		7440	5925	15000		7178	4411
Income from off-farm businesses	10367	5000	9875	30000	1063		29750	7250	13200		12956	9917
Income from non-farm agribusiness	9117	5000	14180		5367	15000	15400	20675	5000		10485	15386
Remittances	6167	5250			3814	5000	8300		3500		5512	5167
Revenues from renting out land or house	6767		7533		4450		17600				8750	
Aid					9000				4400		5550	
Other	200	9800				3000		9600	1200		6100	7467

source									0			
Total	24631	15344	16637	36143	16649	20171	20249	23978	29861	42725	21114	20403

Appendix Table 3: Average land size in ha by household type

	Household type					
	Non-adopter			Adopter		
	Total owned land	Total owned land	Total land	Total owned land	Total owned land	Total land
Bure	0.99	0.63	1.62	1 7	0.55	1.61
Dangla	1.51	0.55	2 6	1.21	0.58	1.80
Mecha	1.49	0.47	1.96	1.75	1.25	3 0
Bako Tibe	1.23	0.42	1.65	3 8	0.20	3.28
Sibu Sire	2.22	0.58	2.80	2.34	0.62	2.96
Total	1.48	0.53	2 0	1.80	0.56	2.35

Appendix Table 4: Conversion factor used for standardizing all types of livestock

Animal Category	TLU
Calf	0.25
Donkey (young)	0.35
Weaned Calf	0.34
Camel	1.25
Heifer	0.75
Sheep and goat (adult)	0.13
Cow and ox	1
Sheep and goat (young)	0.06
Horse	1.1
Chicken	0.013
Donkey (adult)	0.7

Source: Storck et al. (1991)

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Walking with the Farmer