RESEARCH ARTICLE
Agricultural Science Digest, Volume 42 Issue 6: 703-709 (December 2022)

Challenges and Opportunities in the Adoption of Climate Smart Agriculture Practices by Smallholder Farmers in Ethiopia

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10.18805/ag.DF-443

ABSTRACT

Background: Climate smart agriculture (CSA) is an approach to increase farmers' income and agricultural production by adapting to the changing climatic conditions. Ethiopian agriculture is predominantly rain-fed and vulnerable to variability in rainfall and temperature. Adoption of CSA practices and technologies among smallholder farmers remains low.

Methods: This study was carried out in Ambo district, Oromia region, Ethiopia to assess the challenges faced by smallholder farmers in the adoption of CSA. A semi-structured interview schedule was used to collect data from 156 respondents from 3 rural villages.

Result: Crop residue management and mulching faced stiff competition with livestock feeding since crop residues are allowed for grazing by livestock. Hence, it is suggested to promote the cultivation of fodder grasses. Minimum tillage was practiced by only a few farmers in the study area. The farmers' belief on minimum tillage should be changed through proper education, training and result demonstration on the advantages of minimum tillage. The awareness of integrated nutrient and soil management should be enhanced by creating awareness of the benefits of soil testing.

Key words: Adoption, Challenges, Climate smart agriculture, Ethiopian agriculture, Opportunities.

INTRODUCTION

As per FAO (2010), Sub-Saharan Africa has more undernourished people and the population of Africa will be doubled by 2050. Hence, to feed approximately 20 million people added every year, the food production should attain 4.6 percent growth (Winn *et al.,* 2009). Crop production and food security are highly affected among the world's poor who are dependent on agriculture and living in the developing countries situated in tropical zones (Lipper *et al*., 2017). Agricultural production systems must become more resilient to increase productivity, stabilize output and income by the efficient use of natural resources and inputs in the production process (FAO, 2010).

Climate-Smart Agriculture (CSA) is an approach through which farmers can increase their income and agricultural production through adapting to the changing climatic conditions and contribute to the mitigation of greenhouse gas (GHG) emissions. Sustainably increase agricultural productivity and improve farmers' incomes, build resilience and adaptation to climate change and reduce and/or remove GHG emissions where possible are the three concepts in the CSA approach (FAO, 2018). Adoption of CSA improves the efficiency of the agricultural sector by establishing synergies among climate change mitigation, adaptation and food security (FAO, 2011) and better equipped to face climatic challenges.

Problem statement

Ethiopia's agriculture is particularly vulnerable to the impacts of climate change. Further, this is compounded by rain-fed, smallholder farming system, poor soil fertility, reduced soil organic matter, increased occurrence of acidified soils, poor water management practices, extreme poverty, low levels of preparedness to climate change effects and poor infrastructure in rural areas (FANRPAN, 2017). The resource-poor smallholder farmers who are the key producers contributing 95 per cent of the annual gross total agricultural output in Ethiopia (Taffesse *et al.,* 2012) have limited capacity to respond to climate variability and extremes (Wiggins 2009). The gross domestic product (GDP) may be decreased by 8-10 per cent in 2050 due to climate change effects. But, proper adaptation in agriculture reduces losses by half.

In Ethiopia, researches on CSA practices for various types of agro-ecological conditions, soil types, rainfall patternsand farming systems are lacking (Jirata *et al.,* 2016). Ethiopian government promoted the CSA-related efforts since a large proportion of the country's land area is degraded and the adoption of CSA practices and technologies among smallholder farmers remains low (CIAT, 2017). Several studies have been undertaken on CSA in

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How to cite this article: Dabesa, B., Mansingh, J.P., Haile, F., Nisha, A. and Lagese, W. (2022). Challenges and Opportunities in the Adoption of Climate Smart Agriculture Practices by Smallholder Farmers in Ethiopia. Agricultural Science Digest. 42(6): 703-709. DOI: 10.18805/ag.DF-443.

Submitted: 31-12-2021 **Accepted:** 18-04-2022 **Online:** 23-05-2022

Ethiopia that focused on the assessments of CSA, identified and documented the existing practices. Yet, the challenges and opportunities have not been closely identified and were given less attention. Hence, this study was tried to fill the research gap by focusing on practices, challenges and opportunities of CSA by smallholder farmers in Ambo district.

Theoretical framework

The concept of CSA focuses on sustainability through food security and ecological balance and resilient agriculture (Steenwerth *et al*., 2014). The changes in the climatic scenario have urged the need of the CSA practices, *i.e.* the agricultural activities restyled according to the changes in the climate focussing on food security and ecological balance (Capalbo *et al*., 2014) as a sustainable solution for feeding the exploding population. CSA can be defined along the three important parameters of effective natural resource management, food security and improved productivity that aids in increase in income (Fig 1).

The key concepts discussed here are the sustainable agricultural practices such as conservation agriculture, integrated nutrient and soil management, irrigation system, crop diversification, physical soil and water conservationand agro-forestry, CSA programs and policy related services and the financial prospects.

Taking these into consideration, this study explores the existing CSA practices, investigates the challenges in practicing CSAand identifies the opportunities to implement CSA.

MATERIALS AND METHODS

The study was conducted in the Ambo district, Oromia region, Ethiopia during 2018-19. A mixed research approach with qualitative and quantitative data collection methods was used. Cross-sectional survey research design was employed.

Out of 33 rural villages in the district, 3 rural villages *viz.,* Amaro, Gosu Qoraand Uko Qorke were purposively selected based on high agricultural adoption potential and the number of households practicing CSA practices. The number of household heads in the three chosen rural villages was fixed using probability proportion to size technique and the respondents were selected using simple random sampling technique. The sample size of 156 was determined by the Yamane (1967) formula.

A semi-structured interview schedule was designed to collect data. Besides, to complement the data collected through household surveys, the key informant interviews were conducted with 15 key informants selected purposively, six focuses group discussions (FGD) were held and personal observation was used. The data on the adoption of CSA practices were collected through the survey were analyzed with the help of simple descriptive statistics. The data on challenges and opportunities collected through qualitative data collection methods *viz.,* FGDs, key informant interviews and observation were categorized and presented under suitable headings.

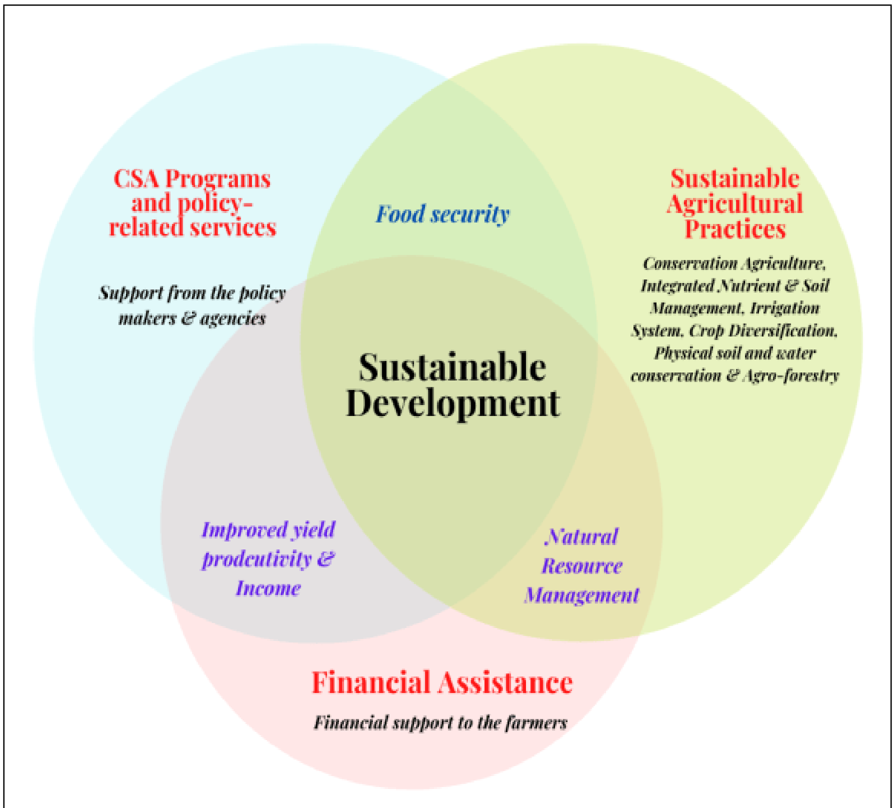

Fig 1: Conceptual framework of CSA.

RESULTS AND DISCUSSION

Profile of the respondents

It was found that majority of the households (73.00%) were male-headed, nearly half of the total respondents (48.10%) were primary educated and slightly more than half of the respondents (51.30%) were male. The average age was 41 years with mean farming experience of 20 years. The average family size was 5. Farming was the major occupation. The mean annual income was 18, 500 ETB (Ethiopian Birr).

The CSA practices followed by the farmers are explored and categorized under: conservation agriculture, integrated nutrient and soil management, irrigation system, crop diversification, physical soil and water conservation and agro-forestry.

Conservation agriculture

Conservation agriculture increases carbon sink in soil, helps to conserve soil and water, reduces nitrogen loss and thereby contributes to increased yield and more income (CIAT, 2015). Application of organic matter improves the availability of micronutrients to crops and is cost effective and environment friendly (Koireng *et al.,* 2018). Among the practices in conservation agriculture (Table 1), 'crop rotation' and 'using the crop residue to improve soil fertility' were practiced by 56.00 and 38.00 per cent of the farmers respectively, followed by intercropping, mulching and minimum tillage. Crop residues: act as a protective cover, improves infiltration and reduce splash erosion (Jirata *et al.,* 2016). Visalakshi and Sireesha (2015) studied the comparative economics of sowing methods and reported that the net income was more with a B:C ratio of 2.5 with zero tillage sowing. But, in the study area minimum tillage was practiced by only a few (10.50%) because farmers are practising repeated ploughing for generations to get rid of weeds thereby reducing the cost of herbicides. In the study area, the maize was intercropped with beans.

Integrated nutrient and soil management

'Compost and green manure application', 'Application of bio fertilizers' and 'Application of lime for lime soil management' were practiced by 21.80, 20.50 and 5.10 per cent of the respondents respectively (Table 1), Though application of lime is an established sustainable practice to ameliorate acidic soils (Holland *et al.,* 2018) the adoption was very low. Most of the farmers did not test the soil because of poor awareness and cost associated with soil testing.

Irrigation system

The irrigation sources available were shallow well, ponds, check damsand small streams, both private and community-owned, which helped the farmers to grow diverse crops like maize and vegetables.

Crop diversification

Slightly more than half of the respondents (55.00%) practiced crop diversification followed by 'use of improved seeds' (46.20%). High-yielding varieties were grown by 46.20 per cent of the respondents followed by short-duration

Table 1: Climate smart agriculture practiced.

Climate smart agriculture practices	Yes		No	
	Frequency	%	Frequency	%
Conservation agriculture				
Minimum tillage	17	10.50	139	89.50
Using crop residue	60	38.00	96	62.00
Mulching	21	13.50	135	86.50
Intercropping	41	26.20	115	73.80
Crop rotation	88	56.00	68	44.00
Integrated nutrient and soil management				
Compost and manure management including green manure	34	21.80	122	78.20
Efficient fertilizer application techniques	67	42.90	89	57.10
Applying bio-fertilizer	32	20.50	127	79.50
Applying lime for acid soil management	8	5.10	148	94.90
Irrigation system	49	31.00	107	69.00
Crop diversification	86	55.00	70	45.00
Using improved seed	72	46.20	84	53.80
Crop varieties				
1. Pest resistance	37	23.70	119	76.30
2. High yielding	72	46.20	84	53.80
3. Short season	47	30.10	109	69.90
Physical soil and water conservation	104	66.70	52	33.30
Agro forestry	98	62.80	58	37.20

Source: Survey data (2019)

and pest resistant varieties (Table 1). Crop diversification helps in reducing uncertainties and improves soil fertility (Lin, 2011). In the study area, farmers cultivated hybrid maize that increased production.

Soil and water conservation

Physical soil and water conservation practices were followed by 66.70 per cent of the respondents (Table 1). In the study area, deep trenching (Fig 2), stone bunding (Fig 3) and bund stabilization by planting different types of grasses such as Bana grass (Hybrid: *Pennisetum purpureum* × *americanum*), Elephant grass (*Pennisetum purpureum*), Desho grass (*Pennisetum pedicellatum*) and vetiver grass were practiced by the farmers. Stone bunds are stable and durable that can limit the runoff and soil erosion in steeply sloping areas and excess water can pass more easily through stone terraces (Teshome *et al*., 2014). Terracing was found to be an effective method according to the FGD farmers. Since it requires cooperative action among the farmers, the farmers were working in the community land by contributing free labor for 20 to 30 days a year. The long term terrace cultivation in acid soils positively affects the nutrients availability and lime requirements of the soil (Ram *et al*., 2015).

Agroforestry

Agroforestry was practiced by 62.80 per cent of the farmers in the study area (Fig 4 and 5). The commonly grown trees are *Grevillea robusta*, Lucern, *Acacia decurrens* and *Acacia albida*. Growing trees help the farmers in soil fertility management, improves micro-climate (if grown as intercrop) and help to improve carbon in the terrestrial ecosystem (Rocheleau *et al.,* 1988).

Challenges in the adoption of CSA practices

Inadequate integration of conservation agriculture

The FGD members mentioned that conservation agriculture practiced in the study area has been promoted mainly by NGOs. CSA is not adequately amalgamated into the existing agricultural advisory system of the district agricultural office.

Problem with Crop residue management and mulching

It was revealed during FGD that soil mulching and livestock feeding faced stiff competition. Even though incorporation of crop residues increases yield and grain quality (Almaz *et al.,* 2017) crop residues are allowed for grazing by livestock.

High input price

Inputs such as fertilizers and pesticides are expensive. Lack of money was the biggest challenge as the prices are beyond the reach of smallholder farmers. Seeds and implements such as ripper and direct seeder were not available. This result confirms the finding of Agbahey *et al.,* (2015). Many practiced the traditional way of mixing ash with water and sprinkling on the plants. Crop residues are burnt for this purpose, rather than using it as mulch.

Fig 2: Deep trenching.

Fig 3: Stone bunding.

Fig 4: and 5: Agroforestry practiced in farmlands.

Erratic rainfall

Irregular rainfall pattern was reported by almost all the farmers. The unpredictability of the weather was a major challenge.

Problems with using natural fertilizer

It was revealed through FGDs that the challenge in using manure is in the collection due to lack of systematic dung collection as the animals were led loose. The agricultural experts mentioned that training farmers to prepare compost from plant waste was recently started. The focal person of Sustainable Land Management Program (SLM) mentioned that the program was designed to focus on agroecological practices, including the use of natural fertilizers.

Lack of applying lime for acid soil management

It is vital to provide the crop nutrition in an integrated manner to maintain the overall balance, flow of nutrients, better productivity, ecological health, economics and sustainability (Prabhu *et al.,* 2018). The farmers mentioned that none tested the acidity of soil as it is expensive. Even if, they get low production they assume farmland as unproductive. Lack of awareness in identifying the problem of the soil, inadequate knowledge on soil testing and applying lime to reduce acidity and the high cost were the main challenges.

Lack of knowledge

The FGD members revealed that the major challenges were the lack of information about the availability and dissemination of knowledge about CSA. As reported by Farooq *et al.,* (2011), lack of information on the benefits of CSA components can hinder adoption.

Shortages of credit facilities

Lack of availability of credit service is an important challenge influencing the adoption of agricultural technologies, especially for farmers with limited financial resources for purchasing agricultural inputs and implements. Similar finding was reported by Daba *et al.* (2018) that the cost of inorganic fertilizers is getting expensive in Ethiopia. Hence, farmers could not afford to buy and use for crop production.

Land fragmentation

The FGD members mentioned that land fragmentation is a big problem. The land is traditionally split up into smaller entities among the siblings upon inheritance, which leads to a decline in farm size. There is a connection between higher population density and smaller farm sizes (Josephson *et al.,* 2014).

Opportunities of CSA

Institutional advisory services

Key informants revealed that most farmers had confidence in the advice given by the agricultural development agents and trusted because they viewed it as government-approved. Extension service is one of the strongest determinants of CSA adoption (Arslan *et al.,* 2014) because they are an important channel to spread knowledge and information among farmers (Ketema and Bauer, 2011).

Non-governmental organizations (NGOs)

NGOs like Integrated Soil Fertility Management (ISFM), Digital Green (DG), Crop Life Ethiopia are actively involved in conservation agriculture and integrated soil fertility programs in the study area.

Integrated soil fertility management

The main goal of ISFM is to increase agricultural productivity through capacity building on CSA related activities. According to key informants, ISFM has several projects in the study area such as vermicompost, compost, crop rotation, green manure and lime application to reduce the acidity of the soil and demonstrated these technologies in the FTCs. The above projects were implemented in the Ambo district on four watersheds each comprised of 50 farmers practicing on their farmlands. The ISFM supported the farmers by distributing fertilizers and improved seeds in the study area.

Digital green (DG)

DG is a global development organization working in the Ambo district. One of the DAs reported that DG builds the capacity of front-line workers which facilitated them to build the capacity of farmers using digital tools. DG facilitated the production and dissemination of relevant videos, enabling farmers to share knowledge with one another. It was revealed by the key informants that the support offered by DG through the digital tool Pico (handheld projector) was useful.

Fig 6: and 7: Agro forestry under SLM program.

Fig 8: and 9: Soil and water conservation practices under SLM program.
Source: Survey data (2019).

Crop life Ethiopia

Crop life Ethiopia trains farmers on integrated pest and weed management through cultural, biological and chemical measures.

Programs and policy-related services

Agricultural growth program (AGP) coordination units

AGP project aims to increase agricultural productivity and enhance market access in the study area through capacity building, providing inputs and demonstrating CSA practices in the training center.

Sustainable land management (SLM)

A government-sponsored SLM program implemented through the district agricultural office, gave training on integrated soil fertility management, water and soil conservation through terracing to prevent soil erosion and agroforestry to regenerate fertility and ecosystems. Key informants revealed that in SLM program II, CSA is adequately incorporated and includes practices that seek to increase agricultural productivity by strengthening farmer's resilience to climate change, reduce GHG emissions and increase carbon sequestration. SLM program II is providing skill training to DAs, farmers and other stakeholders. SLM program contributes to agroforestry (Fig 6 and 7) and water and soil conservation activities (Fig 8 and 9) especially by supplying seeds of indigenous trees and grasses.

CONCLUSION

Among the practices in conservation agriculture, minimum tillage and mulching were practiced by lower number of farmers. To reduce the input cost of herbicides farmers are repeatedly ploughing to get rid of weeds. This was carried out over generations in the belief that this eradicates weeds and increase soil fertility. But, it has been recognized recently that this can lead to reduction of soil organic matter in the long term and soils degrade under prolonged intensive agriculture. Tilling leads to the structural degradation of the soils that results in the formation of crusts and compaction, exposing the biological matter to wind and weather and ultimately leading to soil erosion and reduced agricultural productivity. This also causes carbon emissions from the soil, letting the carbon that has been fixating in the soil over time being released into the atmosphere. Hence, it is high time to change the farmers' belief on minimum tillage through proper awareness, education, training and result demonstration of the advantages of minimum tillage. In the study area, it was noticed that mulching was also practiced by a few farmers. The reason for this is that crop residue management and mulching faced stiff competition with livestock feeding. Crop residues are allowed for grazing by livestock. Hence, it is suggested to promote the cultivation of fodder grasses in the farmlands in areas susceptible to erosion and degraded lands as it arrests soil erosion and provides fodder for cattle. The application of lime for acid soil management was found to be very low in the study area. Lack of awareness among the farmers was the reason for not testing the soil in the laboratories. Hence, the awareness of integrated nutrient and soil management should be enhanced by creating awareness of the benefits of soil testing. The cost associated with soil testing should be reduced or removed through suitable sustainable government policies.

Conflict of interest: None.

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