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ASSESSING ADOPTION LEVEL OF CLIMATE SMART AGRICULTURAL PRACTICES AND TECHNOLOGIES AND THEIR CONTRIBUTION TO FOOD SECURITY OF SMALLHOLDER FARMERS IN ARTUMA-FURSI WOREDA, OROMO-SPECIAL ZONE OF AMHARA REGION, ETHIOPIA

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Abstract

Climate-Smart Agriculture (CSA) is a new agricultural approach designed to improve resilience and food security of farmers in the face of climate change. The study was thus intended to assess CSA adoption level and its contribution to food security of farmers in Artuma-Fursi Woreda, Oromo Zone of Amhara Region, Ethiopia. Two-stage sampling was used to select 259 households, from whom primary data were collected via cross-sectional household survey. Content analysis was used to identify farm level CSA Practices/Technologies (CSAPTs) with close examination of locally specific character of climate-induced food insecurity. Adaptation Strategy Use Index and Composite Score Method were used to assess CSA adoption level and classify households as Low/L, Medium/M and High/H adoption groups (AG). Household Food Balance Model (HFBM) was used to assess food security of households. An ordered Probit regression model was applied to assess factors influencing adoption level of CSAPTs. The study identified 30 CSAPTs. Results showed that Crop and Livestock Management were most frequently adopted, while the later 2 were least frequently adopted CSAPTs. Results also indicated that 22.8%, 32.8% and 44.4% of the households fall under HAG, MAG and LAG with a mean dietary energy scores of 1946.0, 1785.82 and 1692.84kcals/household/day. Results of the one-way between-groups ANOVA showed that the observed differences in mean dietary energy scores of the three adoption groups were larger than what would be expected by chance with $p < .05$ significant level. HFBM showed that 49.2% of HAG were in acceptable consumption category, in which only 4.7% of low adopters were found. On contrary, 64.7% of LAG were in poor consumption category, in which only 13.56% of high adopters were found, implying that increased level of CSA adoption had higher contribution to improve households' food security. Results of the ordered probit model indicated that membership in SACCOs, livestock ownership and education level of household head were significant explanatory variables determining CSA adoption level in LAG, MAG and HAG at 1%, 5% & 10% significant levels, respectively. Marginal effects estimated for the rest of variables were negatively related in LAG, while they were positively related in HAG, implying that increases in these variables make it less likely to find households in LAG and more likely to boost adoption in HAG showing potential entry points for future intervention.

Keywords: Adoption Level, CSA, CSAPTs, Household Food Balance Model

1 Introduction

The challenges of climate change, agricultural productivity and food security are now so inter-twined that any attempt to address them separately makes no sense anymore (World Bank, 2011 & HLPE, 2013). The different food security dimensions (mainly availability and access) and their inextricable links with climate change and agricultural production implies that business as usual will no longer address the inter-connected problems of climate change, smallholder agriculture and food security The strongly pronounced local needs to increase agricultural production and address food security challenges under the new realities of climate change has led to the introduction of the new concept of Climate Smart Agriculture—CSA (Lipper *et al.* 2014; FAO, 2010).

The CSA concept was first launched by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, when CSA was first defined with reference to its triple goals, namely increasing production (Food security), improving resilience (Adaptation) & reducing GHG emission (Mitigation) through efficient agricultural practices or technologies and institutional support systems (Lipper *et al.*, 2014 and UNFCCC, 2015). This does not mean every practice or technology applied in every location ought to produce these triple-goals because the relative importance of each varies depending on circumstances (Lipper *et al.*, 2014 and UNFCCC, 2015). For example increasing production (the food security objective) has been given the highest priority in Ethiopia over the goals of adaptation and mitigation (ATA, 2014) as it has been in many developing countries (Arakelyan, 2017 and FAO, 2016). Equally, smallholder farmers in Ethiopia are most interested in CSAPTs believed to increase production, and often reluctant to compromise short-run production losses over long- and medium-term adaptation or mitigation benefits (PIF, 2010). Therefore, it was of paramount to emphasize food security goal when assessing adoption level of CSAPTs in Ethiopian smallholder farmers' context.

The CSA approach is basically designed to reorient agricultural systems to adjust to new climatic conditions that periodically reverse production performance of smallholder agriculture and lead to increased food insecurity in rural areas (ATG, 2014), where large proportion (75%) of households' food requirement comes from own production (World Bank, 2011). The problem has been so serious in Oromo Special Zone of Amhara Region, a drought-prone area in Northeastern Ethiopia. Erratic rainfall, frequent droughts, flood and other weather extremes such as hailstorms and frosts have been major climatic predicaments liable for repeated production failures and resultant food shortages (Degefa, 2002). The study area, Artuma Fursi Woreda has no exception; it has suffered repeated droughts and crop failure due to extreme rainfall variability over the growing periods. As a result, over one-third of the farm households experience wide food shortage gaps (3 to 4 months) even in normal rainfall years. The area has also been recipient of food aid for significant period in past (Zone Statistical Bulletin, 2016/17; Degefa, 2005).

An empirical review made on previous studies indicated that some researches focused on assessing adoption level (Shames *et al.*, 2012 in Arakelyan, 2017; Affholder *et al.*, 2010; Meybeck and Gitz 2012), while others on factors affecting adoption level of CSAPTs (Tsega A. *et al.* 2018, FAO, 2016, W. Thiong'o, 2016, S. Uzamukunda, 2015, Arslan et al., 2014; McCarthy N. and Brubaker J., 2014). Findings showed that adoption level of CSAPTs remains low for its inherent complexity (Shames *et al.*, 2012 in Arakelyan, 2017) and multiple challenges as financial, infrastructural and knowledge, and weak policy and legislation (Tsega A., *et al.* 2018). A study by Zeleke, Bewket and Alemu (2010) indicated that most farm-level CSAPTs have low-to-medium adoption levels in Ethiopia. Only few studies assessed the effect of CSAPTs on food security (Maxwell *et al.* 2014; W. Thiong'o, 2016; Masakha, 2017; S. Partey et al., 2018) or using yield increment as a proxy for food security (Simret M. 2014; Richards et al. 2014 as in Arakelyan, 2017; McCarthy and Brubaker 2014; F. Maguza-Tembo *et al.* 2016). Results indicated that CSA is the way to a more resilient and higher agricultural productivity leading to improved food security, although a study by P. G. Abinye (n.d) concluded that adoption level of CSAPTs did not impact positively on food security of farmers in Uganda mainly due to lack of adequate institutional support systems.

The study is thus intended to assess adoption level of CSAPTs and its contribution to food security of smallholder farmers, and factors affecting adoption level of existing CSAPTs in the study area.

1.1 Conceptual Framework

Like other practical fields of science, a popular discourse in agriculture has limited shelf-life, since a combination of critiques and theoretical evolution drive scholars to adopt new terminology to describe their ambitions and visions for agricultural development. The language of green revolution of the 1960s and 1970s, through the participatory and environmental movements of the 1980s and 1990s, came to be associated with negative ecological consequences and as attention turned to seeing production growth in Africa a new discourse of sustainable intensification became popularized in the 1990s. Reflecting to the growing prominence of climate change within environmental agendas and need for attention to be paid to adaptive capacities within agricultural production to environmental change, the paradigm of Climate Smart Agriculture that was brought into popular use by UN FAO in 2010, has become the well-established usurper of its predecessors (Pretty *et al.*, 2011).

The CSA concept emerged at a moment in time of considerable controversy around the concept and approaches to sustainable agriculture, and when the specificities of agriculture and its role in food security were not well articulated in climate change policy process. It is put forward as a solution to the challenges of climate change and food insecurity focusing on achieving increases in agricultural production, improved resilience or adaptation to climatic change and reductions in agricultural GHG emissions. Nowadays, these three pillars of CSA have not only become well established, but have also driven major research agendas. In practice, CSA is a call for a set of actions by decision-makers from farm to global level, to enhance the resilience of agricultural systems and livelihoods and reduce the risk of food insecurity in the present as well as future (FAO, 2013; Lipper *et al.*, 2014).

Given the above background, IPCC's 2014 Climate Resilient Transformation Pathways adopted for agriculture was thus modified to illustrate the conceptual framework of the study (Figure 1).

Agriculture, smallholders sub-sector in particular has faced a set of biophysical and socioeconomic stressors, including climate change. Actions taken at various decision points in the opportunity space determine which pathway to follow. The opportunity space refers to decision points & pathways that lead to a range of possible futures with differing levels of resilience and risk. Decision points result in actions or failures to act throughout the opportunity space at present constitute the process of managing or failing to manage risks related to climate change. Within the opportunity space, CSA leads to a more resilient agriculture through increasing scientific knowledge, effective adaptation and mitigation measures, and other choices that reduce risks, whereas pathways that lower resilience of agriculture can involve maladaptation, insufficient mitigation, and other actions that lower resilience; and that can be irreversible in terms of possible futures.

As a climate resilient development pathway, CSA aims to transform farming systems to address the dual challenges of climate change and climate-induced food insecurity through increased/sustained agricultural production and income, while reducing agricultural GHG emissions, which will lead to high resilient and low risk future. In contrary, the pathways that lower resilience also described as business-as-usual potentially involve maladaptation and insufficient mitigation resulted from failure to learn and use knowledge, will lead to low resilient and high risk future in terms of climate change, agricultural production and food security (IPCC, 2014).

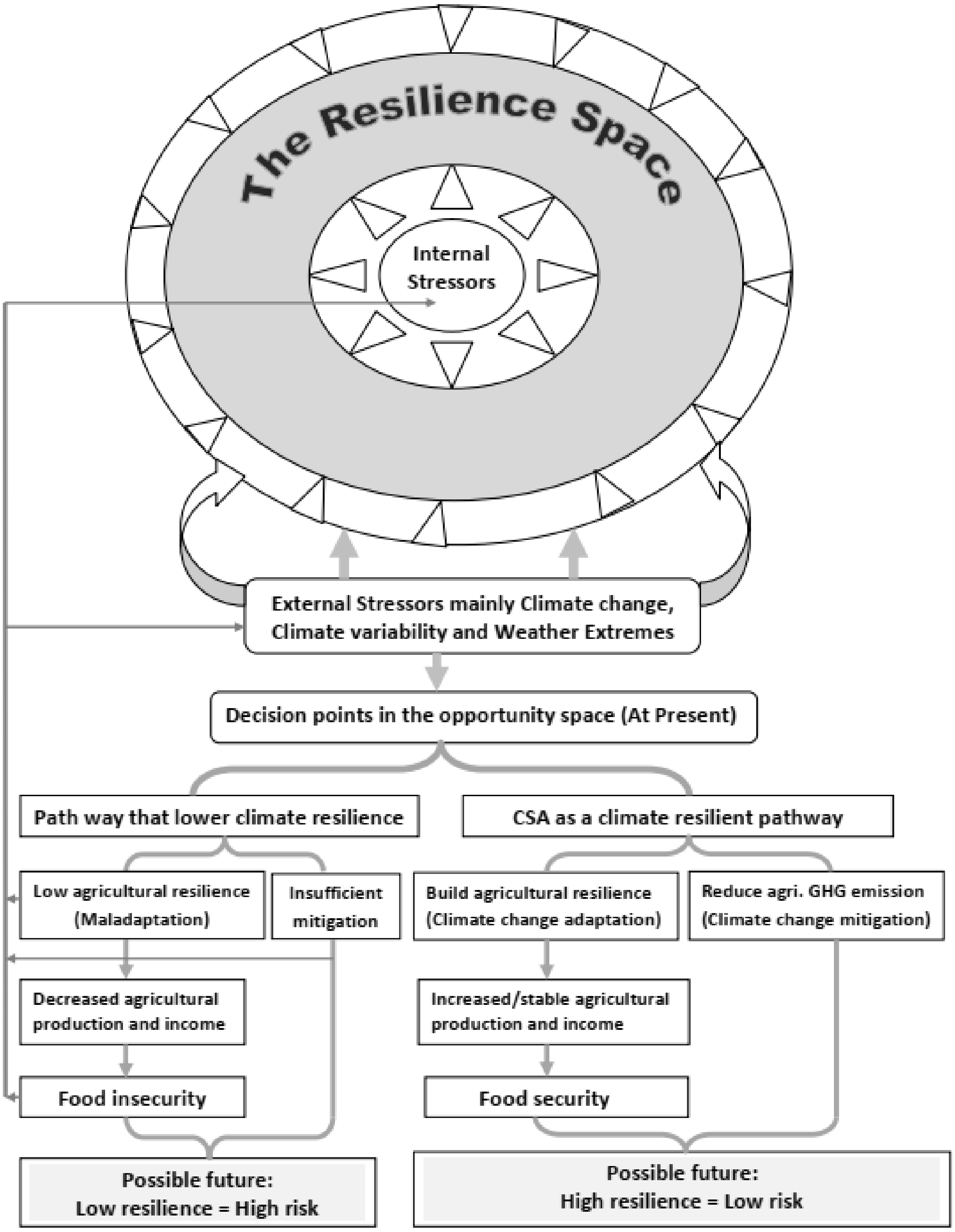

Figure 1. The Conceptual Framework of the Study (Adapted from IPCC's CRTPA, 2014)

2 Materials and Research Methods

2.1 Description of the Study Area

The study was conducted in Artuma-Fursi Woreda, one of the seven (7) administrative Woredas that form Oromo Special Zone of Amhara region, Ethiopia. Relatively, the area is bordered by Semen Shewa zone in the west, Afar regional state in East, Dawa Chefa Woreda in North and Jille Tumuga Woreda in South. The Woreda center, Chefa Robit town is located approximately 300*km* North of Addis Ababa, the federal capital and 560*km* East of Bahir Dar, the regional capital along the main asphalted road from Addis Ababa to Dessie, capital of South Wollo zone in North (WFEDO, 2009/2010).

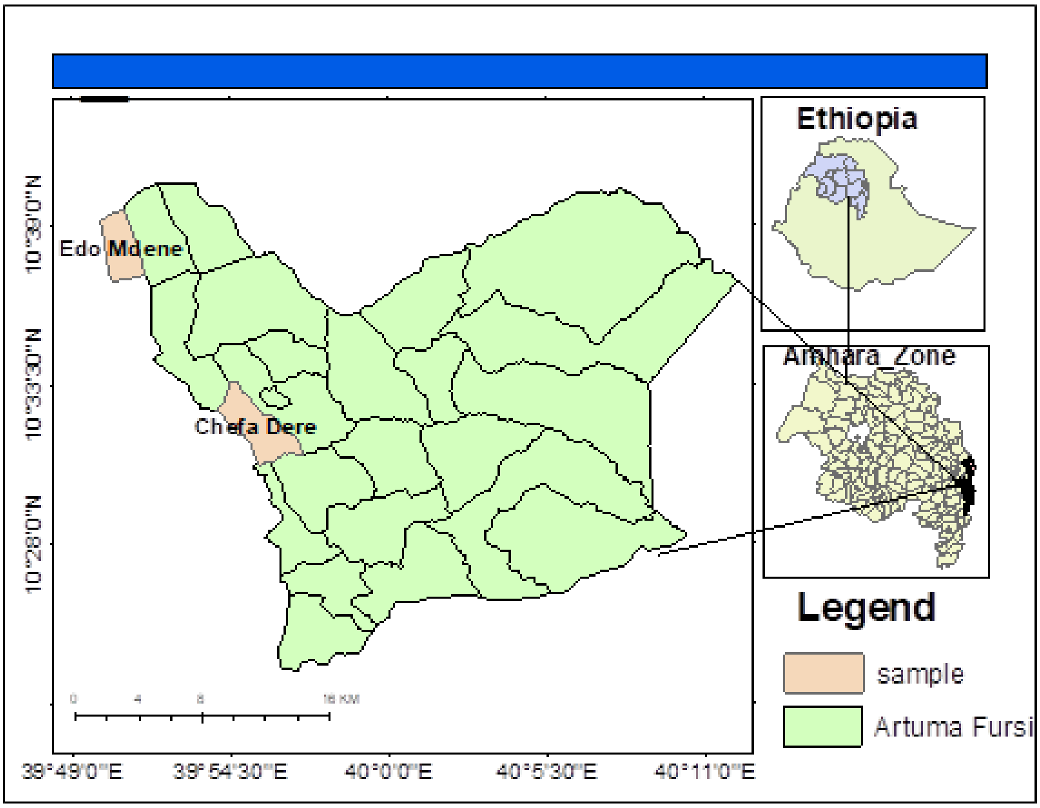

Figure 2. Map of the Study Area

The Woreda experience a uni-modal rain with the main rainy season (Kiremt) occurring between July and September. Total annual rainfall varies from 600-900mm, with high annual and seasonal variability. The annual temperature varies between 15$°C$ and 33$°C$ with a mean value of 21.2$°C$ (Zone DFED, 2007-2017, WFED Office, 2017). The altitude of the Woreda ranges from 1500-2100m asl. According to local climatic classification, about 76% of the Woreda is classified under Kolla agro-climatic zone, while the rest 24% is Weinadega. As to the latest projection (2018), the total population of the Woreda is about 109681 of which about 90% are rural. The total area of the Woreda is 108396 hectares, of which forest and bushlands, grazing land, cultivated land and the land used for construction and other purposes account 62.9%, 18.4%, 10% and 7.8%, respectively. Current Woreda administrative structure is organized in 1 urban and 24 rural Kebeles (WFEDO, 2017/18).

2.2 Sampling Procedures and Sample Size Determination

A two-step sampling method was used to select sample Kebeles and households. Firstly, two rural Kebeles namely Chefa-Dire and Edo-Medene were selected purposely as they were confirmed to be information rich cases in terms of practicing a wide range of CSAPTs. Next, a proportional-random sampling method was employed to select 259 sample households as determined by Kothari (2004):

$$n = \frac{(Z^2 * p * q * N)}{(e^2(N-1) + Z^2 * p * q)}$$

Where,
n is size of sample;
p is proportion agreeing (0.5),
q is 1˘p (0.5);
Z is the value of the standard variate at a given confidence level (1.96);
e is the desired margin of error (0.05), and
N is total population (2230).

Finally, the sample size was calculated to be 259, of which 170 households were selected from Chefa-Dire and 89 households from Edo-Medene from a total sampling frame of 999 households (Chefa-Dire 616 and Edo-Medene 383) using systematic sampling technique.

2.3 Data Collection Methods

The study employed a survey design in which a comprehensive cross-sectional survey questionnaire was prepared to collect the primary data as per the required formats of the different methods used to analyze the data and achieve the objectives. Secondary data were collected from official records and books and journal articles to supplement the primary data collected through the household survey.

2.4 Methods of Data Analysis

Descriptive (mean and composite index scores, and frequency and percentage distribution tables) and inferential (one-way ANOVA and an ordered Probit regression) statistics were used to analyze the data.

2.4.1. Adaptation Strategy Use Index (ASUI)

After a critical identification of existing CSAPTs through content analysis and close examination of local farming practices, a descriptive statistics described by Adesoji and Famuyiwa (2010) in Ojoko *et al* (2017) as Adaptation Strategy Use Index (ASUI) was used to determine the extent of adoption of the identified CSAPTs in the study area as measured by the number of farm households adopting them and their frequency of use as measured by a Four-Point Likert Scale with 3, 2, 1 and 0 for Frequently, Occasionally, Rarely and Not adopted CSAPTs, respectively. The index was expressed mathematically as follows:

$$ASUI = \frac{(N_1 \times 3)+(N_2 \times 2)+(N_3 \times 1)+(N_4 \times 0)}{M}$$

Where:

N_1 = Number of farm households frequently adopt a given CSAP

N_2 = Number of farm households occasionally adopt a given CSAP

N_3 = Number of farm households rarely adopt a given CSAP

N_4 = Number of farm households do not adopt a given CSAP

$M = n$ x 3, and

n = Sample size

2.4.2: Composite Score Method

A Composite Score Method was used to assess farm households' adoption level of existing CSAPs. The resulting composite scores calculated for sample households was used to stratify them in to three adoption groups, namely high, medium and low adoption groups based on the number and frequency of adoption of the identified CSAPs by the sample farm households as applied in the ASUI above. The composite scores ultimately range from 0 to 90, representing hypothetically households adopting none of the identified CSAPs and households adopt frequently all the identified CSAPs, respectively. Afterwards, the sample households were placed in their respective groups as applied by Salimonu (2007), cited in Adepoju *et al.* (2011):

- High adoption group = Composite scores from 90 to (mean + S.D]
- Medium adoption group = Composite scores from (mean + S.D) to (mean – S.D)
- Low adoption group = Composite scores from [mean – S.D) to 0

2.4.3. Household Food Balance Model (HFBM)

Household Food Balance Model (HFBM) initially modified form the Regional Food Balance Model (Degefa, D. 1996 and 2002) was used to assess households' food security status. The rational for using HFBM was that net availability of enough food for a rural household in Ethiopian context and its capacity to acquire food from the market determines its food security status. According to Degefa,

D. (2000 & 2005), households own production is a crucial determinant of the two critical food security components (availability and accessibility) in the Ethiopian context. World Bank (2011) further indicated that about three-fourth (75%) of the household food requirement comes from smallholders' own production.

The model was used to estimate adult equivalent per capita daily kilocalories available for household consumption. The structured survey questionnaire module was made to include questions prepared to call for the data required to capture the net per capita kcal grain available for households over a period of twelve months in the given production year, except for the 5% (Mesay, M. 2001) and 10% (Degefa, 2002) estimates given for the total seed reserve and post-harvest loss, respectively in cases where sample households fail to make their own estimations on these indicators. The model was expressed mathematically as follows:

$$N_{ij} = (C_{ij} + P_{ij} + B_{ij} + F_{ij} + R_{ij}) - (H_{ij} + S_{ij} + M_{ij})$$

Where,

N_{ij} is the net food available for household i in year j

C_{ij} is the total crop produced by household i in year j

P_{ij} is total grain purchased from market by household i in year j

B_{ij} is the total food household i borrowed in the year j

F_{ij} is the total grain received from FFW by household i in year j

R_{ij} is the total relief food received by household i in year j

H_{ij} is post-harvest losses out of total output produced by household i in year j

S_{ij} is amount of grains utilized for seed by household i in year j

M_{ij} is total grain marketed (sold out) by household i in year j

After computing the balance for each grain kind, conversion of the net available grain into dietary calorie equivalent was worked out based on Ethiopian Health and Nutrition Research Institute's food composition table. Next, the calculated per capita calorie was compared against the recommended minimum daily caloric requirement for a moderately active adult (2100$kcal$) to figure out the dietary caloric status of the sample households. The amount of calories a person needs depends on many factors, yet the household size that was obtained from head count of all household members was converted into adult equivalence as derived from Stock *et al.*, (1999) to assess adult equivalent per capita daily kilocalories and net grain available for household consumption based on the recommended minimum daily caloric requirement (2,100$kcal$).

2.4.4. One-Way between-Groups Analysis of Variance (ANOVA)

A one-way between-groups ANOVA statistics was used to determine the casual links between farm households' adoption level of CSAPTs and their food security status as measure by the HFBM.

2.4.5. Ordered Probit Regression Model

Finally, since the dependent variable, households' CSA adoption level, assume a natural ordering as Low (Y = 0), Medium (Y = 1) and High (Y = 2) adoption groups as derived from the Composite Score Method, an ordered Probit regression model was used to assess socioeconomic determinants of adoption level of CSAPs among smallholder farm households in the study area. The ordered Probit model was expressed as:

$$Y_i^* = \chi' \beta + \varepsilon_i$$

Where,

Y_i^* is the unobserved discrete random variable ($Y\mu_{0,1,2}$),

χ_i is the vector of independent variables,

β is the vector of parameters of the regression to be estimated,

ε_i is the vector of error term (Greene, 2003).

In this study therefore, the observed ordinal variable Y_i takes discrete values as $Y = 0$ if $Y^* \leq \mu_1$; $Y = 1$ if $\mu_1 < Y^* \leq \mu_2$ and $Y = 2$ if $Y^* > \mu_2$.

To this end, eleven socioeconomic factors assumed to influence smallholder farmers' adoption level of CSAPs in the study area were defined and then tested as explanatory variables for the ordered Probit regression analysis. STATA version 13 and Microsoft excel spreadsheets were used to manipulate the database and perform all statistical analysis.

3 Results and Discussion

3.1 Type of CSAPTs and Extent of Adoption

The study identified some thirty CSAPTs adopted in the study area with significant variations in the number of farmers adopting them and their frequency using the identified CSAPTs. Some of these CSAPTs were recently introduced, while others have long been part of the traditional subsistence mixed farming system in the study area. These CSAPTs were organized into five major categories, namely Crop Management, Livestock Management, Soil and Water Conservation, Agroecological Practices and Integrated Food-Energy Systems. Summary of the identified CSAPTs in each category, number of adopters and their frequency of adoption, proportion as per cent of the total, as well as adoption extent of each CSAPT in the study area was presented in Table 1 below according to their rank orders as determined by ASUI.

Results in Table 1 indicated that Crop Management (30%) and Soil and Water Conservation (33.3%) Practices together account nearly two-third (63.3%) of the total CSAPs adopted by farmers in the study area, while Livestock Management Practices account 16.7%. Relatively, the number of Agroecological Practices and Integrated Food-Energy Systems were few accounting only 10% each.

As can be seen from Table 1 use of improved crop varieties, alley cropping of cereals, applying fodder conservation and mechanical weed control methods, and use of conservation tillage were the five most widely adopted CSAPs in the study area taking on from the 1st to 5th rank orders as listed. Whereas, production and use of biogas, integrating trees in croplands, precise application of chemicals, beekeeping and use of improved breeds were the least adopted CSAPs in the study area taking on from 30^{th} up to 25^{th} ranks in their order. Thus, Crop Management, Livestock Management and Soil and Water Conservation Practices were widely adopted CSAPTs, while Agroecological Practices and Integrated Food Energy Systems were least adopted CSAPTs in the study area with slight variations in average number of adopters in both cases as shown in Figure 2.

Studies conducted in various places across developing countries including Ethiopia indicated that biogas digesters have shown to reduce fuel consumption within households by up to 40% that would provide a triple win strategy for income, health, and mitigation (AgriFin, 2012). Yet, survey results and secondary statistics indicated that farm households in the study area did not mention it almost at all. As such, adoption level of biogas production and use remained the least ($30th$ rank) in the study area. A key informant at the district agriculture and natural resource office described the reason for this particular case as:

> *“. . . the least biogas adoption level observed in our locality did not emanate from lack of awareness on the multiple benefits of using biogas energy, but due to the high capital investment initially required and the fact that government is the sole promoter and provider of the package of services required to install biogas plants and use the energy obtained from their operation”*

Table 1. Type of CSAPTs and the Extent of Adoption in the Study Area

No.	Type of CSA practices and technologies	No. of adopters	Percent (%)	Frequency of adoption (Number)				ASUI	Rank
				Frequently	Occasionally	Rarely	Not		
1.	**Crop Management Practices**								
1.1	Use of improved crop	248	95.6	196	37	15	11	0.8713	1st
1.2	Change planting dates	176	68.0	32	123	21	83	0.4672	10th
1.3	Apply contingent planting via early maturing varieties	111	42.9	34	44	33	148	0.2870	15th
1.4	Alley cropping of cereals	227	87.6	150	70	7	32	0.7683	2nd
1.5	Precise fertilizer application (type, timing, amount)	101	39.0	13	36	52	158	0.2098	19th
1.6	Precise application of chemicals (timing, quantity)	41	15.8	2	5	34	218	0.0644	28th
1.7	Apply organic fertilizer-compost, animal/green manure	106	40.9	5	35	66	153	0.1943	20th
1.8	Apply mechanical weed control	228	88.0	57	146	25	31	0.6281	4th
1.9	Apply on-farm diversification	171	66.0	18	114	39	88	0.4131	12th
2.	**Livestock Management Practices**								
2.1	Use of improved breeds	59	22.8	6	32	21	200	0.1326	26th
2.2	Diversify livestock species	176	68.0	80	88	12	83	0.5508	7th
2.3	Keep more resilient species	88	34.0	18	24	46	171	0.1905	21st
2.4	Apply fodder conservation	215	83.0	152	56	7	44	0.7400	3rd
2.5	Use cut and carry feeding	178	68.7	37	118	23	81	0.4762	9th
3.	**Soil and Water Conservation Practices**								
3.1	Use small-scale irrigation	88	34.0	30	34	24	171	0.2342	18th
3.2	Use in situ water conservation	179	69.1	41	132	6	80	0.5058	8th
3.3	Use conservation tillage (reduced, minimum tillage)	171	66.0	135	26	10	88	0.6010	5th
3.4	Mulching (stubble retention and planting cover crops)	160	61.8	43	106	11	99	0.4530	11th
3.5	Apply crop rotation	194	74.9	78	106	10	65	0.5869	6th
3.6	Intercropping	67	25.9	13	44	10	192	0.1763	24th
3.7	Strip cropping	82	31.7	6	18	58	177	0.1441	25th
3.8	Leave vegetative strips or construct Fanya juu	120	46.3	70	44	6	139	0.3912	13th
3.9	Reinforce conservation structures with grasses or trees	114	44.0	60	40	14	145	0.3526	14th
3.10	Establish live barriers on farm boundaries and hedges	62	23.9	30	20	12	197	0.1828	22nd
4.	**Agroecological Practices**								
4.1	Integrate trees in croplands	15	5.8	10	3	2	244	0.0489	29th
4.2	Plant trees around croplands	80	30.9	50	20	10	179	0.2574	16th
4.3	Practice bee-keeping	36	13.9	5	12	18	223	0.0734	27th
5.	**Integrated Food-Energy Systems**								
5.1	Biogas production and use	18	6.6	6	8	4	241	0.0489	30th
5.2	Use efficient biomass stoves	60	23.2	30	20	10	199	0.1802	23rd
5.3	Use Improved postharvest storage facilities, techniques	82	31.7	40	35	7	177	0.2535	17th

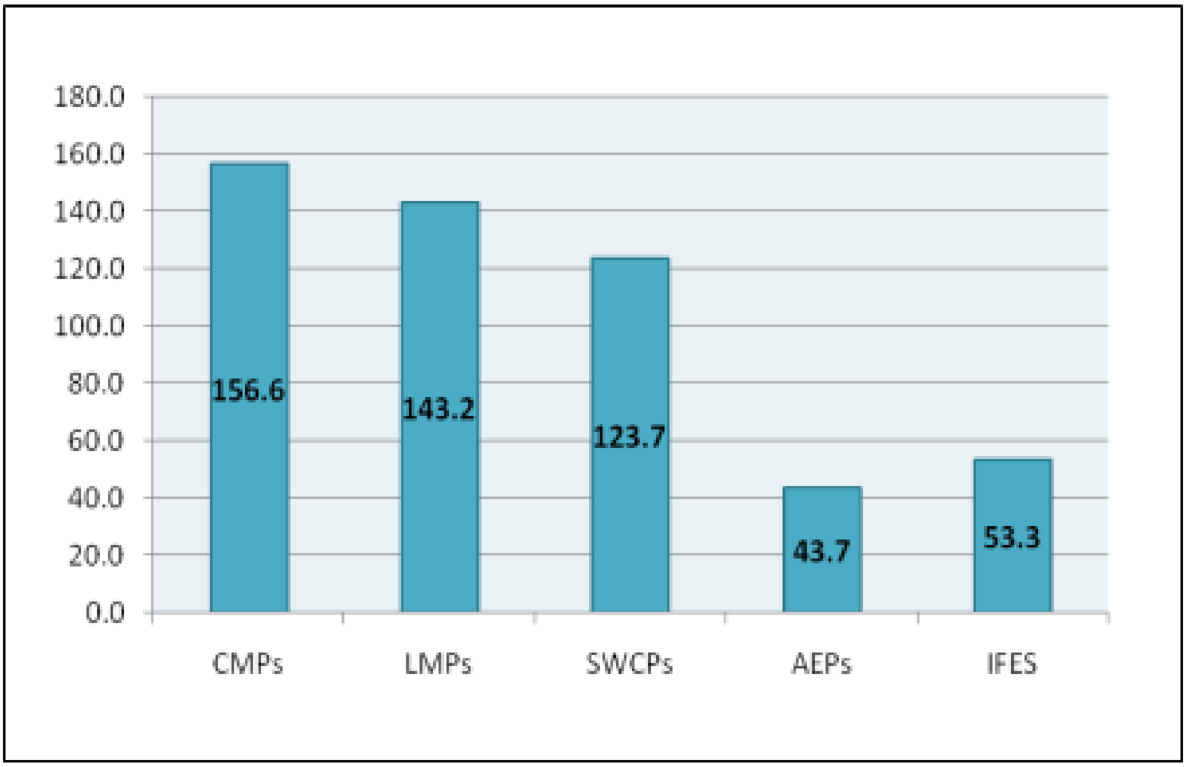

Figure 3. Type of CSA Practices and Average number of Adapters (Source: Household survey, 2019)

3.2 Households' Adoption Level of CSAPTs and their Food Security Status

In this sub-section, farm households' adoption level of the identified CSAPs was determined through the composite score method, which was used to group households in low, medium and high based on their level of adoption of the identified CSAPs. To this end, households were made to respond to questions relating to their frequency of adoption of the identified CSAPs using an ordinal Likert scale by scoring 3, 2, 1 and 0 points for Frequently, Occasionally, Rarely and Not adopted CSAPs, respectively in order to compute the composite score points, which in turn used to group households in Low, Medium and High level adaptors. Results indicated that the mean (μ) and standard deviation (σ) of the distribution of the composite score points were 41.25 and 16.53, respectively.

Thus, households' adoption level of CSAPs was determined as follows:

- High adoption groups: Composite score points between 90 and 57.5
- Medium adoption groups: Composite score points between 57.5 and 25.0
- Low adoption groups: Composite score points between 25.0 and 0

Table 2. Descriptive statistics for Households' adoption Level of CSAPs

CSA adoption groups	Composite score points	Number	Percent (%)
Low adoption group	0.0 - 25.0	85	32.82
Medium adoption group	25.0 - 57.5	115	44.40
High adoption group	57.5 - 90.0	59	22.78
Total	0 - 90	259	100

As can be seen in Table 2, 44.40% of the sample fall in medium adoption group, while 32.8% of them fall under low adoption group. Households included in high adoption group make up 22.78% of the total.

It was also indicated in Table 3 below that the amount of food energy available for the total sample households was 2,105,952.03*kcal* with a mean and standard deviation daily per capita *kcal* of 1795.6 and 446.2, respectively. When compared to the minimum recommended allowance (2100*kcal*), the available dietary energy could cover 85.51% of the recommended daily allowance. Compared to the minimum recommended allowance (2100*kcal*), the available dietary energy could cover 92.67% of the recommended daily allowance for households in the high adoption group, whereas the coverage was 85.04% and 80.61% for households in the medium and low CSA adoption groups, respectively implying that households' increasing level of CSA adoption was likely to improve their food security status.

Table 3. Distribution of mean dietary energy available by adoption level of CSAPTs

Adoption level	Households No and %	Av. family size in AE*	Population in AE	Total dietary energy/*kcal*	Mean DE in *kcal*	Std.	% of the MRA
Low	85 (32.8%)	4.31	366.35	620,171.93	1692.8	462.4	80.61
Medium	115 (44.4%)	4.54	522.1	932,376.62	1785.8	440.6	85.04
High	59 (22.8%)	4.82	284.38	553,403.48	1946.0	422.8	92.67
Total	259/100%	4.5	1172.83	2,105,952.03	1795.6	446.2	85.51

Results in Table 3 also showed that mean dietary energy available for households in high, medium and low adoption groups was estimated to be 1946.0, 1785.82 and 1692.84*kcals*, respectively. Besides, results of the one-way between-groups analysis of variance with post-hoc tests conducted to assess contribution of households' adoption level of CSAPTs on their food security status indicated that there was statistically significant difference at the $p < .05$ level in the mean HFBM scores for the three adoption groups $F(2,256)$=3.96, p=.013. The actual difference in mean scores between the groups appears to be large enough, the calculated eta squared value was .07 would be considered as a medium effect size according to Cohen (1988). Post-hoc comparisons using the Tukey HSD test showed the mean HFBM score of the Low adoption group (μ=1692.8, σ=462.4) was significantly different from the High (μ=1946.0, σ= 422.8) adoption group, whereas the mean HFBM score of the Medium adoption group (μ=1785.8, σ=440.6) did not vary significantly from either the Low or High adoption groups. Thus, the difference in food security status of households in the low and high adoption groups was not just a matter of chance, but attributed to the variation in adoption level of existing CSAPTs.

There is no consensus among literature in measuring household food security on specific calorie consumption thresholds to define levels of calorie intake, it was decided at a World Food Program Workshop to use the thresholds of 0 and 20% shortfalls below the average $2100kcal$ per person per day (Lovon and Mathiassen, 2014). This was used to establish the following calorie consumption ranges:

- Poor calorie consumption ($\leq$1680 $Kcal$ per capita per day);
- Borderline calorie consumption (>1680 – <$2100Kcal$ per capita per day, and
- Acceptable ($\geq$$2100Kcal$ per capita per day)

Summary of the descriptive statistics showing distribution of households under each adoption group in the poor, borderline and acceptable calorie consumption ranges is presented in Table 4.

Table 4. Distribution of Households' Calorie Consumption by adoption level of CSAPTs

Calorie consumption	**Consumption ranges**	**N**	**%**	**Mean** *kcal*	**Calorie consumption by adoption levels** LAG (%)	**MAG (%)**	**HAG (%)**
Poor	*leq*1680	103	39.8	1588.4	64.71	34.78	13.56
Borderline	>1680 – <2100	111	42.9	1847.6	30.59	54.78	37.29
Acceptable	*geq*2100	45	17.4	2119.2	4.71	10.44	49.15

The results in Table 4 indicated that 49.15% of households in the high adoption group were found out to be in the acceptable calorie consumption range ($\geq$2100), in which only 10.44% and 4.71% of the households were included from the medium and low adoption groups, respectively. Contrary, results also showed that 64.71% of the households in the low adoption group were found out to be in the poor calorie consumption range ($\leq$1680), in which only 34.78% and 13.56% of the households were included from the medium and high adoption groups, respectively. Besides, (54.78% of the households in medium adoption group were found out to be in the borderline calorie consumption range (>1,680 – <2100), in which only 30.59% and 37.29% of households were included from the low and high adoption groups, respectively.

Proportion of households (%) according to different calorie consumption ranges in the low, medium and high CSA adoption groups was presented in Figure 4.

Figure 4 indicated a shift of farm households from the low to medium CSA adoption level filtered some 5.73% (10.44%-4.71%) of households from borderline to acceptable calorie consumption range, but 29.93% (64.71%–34.78%) of households from poor to borderline calorie consumption range. However, the implication of CSA adoption level of households on their calorie consumption, and thus food security status was larger when households were shifted from low to high adoption levels as it transferred all the households (100%) from borderline to acceptable and also enabled 13.85% of the households to leapfrog from the poor to acceptable calorie consumption range by escaping over the borderline calorie consumption range. Similarly, the shift also poured 13.57% of households from poor to borderline calorie consumption level. Results in this regard also indicated that CSAPTs contributed substantially to improve the food security status of farm households in the study area.

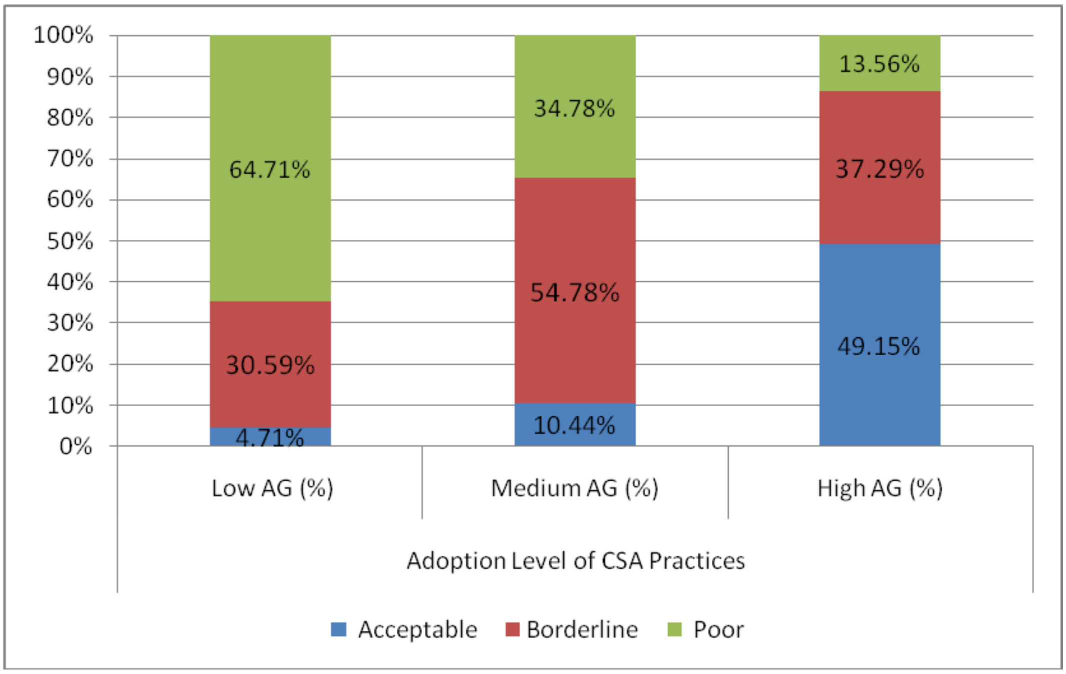

Figure 4. Proportion of households (%) in different CSA adoption groups, (Source: Computed from the Household survey, 2019)

3.3 Factors Influencing Households Adoption Level of CSAPTs in the Study Area

Albeit for different CSAPs, various factors have been indicated in previous studies to affect adoption level of households among smallholders. In this study thus, eleven socioeconomic factors assumed to influence adoption level of CSA at household level were identified, and then tested through Ordered Probit Regression Model. The ordered Probit model on module of STATA version 13 was used to perform the regression since the dependent variable (CSA Adoption level) was assumed to have a natural ordering as Low (Y=0), Medium (Y=1) and High (Y=2) adoption groups. Log likelihood of -96.2285 with a *p*-value of 0.0000 revealed that the model as a whole was statistically significant. Estimated cut-off points (μ) showed that the categories were ranked in an ordered way of $\mu_2 > \mu_1 > \mu_0$.

Marginal effect estimates indicated that years of education, livestock and membership in SACCOs were significant explanatory variables influencing adoption level of CSAPTs among households in low and high adoption categories at 10%, 5% and 1% level of significance, respectively. On the other hand, none of the explanatory variables significantly influenced adoption level of CSAPTs among households in the medium adoption category. Results of the Ordered Probit Model were presented in Table 5.

As can be seen in Table 5, the marginal effects in the LAG for all variables have negative signs, while the signs in HAG were positive indicating that the higher the values for this variable means the less likely they were in the LAG and the more likely they were in the HAG. The negative sign in the LAG and MAG implied an increase in all the explanatory variables will cause the farm households therein to increase their adoption level of CSAPTs, although marginal impacts were not significant, except for those mentioned above. In the HAG, on the other hand, all the explanatory variables were positively related, as the value of these variables increase, there will be a boost in adoption level of existing CSAPTs in the HAG.

Table 5. Distribution of Households' Calorie Consumption by adoption level of CSAPTs

Variables	Coefficients	Low adopter group			Medium adopter group			High adopter group		
		SE	***P*-Value**	**ME**	**SE**	***P*-Value**	**ME**	**SE**	***P*-Value**	**ME**
AGE	.0003895	.005990	.98300	-.000125	.000470	.98300	-9.68e-06	.006450	.98300	.0001340
GENDER	.150110	.36620	.89300	-.04950	.018290	.96900	-.00070	.349310	.88600	.050160
EDUCATION	.0553309	.010560	.09500*	-.017660	.002740	.61600	-.001380	.011410	.09500*	.0190350
HH SIZE (AE)	.04984	.01141	.16300	-.0159	.00252	.62300	-.0012	.01233	.16400	.01715
FARM INCOME	6.04e-07	.00000	.69400	-1.93e-07	.00000	.75300	-1.50e-08	.00000	.69400	2.08e-07
OFF-FARM INCOME	1.02e-06	.00000	.82400	-3.25e-07	.00000	.84500	-2.53e-08	.00000	.82500	3.50e-07
FARM IMPLEMENTS	3.04e-076	.00000	.54900	-2.23e-07	.00000	.79500	-4.35e-08	.00000	.75200	2.68e-07
MEMBERSHIP	.7728677	.08350	.00300***	-.2466735	.036790	.60200	-.019210	.089050	.00300***	.2658835
CREDIT ACCESS	.52498	.08503	.0740*	-.1521	.04492	.39600	-.0381	.12216	.12000	.19016
EXTENSION	-.132690	.040820	.30000	.0423491	.006820	.62900	.0032980	.04360	.29500	-.045647
LIVESTOCK	.5798643	.115610	.05000**	-.149310	.122820	.56700	-.070381	.234460	.05000**	.2196904
LAND SIZE	.01588	.00440	.25100	-.0051	.00079	.61700	-.0004	.00468	.24300	.00546
Cut 1 -.631523										
Cut 2 1.003240										

4 Conclusion and Recommendation

4.1 Conclusions

The following conclusions emerged from the main research findings. Smallholder farmers in the study area adopt a wide variety of CSAPTs at different level, composition and for variety of reasons. Based on the findings, Crop and Livestock Management and Soil and Water Conservation Practices were most widely adopted CSAPTs, whereas Agroecological Practices and Integrated Food Energy Systems were least adopted CSAPTs in the study area, with slight variations in average number of adopters on both cases. Some of these identified CSAPTs were recently introduced, while others have long been part of the traditional subsistence mixed farming system of the study area.

More specifically, results also indicated that crop management practices (such as use of improved crop varieties, alley cropping of cereals and application of mechanical weed control methods, change planting dates), livestock management practices (such as applying fodder conservation, diversify livestock species and use cut and carry feeding) and soil and water conservation practices (such as conservation tillage, crop rotation and use in situ water conservation practices) were widely adopted CSAPTs in the study area, whereas agroecological practices (such as integrating trees in croplands and practicing beekeeping) and integrated food energy systems (biogas production and use of efficient biomass stoves) were least adopted CSAPTs.

Further results indicated the overwhelming majority ($\sim 4/5^{th}$) of the households were medium or low CSA adopters, whereas only a fifth ($1/5^{th}$) of them were happened to be in the high adopters group, which is the empirically identified best adoption level in this study. Finding in this study was that CSAPTs contributed to food security status of households in the study area, especially when they were adopted by households with increased variety and degree of frequency. Besides, the food security contribution of CSAPTs increase substantially when households were shifted from low to high adoption groups than when they were shifted from low to medium or from medium to high adoption groups.

Results further indicated that age of household head, gender of household head, years of education of household head, household size, group membership, access to credit, farm size and farm income, off-farm income and value of productive farm implements were all negatively related, implying that an increase in all these explanatory variables will cause farm households in low and medium adoption groups to increase their level of adoption of CSAPTs, thereby improve their food security status. On the other hand, all explanatory variables mentioned above were positively related implying that as these variables increase, there would be a boost in adoption level of CSAPTs in high adoption group, which is perhaps likely to boost their food security status and improve overall livelihoods via surplus food production (availability) and increasing supply to local food markets (accessibility).

4.2 Recommendations

This particular sub-section is devoted to pertinent recommendations drawn from major findings of the study. Findings showed unlike crop and livestock management, and soil and water conservation practices, agroecological practices (integrating trees in croplands and practicing bee-keeping) and integrated food energy systems (biogas production and use of efficient biomass stoves) were the least adopted CSAPTs in the study area. Therefore, local government and their development partners such as NGOs and donors should collaborate to roll out programs intended to increase the demand for agroecological practices (mainly integrate trees in croplands and practice bee-keeping) and integrated food energy systems (mainly biogas production and use of efficient biomass stoves) with the efforts to boost crop and livestock management, and soil and water conservation practices.

One of the key findings of the study was that CSAPTs contributed significantly to food security status of farm households, especially when the level of adoption was higher both in terms of number (diversity) and frequency of use. As to the findings of the study, it is important to diversify farm households' income sources and their access to extension and credit services enhance adoption level of existing CSAPTs among smallholder farm households, and thereby improve their food security status.

In addition, smallholder farmers should be sensitized about the needs to invest in productive assets to enable them absorb more risks associated with climate change. The sensitization can be carried out in groups by extension workers or other local development agents. Smallholders should also be encouraged to participate in such farmers' association as RSACCOs so that they will be able to share information on benefits of increased adoption level of CSAPTs to improve households' food security status. To this end, the present study calls for increased participation and collaboration of local and international development agencies in the efforts to deal with interlinked challenges of climate change, smallholder agriculture and food security.

Future studies in the study area should focus on the contribution of adoption level of individual CSAPTs on food security status of farm households in order to come up with more refined entry points for future intervention. Further studies should also focus on how to enhance synergies and reduce tradeoffs between the triple goals of CSA, namely improving food security via increased agricultural production and income, enhancing resilience through increased adaptation to climatic change and enhancing climate change mitigation through reducing agricultural GHG emissions.

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Conflict of Interest:

The author would like to declare that there is no conflict of interest.

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