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Smallholder Farmers Adoption of Climate Smart Livestock Production: Practices, Status and Determinants in HidebuAboteWoreda, Centeral Ethiopia

Bassa Mamo[a], DesalegnYayeh[b],

Corresponding Author: desalula@gmail.com

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Abstract

This study is aims at identifying the status, determining factors and challenges in adopting Climate Smart livestock production practices. Three-staged sampling techniques were used to select the targeted area and sample household respondents. A total of 233sampledhouseholds were selected using simple random sampling method and household survey was conducted with pre-tested structured questionnaire. Key Informant Interviews and Focus Group Discussions were also conducted to complement the study. Various descriptive and inferential statistic techniques were applied to analyze the collected survey data. Ordered logistic regression model wasalso used to analyze the determinant factors which affect the adoption status of the sampled household.Descriptive result shows that the mostly adopted practices are composting (85.41%) and manure management (70.39%) while the least adopted technologies were bio-gas generation (3.86%) and rotational grazing (22.32%).Theadoption status of the sampled household were also categorized into low (19.74%), medium (67.81%) and high adopter(12.45%).High cost of improved breed, use of manure for fuel, free grazing and lack of information and awareness are the major constraints to adopt technology. The result of ordered logistic regression revealed that education, grazing land, total livestock holding, and extension contact contributed significantly and positively to adoption status, while distance from water source weed had a significant and negative effect adoption status of climate smart livestock production practices.

Key Words*:* Adoption, Climate Smart, Constraints, HidabuAbote,Livestock, Ordered Logit

Introduction

Food and Agricultural Organization of the United Nations (FAO) (2013) estimates that agricultural production has to increase by 60% by 2050 to satisfy the expected demands for food and feed across the world. Most of the additional 2 billion people will live in developing countries (Williams et al., 2015).

Agriculture in Africa has a massive social and economic footprint. More than 60% the population of Sub-Saharan African smallholder farmers, and about 23% of SSAs GDP comes from Agriculture. Yet Africa's full agricultural potential remains untapped (FAO, 2018). Agriculture is the backbone of Ethiopia's economy. At national level the sector accommodates 85% of employment and contributes 90% of foreign exchange earnings. Most importantly 90% of the agricultural output is contributed by small scale farming (Abebaw et al., 2010). According to Federal Democratic Republic of Ethiopia (FDRE) Growth and Transformation Plan II (2016) the agriculture sector contributed 39% of GDP at the end of 2015.

The adverse impact of climate change and variability is manifested in Ethiopia through drought, flood, increase in temperature and change in rainfall patterns which has direct and indirect effects on livestock production (Nyengere, 2015). In reverse, the business as usual livestock production system contributes both directly and indirectly to the climate change and variability through release of greenhouse gases (GHG) emissions in the form of carbon dioxide (CO_2), methane(CH_4) and nitrous oxide (N_2O)(Rust, 2013). Ethiopia adopted the climate change adaptation and mitigation policy framework called Climate Resilient Green Economy (CRGE) to mainstream the environment issues to all development effort in which the Climate Smart Agriculture development is the main component (CRGE, 2010).

In the context of CSA approach, livestock production is an agricultural sub-sector that is preferred to adapt to climate change, especially in arid and marginal land, because of the mobility of live animals, opportunity to relative gestation period and less water requirement (IFAD, 2010).

In the effort to support local smallholder Livestock's producing farmers in the Hidebu Abote *Woreda* local government and partner organizations have implemented different development programs out of which Growth and Transformation Plan (GTP I and II1),Agricultural Growth Program(AGP) and Sustainable Land Management(SLM)are some that have integrated a Climate Smart livestock production since the year 2010/11.In AGP-II Climate Smart livestock production practices like zero-grazing, cut and carry system, area closure, bull fattening, breed improvement for dairy livestock production, Artificial Insemination (AI),animal health services and composting are included in the document and implemented since 2015 (GTP-II,2016).

There were insufficient empirical studies and scientific evaluation of context based Climate Smart livestock production program in the study area and elsewhere in Ethiopia so far to identify the adoption status, determining factors and challenges in using the practices. In order to contribute to fill the mentioned research gap this study is aimed to identify the status of adoption, analyze determining factors and challenges in adopting Climate Smart livestock production practices and forward problem-oriented context specific strategic action to enhance adoption and scaling up/out the practice by smallholder farmers in Hidebu Abote *Wored*a, North Shoa Zone, Oromia National Regional State, Ethiopia.

Description of the study Area

Hidabu Abote district is located between 9047′15″- 100 0′45″N and 38026′ 15″-38038′45″ E astronomically and altitude ranging from 1160m to 3000m above sea level (Figure 1). It has a total population of 104,442 of which 15,086 are agriculturally based households. The total area of the district is 50870.39 ha from which 32,917(64.7%) ha is used for agricultural production. Agriculture contributes much to meet major objectives of farmers such as food supplies and cash needs. It is characterized as rain-fed and subsistence nature with traditional farming techniques. The agricultural system is mixed farming type where crop and livestock productions are practices jointly. The dominant crops grown in the study district are *teff*, sorghum, wheat, chickpea, faba bean and lentils. The number of livestock resources in the study area were cattle (81156), sheep (23899), goats (47596), horses (439), donkeys (12528), mules (173), poultry (43814) and honeybee colonies (15648) (HALFRDO, 2019).

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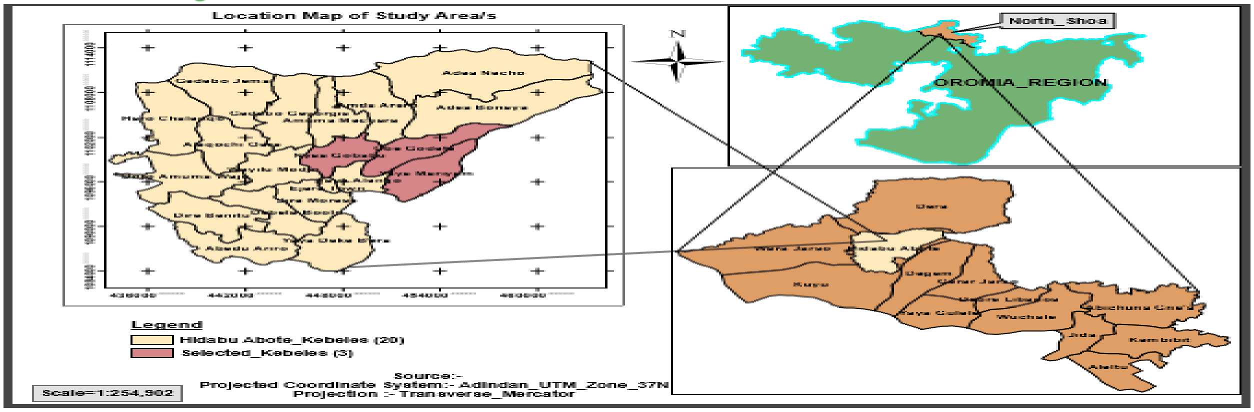

Figure 1: Map of the study area ***(Source: GIS, 2020)***

Methodology

Sampling frame and sample size determination

This study follows multi-staged sampling technique, where a combination of sampling techniques was used to select the study siteand participants. Purposive sampling method was employed to select the study *Woreda*and the three *kebeles* namelyYayamarami, Kobigodeti and Gneagebabuintentionally due to their livestock production potential and climate change related risks. The study sites are also affected by population pressure. Smallholder livestock producing farmers were selected using simple random sampling technique for household survey.The Key Informants (five members in each *kebeles*) and focus group participants (six up to seven membersin each *kebeles*) were also selected purposively due to their skill and knowledge to explain the status and challenge related to CSA in livestock production. Yamane (1967) provides a simplified formula to calculate sample sizes. This formula was used to calculate the sample size as shown below in Table 1.

$$\mathrm{n} = \frac{N}{1 + N(e)^2} = \frac{1447}{1 + 1447(0.06)^2} \approx 233$$

Where n is the sample size, N is the population size (1447), and e is the level of precision (6%).

Research design

Descriptive research design was appropriately applied in this research. Descriptive research set out to describe and to interpret thequestions and looks at the study units with the aim to describe, compare, contrast, classify, analyzeand interpret the entities, and the events that constitute the study. Different socio-economic, institutional and demographic situations were described at first. Household survey and field observations as methods enabled the researcher to describe the phenomena.

The regression model was used to determine the kind and magnitude of relationship among the dependent and independent variables under study. In this study, both qualitative and quantitative data collection and analysis approach was followed to triangulate the interpretation of data and results to enhance the reliability and validity of findings. In qualitative approach in-depth Key Informants Interview (KIIs), Focus Group Discussions, field observations were techniques for data collection.

In the quantitative research method household survey on the basis of structured questionnaire interview was conducted by researcher and enumerators. This mixed approach research design is thought to be appropriate to answer the research questions and then met the objectives, because it helps to identify and analyze the existing physical and non-physical (behavioral) dimensions of determining factors in adopting climate smart livestock production practices.

Data sources and tools

The research was accomplished using primary and secondary data sources, which are qualitative and quantitative nature. The primary data necessary to achieve the designed objectives were obtained from sample households through semi structured questionnaire for sampled household and checklist for focus group discussion and key informant's interview. Secondary data was collected from relevant sources such as, articles, proceedings, journals, scientific reports, MoA, CSA, Zonal and district annual reports which were vital to the study.

Data analysis method

To address the objectives of this study, both descriptive statistics and econometric methods of the data analysis were employed.Descriptive statistics such as mean, minimum, maximum, percentages, frequencies and standard deviation were applied to describe demographic, socio-economic, farm characteristics, institutional characteristics in the study area. Econometric analysis model was used to identify factors affecting smallholder farmers 'decision to choose climate smart Livestock production practices to response to climate change and variability. Ordered logit regression modelwas used to identify and interpret main socio-economic factors affecting adoption of climate smart livestock production practice. This model suits such type of analysis as it permits the analysis of categorical variables, allowing the determination of choice probabilities for different categories. The ordered regression modelwas used to answer the research questions related to the specific objective of determining the factors of adoption and how they are related with adoption level (Long and Freese, 2014).Inferential statistic like the one way ANOVA-F test and Chi-square were used in order to compare the difference among adoption categories for different continuous and categorical variables and also whether the difference is significant or not.

According to Long and Freese (2014), the ordered logit regression model is expressed as:

$$\text{P(Yi} > j) = g(X\beta j) = + \frac{\exp\,(\alpha j + Xi\beta j)}{1 + \{\exp(\alpha j + Xi\beta j)\}}, \qquad j = 1.2, .., M - 1$$

Where M is the number of categories of the ordinal regressed. From the equation stated above, theprobabilities that Y will take on each of the values 1,… M are equal to:

$$P(Yi = 1) = 1 - g(Xi\beta j)$$

$$P(Yi = j) = g(Xi\beta j), J = 2, \ldots, M - 1P(Yi = M) = g(Xi\beta M - 1)$$

$$Yi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \beta_n X_n + \mu i.$$

The dependent variable Yi = level of usage of climate-smart livestock production practices (high user = 3; medium user = 2; low user = 1). $X_1 \ldots X_n$ represents the explanatory variables; $\beta_1 \ldots \beta_n$represent the parameters of the explanatory variables; and β_0 represents the intercept, while μirepresents the error term.

Variable description

Dependent variable

Adoption quotient, developed by Sengupta (1967) is the dependent variable used in this study. Adoption quotient for an individual farmer was calculated based on the adoption scores gained by the farmer for the adoption of climate smart livestock production practices. A total of 8 climate smart livestock production practices (improved breed, composting, manure management, fodder planting, feed conservation, rotational grazing, biogas generation and destocking) were used for calculation of the adoption quotient.

Adoption Quotient = (Total adoption scores gained by farmer/Maximum adoption score) x 100.

Depending on the adoption quotient, sampled household were divided into three categories for analysis such as low adoption = < (Mean – SD), medium adoption = (Mean ± SD) and high adoption = > (Mean + SD); and also the same three categories applied for ordered logistic regression analysis (Faridet al.,2015).

Independent variable

The independent variables that are hypothesized to affect the smallholder farmers' adoption of climate smart Livestockproduction practices are combined effects of various factors, such as: household demographic characteristics, socio-economic characteristics, and institutional characteristics in which farmers operate. Based on the review of related literatures, and past research findings, 13 potential explanatory variables were considered in this study and examined for their effect on adoption of climate smart livestock production practices by smallholder farmer practices.

Table 1: Summary of variable definition

Types of variables	Definition	Types variables	Measurement	Expected sign
Sex	Sex of the sampled household	Dummy	1 for male,0 female	+
Education	Education level of sampled household	continuous	School years	+
Family size	Family size of sampled house hold	Continuous	AE	+
Livestock income	Livestock income earned from livestock	Continuous	Birr	+
Saving and Credi use	Saving and Credit use of the sampled household	Dummy	1 for saving and credit use and 0 for not use	+
Extension contact	Extension service of the sampled household	Dummy	1 for extension contact ,0 for not contact	+
Information on climate change	Information on climate change by sampled household	Dummy	1 have information,0 not have information	+
Landholding	Total number of land that sampled household have	Continuous	ha	+
Livestockholding	Total livestock hold by sampled household	Continuous	TLU	+
Grazing land	Total grazing hold by sampled household	Continuous	ha	+
Distance from water source	Distance from the nearest water source	Continuous	Walking minute	-
Experience	Experience of sampled household on livestock production practices	Continuous	Years	+

After coding and feeding the collected primary data into the computer, STATA version 15 was used for analysis.

Results and discussion

Socio-economic and Demographic Characteristics of Respondents/ Smallholder farmers' perception on climate variability against metrological records

Nearly 26.18% of the sample households were female headed and the remaining 73.82% were male headed households. The result of the Chi-square shows insignificant relationship of sex with adoption level (X^2=1.229, P=0.541) but the majority of male sampled households (69.19%) were in medium level of adoption status as compare with female headed household.

With respect to saving and credit facilities, 40.77%and 59.23% of sampled households were beneficiaries and non-beneficiaries respectively. The majority of saving and credit beneficiaries and non-beneficiaries fall under medium adoption level with 72.63% and 64.49% respectively. The Chi-square test result shows statistically insignificant relationship between the credit users and adoption status (X^2=15.426, P=0.144) but we can see the majority of medium adopters were credit users which shows the importance of credit in positively influencing the adoption status.

The scale of extension service extends from 13.74% to 69.67%. Medium adopters lie score the highest value and the lowest value corresponds to high adopters while the low adoption constitutes 16.59% of access to extension services. There is significance statistical difference between farmers choice of climate smart livestock production practice at less than 0.01 (1%) significance with regards to extension service (X^2= 5.038, P=0.000). This shows that extension service is a basic determining factor for adoption of climate smart livestock production practices and extension users were use more technology as compared with extension nonusers. On the other hand, the majority of respondents (75.54%) have climate information.

Table 2: Summary of socioeconomic and demographic characteristics

Variable	Measurement	Mean	Std.Dev.	Min	Max
Age	Year	45.82	11.08	23	77
Education	School years	3.63	3.91	0	13
Family size	AE	5.42	2.06	1.6	12.15
Landholding	ha	2.6	0.99	0.25	5.4
Grazing land	ha	0.46	0.35	0	2
Livestock holding	TLU	5.77	2.57	0.84	13.15
Livestock income	Birr	11300.48	13926.64	0	66000
Distance from water	Walking minute	13.70	10.85	2	60
Experience	Years	12.39	5.78	2	52

Age of respondents ranged between 23 to 77 years. The average age categories of the three adaptation levels were found to be 44.37, 45.96 and 47.41 for low, medium and high adaptation levels respectively. The one-way ANOVA result indicate that there is significant mean difference between the groups of adoption categories at less than 0.01 significance level (F=2.011, P =0.001). The result implies that middle adult age significantly determines the adoption level and is important factor to enhance adoption of climate smart livestock production practices.

The average years of schooling in the study area was 3.63, with a minimum of 0 year (illiterate) and maximum of 13 year of schooling. The cross-tabulation indicates that the mean level of education level for the respondent family members that fall in the adoption categories of low, medium and high were 2.61, 3.64 and 5.21.The one way ANOVA result in the Table 5 shows that there is significant mean difference between the groups of adoption categories at less than 10% significance level(F=1.589, P =0.090) with regards to education level of the sampled household in the study area. The possible reason is that level of education can enable the smallholder farmer to be open to receive, understand and implement the information relevant for the adoption of a new technology.

The average family size of the sample household heads was 5.42, with a minimum of 1.6 and maximum family size of 12.15 in terms of adult equivalent (AE). The average family size of the households shows the potential labor endowment in the study area.

The average land of the sample households was 2.6 ha with a minimum of 0.25ha and maximum of 5.4ha. The cross tabulation shows that the mean land holding for the respondents falls in the adoption categories of low, medium and high were1.88, 2.03 and 2.52 with standard deviation of 1.03, 0.87 and 1.25 respectively. The result shows there is a significant relationship between climate smart livestock production practices adoption in all categories at 10% significance level (F=1.327, P=0.087) with regards to landholding in the study area. This shows that secured land access is a basic determining factor for adoption of climate smart livestock production practices.

The average total grazing land of the farm households was about 0.46ha with a minimum of 0 ha and 2ha. The mean grazing land for the respondents falls in the adoption categories of low, medium and high were0.29, 0.46 and 0.69 with standard deviation of 0.26, 0.33 and 0.45 respectively. The result of one way ANOVA shows that there is a highly significant mean difference between climate smart livestock production practices adoption in all categories at 1% significance level (F=2.669, P=0.000) with regards to landholding in the study area.

On average, the livestock holding of the sampled farmers in the study area was 5.77 per household with a minimum of 0.84 and maximum of 13.15 in TLU. The mean livestock holding of the respondent households in Tropical Livestock Unit (TLU) are 4.71, 5.84, and 7.14 for low, medium and high adoption categories with the standard deviation of 2.37, 2.62 and 1.89 respectively. The result of the study shows there is a highly significant relationship between climate smart livestock production practices adoption in all categories at 1% significance level (F=2.361, P=0.000). This indicates that farmers who have more livestock can participate in climate smart livestock production practices.

The average yearly livestock income of the sampled farmers in the study area was Birr 11300.48 with standard deviation of 13926.64. The maximum livestock income was Birr 66,000 with minimum of Birr 0. The result indicates that household can generate more income livestock production in the study area.

When the cross-tabulation is analysed the mean livestock income for the respondents that fall in the adoption categories of low, medium and high are Birr 9976.09, 10762.74 and 16331.03 respectively. In a similar manner the standard deviation of livestock income for low, medium and high adoption categories are 17229.11, 12087.03 and 16734.72 respectively. The one-way ANOVA result in the Table 5 shows that there is significant mean difference between the groups of adoption categories at less than 5% significance level (F =1.477, P=0.019). This result implies that livestock income has a significant role to determine the adoption level and is important factor to enhance adoption of climate smart livestock production practices.

The mean distance from home to the nearest water source was 13.7 walking minute with a minimum of 2 and maximum of 60 walking minutes.The average distance from home to nearest water source of the respondent households in walking minute are 18.46, 12.70,and 11.55 for low, medium and high adoption categories with the standard deviation of 12.96, 10.24 and 8.33 respectively. The result of the study shows there is insignificant relationship between climate smart livestock production practices adoption in all categories (F=1.218, P=0.22).

The average years of farming experience in the study areawas 12.39 years, with a maximum of 52 and minimum of 2 years. The mean experience of the sampled households falls in the adoption categories of low, medium and high were12.19, 12.10 and 14.24 with standard deviation of 4.89, 5.26 and 8.91 respectively. The result of one way ANOVA shows that there is a highly significant mean difference between climate smart livestock production practices adoption in all categories at 5% significance level (F=2.056, P=0.004) with regards to experience the study area. This is due to as one gets skillful in the methods of livestock production; he/she would be better in adopting climate smart livestock production practices

Table 3: Climate smart livestock production practices adoption status in relation to continuous explanatory variables

Variables	Adoption	Mean	Std.Dev.	F-value	P –value
Age	Low	44.37	11.27	2.011	0.001
	Medium	45.96	10.86		
	High	47.41	12.08		
Education	Low	2.61	3.01	1.589	0.090
	Medium	3.64	3.94		
	High	5.21	4.57		
Family size	Low	4.93	2.06	1.469	0.021
	Medium	5.44	1.94		
	High	6.08	2.54		
Landholding	Low	1.88	1.03	1.327	0.087
	Medium	2.03	0.87		
	High	2.52	1.25		
Grazingland	Low	0.29	0.26	2.669	0.000
	Medium	0.46	0.33		
	High	0.69	0.45		
Livestockholding	Low	4.711	2.37	2.361	0.000
	Medium	5.84	2.62		
	High	7.14	1.89		
Distance from water	Low	18.46	12.96	1.218	0.226
	Medium	12.70	10.24		
	High	11.55	8.33		
Experience	Low	12.19	4.89	2.056	0.004
	Medium	12.10	5.26		
	High	14.24	8.91		
Livestock income	Low	9976.09	17229.11	1.477	0.019
	Medium	10762.74	12087.03		
	High	16331.03	16734.72		

Adoption of Climate Smart livestock production status

The eight climate smart livestock production practices that have been promoted by development actors and adopted by smallholder livestock herders at different level are rotational grazing, improved fodder, destocking, feed conservation, composting, manure management, genetic breed improvement and bio-gas generation.

Table 4 below revealed that the widely adopted practices are composting (85.41%) and manure management practices (70.39%) and the less adopted one is bio-gas generation (3.86%). Adoption of destocking (63.95%), improved breed (60.09%), fodder (29.18%), rotational grazing (22.32%) are intermediary adopted climate smart livestock production practices. As it can be seen from the same Table in all practices male households are the major adopters. The result is in line with the study result of Deressa *et al*. (2008) that showed male headed households could be more likely to have access to technologies and climate change and variability information than female-headed households. As a result, they are in a better position to practice diverse adaptation and mitigation strategies than the female-headed ones.

Table 4: Types of climate smart livestock production practices commonly practiced in the study area.

Types of climate smart practices	Adopters						Non adopters					
	Female		Male		Total		Female		Male		Total	
	Count	%	Count	%	count	%	count	%	count	%	count	%
Improved breed	34	55.74	106	61.63	140	60.09	27	44.26	66	38.37	93	39.91
Manure management	37	60.66	127	73.84	164	70.39	24	39.34	45	26.16	69	29.61
Fodder planting	20	32.79	48	27.91	68	29.18	41	67.21	124	72.09	165	70.82
Feed conservation	34	55.74	121	70.35	155	66.52	27	44.26	51	29.65	78	33.48
Composting	47	77.05	152	88.37	199	85.41	14	22.95	20	11.63	34	14.59
Rotational grazing	12	19.67	40	23.26	52	22.32	49	80.33	132	76.74	181	77.68
Biogas generation	5	8.2	4	2.33	9	3.86	56	91.8	168	97.67	224	96.14
Destocking	37	60.66	112	65.12	149	63.95	24	39.34	60	34.88	84	36.05

In the study area respondents are grouped based on the adoption quotient derived from calculated adoption scores and compared the result with arithmetic's of adoption mean and standard deviation that is mentioned in table below. The result of analysis of adoption quotient of smallholder farmers indicates that the minimum adopted practices are 0 (0%) and the maximum adoption practice is 7 (87.5%). The mean adoption quotient is 0.4796 (47.9%) and standard deviation is 19.96 (Table 5) which show that there is an encouraging adoption practice which needs to be scaled up/out in the study area

Table 5: Summary of adoption quotient of sampled households (in percentage)

Variable	Observation	Mean	Std.Dev.	Min	Max
Adoption quotient	233	47.96	19.96	0	87.50

Source: Own survey (2020)

Table 6 below shows that 46 (19.74%), 158(567.81%) and 26(12.45%) of the respondent categorized under low, medium and high adoption level respectively for Chi square and ordered logistic regression model.

This indicates that the majority of the respondents are categorized under medium adoption level while the minority of adopters categorized under higher adoption category.

Table 6: Adoption categories of sampled households

Adoption status	Frequency	Percentage
Low	46	19.74
Medium	158	67.81
High	26	12.45
Total	233	100

Source: Own survey (2020)

Determinate factors of Climate Smart livestock production

Diagnostic test

Ordered logit regression model was applied to estimate the determinants of farmers' choices of adopting climate smart livestock production practices that aimed to reduce the adverse impact of climate change and variability. The dependent variable of the model is the category of users of CSA practices (high, medium and low). Before running the ordered logistic regression model, different econometric assumptions were tested using appropriate techniques. The existences of multicollinearity between the explanatory variables were checked by using VIF for continuous variable while the coefficient of contingency was used for dummy variable. As the rule of thumb VIF values, less than 10 is said to be weak association among explanatory variables.

Therefore, in this study, the computational results of the VIF for continuous variables is lower than 1.58 and the mean/average of VIF is 1.26, confirmed the non-existence of severe multicollinearity problem among the continuous predictor variables, and were included in the model (Appendix table 3). Besides, the values of contingency coefficient regarding dummy variables were less than 0.29 (Appendix table 4) which is less than the rule of thumb of 0.75 implying that a weak degree of association among the variables considered. Moreover, from Table 12 below Prob> chi2=0, which indicates the fitness of the model during analysis.

Hence, the parameter estimates of the ordered logit model were used to provide the direction of the effect of the independent variables on the dependent (response) variable, whereas estimates represent neither the actual magnitude of change nor the probabilities. The marginal effects of marginal probabilities are a function of probabilities and measures expected change within the probabilities. In the subsequent section, only the variables that were statistically significant at less than or equal to 10% probability levels are interpreted and discussed.

Education: The result of ordered logit regression model showed that educational status is statistically significant and has a positive influence on the level of adoption of climate smart livestock production practices at 1%(P=0.003). It indicates that as sampled household educated more there is the more likely to be in the higher category and less likely in the lower category. The marginal effect in Table 13 shows that as education increase by one school year keeping other variables constant, the probability to be in the lower adoption level decrease (less likely in the low adopter category) by 1.5%, the probability in medium category increase (more likely in the medium category) by 0.6% and the probability in the higher category increase (more likely in the higher category) by 0.9%.

This is due to relatively better educated farmers are engaged in the adoption of new technology. The result also revealed that better exposure to education increases farmers' better understanding of the benefits and constraints of climate smart livestock production practice. A positive impact of education on technology acquisition is generally expected as it enhances farmer's ability to acquire and analyze new ideas and provides specific or general skills that contribute to livestock productivity.

Similar to the finding of this study, (Daniel and Muluget, 2017; Workneh, 2015; Eric ,2012) reported that education gives farmers the ability to perceive, interpret and respond to new information much faster than farmers with lower education level (non-educated). Thus, those household heads with better education level have a higher probability of adopting best practices.

Grazing Land: This variable has a statistically significant and positive influence on the level of adoption of climate smart livestock production practices at 1%(P=0.003) as indicated in Table 12 below. The result indicates that farmers who have larger grazing land are more likely to be in the higher category and less likely in the lower category to adopt climate smart livestock production in the study area. Furthermore the marginal effect in Table 13 indicates that as grazing land increase by one hectare assuming other factors constant the probability to be in a lower category decrease by 18.7%, the probability to be in the medium category increase by 7.3% and the probability to be in the higher category increase by 11.3%. This is due to grazing land is the main source of feed like different fodder, grasses and etc which increase the probability of farmers to adopt new technology.

Total livestock holding: As expected total livestock holding was found to be positively and significantly associated with adoption status at 10%(P=0.064) significance level. The finding implies that farmers who have more livestock are more likely to be in the higher category and less likely in the lower category to adopt climate livestock production in the study area. The marginal effects in Table 13 also shows that as livestock increase by one unit keeping other variables constant the probability to be in the lower category decrease by 1.6%, the probability to be in the medium category increase by 0.6% and the probability to be in the higher category increase by 1%.

The possible reason is livestock are important providers of manure for compost preparation, as farmers' hold more livestock; by far they are encouraged to prepare and apply compost in their farmlands. Also, livestock holding in rural Ethiopia in general and in the study area in particular is considered as indicator of income level and hence wealth status of the households. It shows farmers financial ability to buy even different inputs for farmlands. On the other hand, some of the livestock type like donkey and horse are still important means of transports for goods and human being in the study area. So, a farm household having a number of livestock is not challenged in applying compost to their farmlands. So, a large number of livestock presences in study area increase the probability to adopt climate smart livestock production practices. The result is agreed with that of Workneh (2015); Mengistu and Bauer (2011).

Extension contact : The result of ordered regression model in Table 12 revealed that there is a positive and statistically significant effect of extension contact on adoption status at 1%(P=0.008) significance level. The result indicates that farmers who contact extension experts are more likely to be in the higher category and less likely in the lower category to adopt climate livestock production in the study area. Moreover the marginal effect in Table 13shows that a change of extension contact from who do not get extension to who get extension service (from 0 to 1) assuming other factors constant the probability of the sampled household to be in the lower category would be decrease by 25%, the probability of the farmers to be in the medium category increase by 18% and the probability to be in the higher category increase by 7% in the study area.

The possible explanation is that extension services are important sources of information and knowledge for rural farmers. It is expected that frequent contact with extension agents would brighten the chances of awareness of climate change and CSA practices that can be adopted to adapt to climate variability and shocks. Besides, farmers, through extension services, can learn climate change mitigation measures and strategies that can enhance resilience. Based upon the innovation diffusion theory, farmers who have contacts to extension services tend to be more progressive and receptive to new innovation. Farmers with more access to information and technical assistance on agricultural activities have more awareness about the consequence of climate change. Agricultural extension services serve as a crucial source of information on climate change, climate change adaptation and resilience, as well as livestock management practices. Additionally, as the extension workers frequently visit and follow up farmers more, farmers may obtain important and influential information. This result agrees with the finding of Onyeneke et al. (2018) who confirmed that contact with extension agents increases the likelihood of the adoption of CSA practices. More over this finding also consistent with those of Daniel and Mulugeta (2017) and Workneh (2015) who analyzed the adoption of soil and water conservation techniques and composting in south Wollo zone of Amhara region and Beseku district of Oromia region respectively. Also, Wang *et al*. (2016); Eric (2012) and Somada et al. (2002) reported similar findings on composting technology adoption in China, Kenya, and Burkina Faso respectively.

Distance from water source: It affects adoption status negatively and significantly at 1% (P=0.003) significance level as indicated in Table 12 below. According to the result of ordered logit regression model the more distance from the resident of the sampled household the more likely in the lower category and the less likely in the higher category. The marginal effect also implies that a unit increase (1 walking minute) from the resident to the nearest water source the probability of the farmers to be in the lower category would increase by 0.5%, the probability of the farmers to be in medium category would be decrease by 0.2% and the probability to be in the higher category would be decrease by 0.3% in the study area (Table 7).

This is due to the fact that if there is far distance from the household home to water source, it is more difficult to manage the livestock. This could be attributed to the fact that the farther the water source from the respondent's residence, the greater would be the cost of consuming time (opportunity cost), management and supervision. This implies that farmers whose water sources are far from their homesteads would likely adopt fewer CSA practices. This could be attributed to the challenges they would be facing in exercising proper and effective management as a result of stress posedbydistancewhencomparedwiththeircounterpartswholivecloserto their water source.

Moreover the farmer whose water source is far from his residence is less likely to continuously watering his/her livestock as compared to those whose water source nearer to their home. Thus, it is expected that farmers who live near to their water source are likely to have regular watering of their livestock, hence motivated to respond to climate change on their agricultural activities. The result is similar with the finding of Malefiya (2017).

Number of obs = 233

LR chi2 (12) = 57.56

Prob> chi2 = 0

Pseudo R2 = 0.1465

Log likelihood = -167.65183

Table7: Result of ordered logistic regression model

Adoption status	Coef.	Std. Err.	z	P>z
Sex	0.174	0.354	-0.49	0.623

Education	0.118***	0.040	2.94	0.003
Family size	0.058	0.081	0.71	0.475
Landholding	0.166	0.192	-0.87	0.386
Grazingland	1.470***	0.499	2.94	0.003
Total livestock holding	0.128*	0.069	1.85	0.064
Livestock income	0.000	0.000	0.57	0.567
Credit use	0.079	0.310	-0.25	0.802
Extension contact	1.396***	0.529	2.64	0.008
Distance from water source	-0.043***	0.014	-3	0.003
Climate information	0.112	0.366	0.31	0.76
Experience	0.039	0.027	1.44	0.15
/cut1	1.233	0.737		
/cut2	5.360	0.837		

Note: *** and * Significant at 1% and 10% level respectively
Source: Model result (2020)

Table 8: Marginal effects after ordered logit model

Adoption status	**Marginal Effect (dy/dx) for low adopter**	**Marginal Effect (dy/dx) for medium adopter**	**Marginal Effect (dy/dx) for high adopter**
Sex	0.021	-0.008	-0.014
Education	-0.015	0.006	0.009
Family size	-0.007	0.003	0.004
Landholding	0.021	-0.008	-0.013
Grazing land	-0.187	0.073	0.113
Total livestock holding	-0.016	0.006	0.010
Livestock income	0.000	0.000	0.000
Saving and credit use	0.010	-0.004	-0.006
Extension contact	-0.250	0.180	0.070
Distance from water source	0.005	-0.002	-0.003
Climate information	-0.014	0.006	0.008
Experience	-0.005	0.002	0.003

Source: Model result (2020)

Table 9 below shows that the mean predicted value of low, medium and high adoption category are 0.197(19.7%), 0.68 (68%) and 0.133 (13.3%) which is almost similar with the mean value explained in Table 10 above. This indicates that the model correctly predicted the value.

Table 9: Predicted probability for adoption category.

Variable	Obs	Mean	Std.Dev	Min	Max
predicted probability (low)	233	0.197	0.168	0.004	0.829
predicted probability (medium)	233	0.680	0.127	0.167	0.775
predicted probability (High)	233	0.123	0.120	0.003	0.794

Source: Model result(2020)

Constraints to Climate Smart livestock production Adoption

Adoption smallholder livestock producing farmers faced a number of challenges in the study area. The major challenges that prohibited these farmers from adopting the practices are identified and presented in Table 11 below. According to the results of respondents, key informant interviews (KIIS) and focus group discussions (FGDs) the general challenges in adopting climate smart livestock production practice by smallholder farmers are high cost of improved breed, low availability of feed, use of manure for fuel and crop residue for animal feeding, problem of free grazing, low awareness, small grazing land and lack of finance are the major ones in the study area. This finding is in agreement with the study of Williams et al.(2015) that described the number of challenges faced climate smart agriculture in relation to the conceptual understanding, practice, policy environment and financing of the approach. Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from feed crop production and through grass land carbon sequestration. Animal grazing on pasture also helps reduce emissions attributable to animal manure storage (IFAD, 2010).

Non-adopting smallholder respondent farmers in the study area stated different primary constraints as a reason for not practicing improved breed. Improved livestock breeding practice has a potential to address the three pillars of climate smart livestock production(productivity and income, adaptation and mitigation) and widely promoted in the study area by government and non-governmental organizations since for long period of time according to key informant interviews (KIIs).According to the results from the household survey 93(39.91%) of the respondent did not adopt improved breed mainly due to high cost of improved breed(38.71%),lack of technical practice (15.05%), low awareness about AI(11.83%), low availability of feeding (21.51%), far distance from the health service (8.6%) and lack of interest (4.3%).

Composting is one of the climate smart livestock production practices widely promoted by concerned government sector program like regular extension program, Sustainable Land Management (SLM) and Agricultural Growth Program(AGP) during the past few years. Composting has an advantage of cost effective soil fertility improvement to increase the crop yield, reduce the greenhouse gas concentration through methane reduction, offset nitrous oxide ($N2O$) released by application of inorganic fertilizer, and stabilize the soil moisture and organic matter content(FAO,2013). Regarding to preparing compost in the study area as indicated in Table 11, from the total non-adopters 34(14.59%) of respondents are not using compost in the study area. The main reasons are use of manure for fuel and crop residue for animal feeding (47.06%), shortage of compost materials (23.53%), lack of labour (17.65%), unavailability of water (8.82%) and low awareness (2.94%). This practice is the dominantly adopted practice where 199 (85.41%) respondents reported to practice it in the farming season. The result is in confirmation with Nyengere (2015) that identified family labour and poor awareness as major constraints that determines adoption of composting.

Proper conservation feeding to livestock production is efficient and productive feeding practice that enhances the yield and compensates the shortage of feed occurring during dry seasons which helps to adapt to climate change impacts. It also contributes to high animal feed conversion rate and then reduces the amount of methane ($CH4$) gas released per head of animals in the effort to mitigate greenhouse gas release to the ambient atmosphere (IFAD, 2010). The study result in Table 11 indicates 78 (33.48) of the respondent didn't adopt the practice mainly due to limited of feed storage (67.95%) and low awareness (32.05%).

Fodder is planting trees together with crops on the farm. These are trees that produce or are primarily used for fodder (for animal feed), or fuel wood production or that provide other benefits such as reducing runoff or erosion, increase water percolation, enhancing soil fertility, providing shade, fencing and wind break. Beside its uses it has a huge potential to adapt adverse impact of climate change and mitigate the long-term climate change impact through carbon sequestration (Alemayehu, 2002). Local farmers traditionally used to practices fodder planting in the area according to key informants and focus group discussions. In the study area from the total nonadopters 165 (70.82%) is not using fodder planting. This is mainly due to problem of free grazing (58.19%),land allocation for crop production (13.36%), small land (7.88%), unavailability of water through a year (12.73%),unavailability of improved fodder seed (4.24%) and other (0.6%)(Table 11).The result is in agreement with that of Mutambara, Dube and Mvumi (2012) which identified land size and availability of information as determining factors for adoption.

Proper pasture management through rotational grazing would be the most cost-effective way to mitigate GHG emissions from feed crop production and through grass land carbon sequestration. Animal grazing on pasture also helps reduce emissions attributable to animal manure storage (IFAD, 2010). Non-adopting smallholder respondent farmers in the study area mentioned different primary constraints as a reason for not practicing rotational grazing. According to the results from the household survey which indicated in Table 11 below181(77.68%) of the respondent did not adopt rotational grazing practice mainly due to poor awareness and knowledge on benefit (23.76),small grazing land (53.59),weak land use policy enforcement (11.6%) and communal ownership of grazing land(11.05%).The finding of the Alemayehu (2002) supports this result in that overgrazing and absences of land use policy in Ethiopian are the major constraints in adopting planned pasture management practices.

Biogas units can be used to convert human and animal waste into a mixture of methane and carbon dioxide that can be used for lighting, heating and cooking (Melaku, 2017).According to the result from the key informant interviews this technology also save labour (especially women and girls productive labour), protects deforestation by substituting fire wood, improve garden vegetable production through the usage of by-products/slurry/ from biogas generation as organic fertilizer and also protect women from the health adverse impact of smoke.

The study result in the Table 11 indicates only 9 sampled household were adopted and the remaining 224 (96.14%) of the respondent didn't adopt the practice mainly due to lack of information and awareness (45.54) lack of finance(43.75%), small quantity of manure (8.93%) and other (1.79). This technology is the least adopted (3.86%) practices in the study area. Beside the household survey result government energy resource expert as a key informant responded that shift in household livestock number, management and technical capacity are additional challenges in adopting and maintaining biogas technology. The finding of the study is in line with FAO (2013) literature that mentioned high investment costs as major constraint for adoption.

Livestock are unable to find adequate fodder and grow weak and die from malnutrition or disease. Availability of supplementary grain and fodder on the local market may decrease. As a result, livestock prices drop too low and the price of grain climbs to high. Emergency destocking programmes allow for the removal of animals before they die. Destocking of livestock is the reduction of the number of livestock especially during shortage of feed, dry season in order to adjust the number of livestock with their feed capacity. According to the Table 11 below 84(36.5%) of the respondent did not adopt destocking of livestock practice. The main reasons are low awareness on destocking (69.05%), cultural attitude (25%) and other (5.95%).

Table 1:The main constraints in adopting climate smart livestock production in the study area

Types of climate smart livestock production practice	**Major constraints**	**Count**	**%**

Main reason not to use improved breed	High cost of improved breed	36	38.71
	Lack of technical practice	14	15.05
	Low awareness about AI	11	11.83
	Low availability of feed	20	21.51
	Far distance from the health service	8	8.60
	Lack of interest	4	4.30
	Other	0	0
Main problems to prepare compost	Use manure for fuel and crop residue for animal feeding	16	47.06
	Shortage of compost materials	8	23.53
	Lack of labour	6	17.65
	Un availability of water	3	8.82
	Low awareness	1	2.94
	Other	0	0
Reasons not to use fodder planting	Problem of free grazing	96	58.19
	Land allocation for crop production	27	16.36
	Small land	13	7.88
	Unavailability of water through a year	21	12.73
	Unavailability of improved fodder seed	7	4.24
	Other	1	0.60
Main problem of not use feed conservation	Limited of feed storage	53	67.95
	Low awareness	25	32.05
Reasons not to use rotational grazing	Poor awareness and knowledge on benefit	43	23.76
	Small grazing land	97	53.59
	Weak land use policy enforcement	21	11.60
	communal ownership of grazing land	20	11.05
	Other	0	0
Reasons not to practice biogas	Lack of information and awareness	102	45.54
	Lack of finance	98	43.75
	Small quantity of manure	20	8.93
	Other	4	1.79
Reasons not to use destocking	Low awareness on destocking	58	69.05
	Cultural attitude	21	25.00
	Other	5	5.95

Source: Own survey (2020)

Conclusion and Recommendations

Climate smart livestock production practices adopted by smallholder farmers in Hidabu Abote *Woreda* with respect to livestock farming in the study area were composting, manure management, feed conservation, destocking, improved breed, fodder planting, rotational grazing and biogas generation. Composting was ranked as the first among adoption practices followed by manure management, while bio-gas generation was ranked as least adopted.

The wider adoption of composting and manure management and limited adoption of bio-gas generation practices indicates that smallholder farmers are commercially oriented and resource efficient.

Moreover, different climate smart livestock production constraints were identified by the sampled households, FGD and KII in the study area. These are mainly high cost of improved breed, low availability of food, use of manure for fuel and crop residue for animal feeding, problem of free grazing, low awareness, small grazing land and lack of finance.

Therefore, it could be concluded that livestock herders having higher education level, grazing land, total livestock holding, extension contact are more likely to adopt climate smart livestock production practices whereas farmers whose water source are far from their home are less likely to adopt climate smart livestock production practices.

Accordingly, the following recommendations are made.

- Government and non-government organizations need to work in collaboration in strengthening the existing initiatives and works to alleviate the identified challenges faced by smallholder farmers in adopting the climate smart livestock production practices.
- Improving and strengthening contact with agricultural extension agents, increased exposure to media, and raising awareness on the impacts of climate change are critical in promoting the level of adoption of CSA practices
- There is a need to design appropriate policy and strategies for improving livestock production systems by solving the shortage of feed and providing various technical and advisory support services, which in turn would enhance the adoption of climate smart livestock production practices.
- Proper management of grazing land should be done by the farmers and concerned body since more and properly managed grazing land provide sufficient food for the livestock as well as it can reduces land degradation and overgrazing.

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