

An analysis of the Maasai pastoralists' knowledge on climate-smart agricultural practices: Implications for sustainable cattle production in Arusha Region, Tanzania

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ABSTRACT: Climate-smart agriculture (CSA) is widely acknowledged to ensure agricultural sustainability in the face of climate change. The study analysed the knowledge of the Maasai pastoralists on CSA practices for sustainable cattle production in the Arusha region, Tanzania. CSA practices selected for the study included improved fodder production and conservation, rainwater harvesting, rotational grazing, manure management, zero grazing and improved cattle breeds. Purposive and random sampling techniques were employed in selecting 270 pastoralists. Data was collected through a semi-structured questionnaire survey and analysed using descriptive statistics and multiple regression. Descriptive results showed that the majority (70%) of pastoralists have no knowledge about improved fodder production and conservation, low knowledge on improved cattle breeds (57.8%), zero grazing (53.7%), manure management (41.5%) and rotational grazing (48.9%), while 61.5% have moderate knowledge on rainwater harvesting. Multiple regression results revealed that socio-economic factors such as literacy, access to extension services, household income, farm size and method of feeding cattle significantly influence the knowledge level of pastoralists on CSA practices. The study recommends the need for the government to increase knowledge dissemination of CSA practices to the Maasai pastoral communities, through improvement of agricultural extension services and support accessibility of most Maasai pastoralists to formal education, so as to enhance knowledge acquisition of CSA practices from various sources, such as written materials.

Keywords: Cattle production, climate-smart agricultural practices, knowledge, pastoralists.

INTRODUCTION

Livestock production makes a significant contribution to the livelihood of most rural communities in low-income developing countries, particularly those in the semi-arid, arid and marginal environments (de Glanville *et al.*, 2020). Livestock keeping provides a range of goods and services such as sources of food, income, manure, insurance and savings, socio-cultural symbolism, energy, and draught power (Tittonell *et al.*, 2015; Zane and Pica-Ciamara, 2021). Additionally, Mujibi *et al.* (2019) highlight that livestock activities contribute about 40% of the agricultural gross domestic product in most African countries. Despite the important contribution of the livestock sector, it is faced with several constraints, which affect its growth and directly affect the livelihood of the smallholder livestock

keepers who mainly depend on livestock production for survival.

In Tanzania, the livestock sector is one of the slowest-growing economic sectors, with an annual growth rate of 2.3% (Michael *et al.*, 2018) and contributes about 7.5% to the national gross domestic product (Kitole and Sesabo, 2022). Approximately 99% of the livestock are reared by the smallholder farmers and pastoralists, while commercial ranches and dairy farms constitute only 1% (Hyandye *et al.*, 2018). The sector is dominated by cattle production, and the country ranks third in Africa with the largest cattle population after Ethiopia and Sudan (Paul *et al.*, 2020). About 98% of the total cattle herd is indigenous breeds (Paul *et al.*, 2020), commonly consisting of Tanzania

shorthorn zebu and Ankole cattle breeds, grazed on natural grasslands and shrubs under communal rangelands.

The livelihood of the pastoralists is primarily dependent on livestock keeping. In Tanzania, they are mostly found in the semi-arid rangelands in the northern part of the country and are dominated by the Maasai ethnic groups (de Glanville *et al.*, 2020). Approximately 90% of the cattle herd in the country is kept by the pastoralists (Wakhungu *et al.*, 2014). Mobile pastoralism has long been an important livelihood for the Maasai pastoralists. However, continued reduction of the communal rangelands (Rabinovich *et al.*, 2020) due to population increase, conversion of the lands into crop farming, and establishment of new conservation and administrative areas (Msoffe *et al.*, 2011; Wynants *et al.*, 2018) limit the mobility of the pastoralists. Hence, creating increased pressure for the Maasai pastoralists to shift from transhumance to sedentary livelihood (Ripkey *et al.*, 2021).

Cattle production is constrained by several issues classified into economic, social, and environmental, which hinder sustainability (Leonard *et al.*, 2016). Regarding the economic aspect, cattle production is mainly for subsistence, characterised by low productivity due to the dominance of indigenous cattle breeds, which have low milk production (Marshall *et al.*, 2019), and climatic variations such as drought, which cause massive death of cattle as a result of severe feed shortages and water scarcity (Leweri *et al.*, 2021). Some of the social issues are related to recurrent conflicts between pastoralists and farmers (Falanta *et al.*, 2018) associated with land use disputes, which lead to farmers' crops damage by the pastoralists' livestock, mostly through open grazing. Environmental issues in cattle production are mainly attributed to poor cattle husbandry practices common among pastoralists, which cause land degradation such as overgrazing (Blake *et al.*, 2018), continuous grazing (Koka *et al.*, 2024) and vegetation destruction due to trampling, clearing of bushes and the cutting down of trees (Basamba *et al.*, 2016). Furthermore, cattle are also among the main contributors of methane emissions to the environment through enteric fermentation associated with low-quality feed (Shikuku *et al.*, 2017) and poor management of the cattle manure.

Due to several economic, social and environmental constraints in cattle production, the sustainability of cattle production practised by the Maasai pastoralists should be taken into consideration. It is commonly agreed that agricultural sustainability should at least address three basic interlinked pillars of sustainable development, which are economic, environmental and social issues related to agricultural practices (Fauzi *et al.*, 2010; Van Pham and Smith, 2014). Climate-smart agricultural (CSA) practices are considered to sustainably increase productivity, enhance climate resilience and mitigate the emission of greenhouse gases from agricultural activities (Lipper *et al.*, 2018; Wassmann *et al.*, 2019; FAO, 2021). Sustainability

of cattle production among the pastoralists can be enhanced through the adaptation of CSA practices. CSA practices selected for this study are based on various literature which demonstrate that improved fodder production and conservation, rainwater harvesting, zero grazing, improved cattle breeds, manure management, and rotational grazing can positively foster sustainable cattle production. According to Meijer *et al.* (2015), knowledge is the factual information and understanding of how a certain technology works and its benefits. In addition, knowledge can influence the adaptation of sustainable farm practices (Agula *et al.*, 2018).

Little is known about the knowledge level of the Maasai pastoralists on CSA practices in cattle production. Some studies in the study area have focused on climate change perception and impacts on cattle production (Kimaro *et al.*, 2018), socio-economic vulnerability of Maasai pastoralists (Theodory and Malipula, 2014) and predictors of willingness to mitigate communal land degradation among the Maasai pastoralists (Rabinovich *et al.*, 2020). Understanding the knowledge of the Maasai pastoralists on CSA practices could provide an important route towards fostering adaptation, which will result in sustainable cattle production. Therefore, this study seeks to fill the knowledge gap by assessing the knowledge of the Maasai pastoralists on CSA practices in cattle production.

The broad objective of the study was to analyse the knowledge of the Maasai pastoralists on climate-smart agricultural practices for sustainable cattle production in the Monduli district of Arusha region, Tanzania. While the specific objectives were to:

1. Describe the socio-economic characteristics of the Maasai pastoralists.
2. Examine the knowledge level of the Maasai pastoralists on each CSA practice.
3. Identify the socio-economic factors influencing the knowledge of the pastoralists on CSA practices.

METHODOLOGY

Monduli district of the Arusha region is in the Northeastern part of Tanzania, lying between latitudes 3°00' S and 4°50' S of the equator and longitudes 36°50'E and 36°45'E of the Greenwich meridian. According to the United Republic of Tanzania's 2022 population census, the district had a total population of 227,585 people. Monduli district has a semi-arid climatic condition, characterised by low rainfall with an average range between 500 to 900 mm annually. Most of the lands in the area have been affected by extreme climatic variations such as frequent droughts (Theodory and Malipula, 2014). The main economic activity in the district is livestock keeping (Kimaro *et al.*, 2018). Approximately 97% of the inhabitants belong to the Maasai ethnic group (Kimaro *et al.*, 2017), and the majority are pastoralists (Mguluka *et al.*, 2024).

Data was collected through a semi-structured questionnaire. Purposive and random sampling techniques were employed for the study. The first stage involved the selection of two divisions of Monduli district, namely Lashaine and Engutoto, which were purposively selected based on a high concentration of the Maasai pastoralists. The second stage involved random sampling, which was used to select one hundred and thirty-five (135) pastoralists from each division, making a total of two hundred and seventy (270) pastoralists used as the sample size.

Knowledge of the Maasai pastoralists on CSA practice was measured using a self-rated test. The pastoralists were asked to rate their knowledge level on each CSA practice in a four-point Likert scale of high (whole), moderate (almost all), low (some part) and zero (not at all). The four-point Likert scale was assigned numerals 1, 2, 3 and 0, respectively. Descriptive statistics (frequency and percentage) were used to describe the socio-economic characteristics of the respondents (objective 1) and the knowledge level of the pastoralists on each CSA practice (objective 2). Multiple regression analysis was used to determine the socio-economic factors influencing the knowledge of the pastoralists on CSA practices (objective 3).

RESULTS AND DISCUSSION

Socio-economic characteristics of pastoralists

The socio-economic characteristics of the Maasai pastoralists in the study area are summarised in Table 1. Descriptive results presented in Table 1 showed that the majority of the participants in the study were male (56.3%) compared to female (43.7%), which is attributed to the presence of male dominance in livestock ownership in most of the Maasai pastoral communities. Most of the pastoralists (50.4%) were aged between 36 to 54 years, 33.3% were between 18 to 35 years, while 16.3% were 55 years and above. The majority had primary education (55.6%) while secondary education (20.7%), never attended school (15.2%), and 8.5% had post-secondary education. Farming experience in cattle production for most of the pastoralists was between 11 to 20 years (43.7%) and 21 to 30 years (32.2%). The number of people per household head was mostly between 4 to 6 people (52.6%). The majority (59.3%) had a small farm size of less than five hectares. For cattle feeding systems, 93.7% practice open grazing, which mostly causes environmental degradation and conflicts between farmers and pastoralists. 71.1% of the pastoralists do not have access to extension services, while only a few (28.9%) have access to extension services.

Knowledge level of the pastoralists on each CSA practice

The results in Table 2 show the knowledge level of the

Table 1. Socio-economic characteristics of the pastoralists (n=270).

Variables	Frequency	Percentage
Gender		
Male	152	56.3
Female	118	43.7
Age (years)		
18-35	90	33.3
36-54	136	50.4
≥55	44	16.3
Education level		
Not attended	41	15.2
Primary education	150	55.6
Secondary education	56	20.7
Post-secondary	23	8.5
Household size		
1-3	38	14.1
4-6	142	52.6
≥7	90	33.3
Farming experience (years)		
≤10	14	5.2
11-20	118	43.7
21-30	87	32.2
≥31	51	18.9
Farm size (hectares)		
≤5	160	59.3
6-10	57	21.1
11-15	31	11.5
≥16	22	8.1
Cattle feeding system		
Open grazing	253	93.7
Open grazing and intensive grazing	17	6.3
Access to extension services		
Yes	78	28.9
No	192	71.1

Source: Field survey, 2024.

pastoralists on each CSA practice. The majority of the pastoralists have low level of knowledge on improved cattle breeds (57.8%), zero grazing (53.7%), manure management (41.5%) and rotational grazing (48.9%). Moderate knowledge level on rainwater harvesting (61.5%), and 70% do not have knowledge at all about improved fodder production and conservation.

In most of the Maasai pastoral communities, the pastoralists were used to keeping indigenous cattle breeds and most of them are not exposed to rearing improved cattle breeds; hence, this limits the knowledge level of the pastoralists on how to keep new cattle breeds that are not familiar in their local environment. The open grazing feeding system is common among pastoralists. In this system, it is difficult for the pastoralists to practice manure

Table 2. Distribution of pastoralists according to knowledge level measured on four-point Likert scale (n=270)

CSA practices	Percentage of the respondents			
	High	Moderate	Low	Not at all
Improved cattle breeds	3.7	13.3	57.8	25.2
Zero grazing	5.6	14.8	53.7	25.9
Manure management	10	29.3	41.5	19.3
Rotational grazing	4.4	15.2	48.9	31.5
Improved fodder production and conservation	6.3	8.9	14.8	70
Rainwater harvesting	8.1	61.5	24.8	5.6

Table 3. Multiple regression analysis results (n=270).

Coefficients	Estimate	Std. Error	t value	pr(> t)	Level of significant
(Intercept)	-1.25e+01	5.83e+00	-2.143	0.033	*
Age	7.21e-02	1.04e-01	0.697	0.487	
Literacy	2.33e+01	4.02e+00	5.809	0.000	***
Farming experience	-4.98e-02	1.23e-01	-0.404	0.687	
Household size	5.03e-01	5.25e-01	0.958	0.339	
Access to extension services	1.06e+01	3.05e+00	3.461	0.001	***
Household income	6.53e-06	2.14e-06	3.052	0.003	**
Farm size	6.81e+00	6.36e-01	10.701	0.000	***
Cattle feeding system	7.15e+00	2.06e+00	3.463	0.001	***

Signif. codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; Adjusted R-squared: 0.6552 (Source: Field survey, 2024).

management as cattle manure is scattered in the environment and not in one area to be used for other production purposes, and this can explain the reason most of them have a low level of knowledge on manure management. Low knowledge level on rotational grazing can be associated with most of the pastoralists relying on the shared grazing lands, which belong to the government. This makes pastoralists have less interest in seeking knowledge to practice land conservation practices, such as rotational grazing, in the lands that they do not own.

In Tanzania, the practice of rainwater harvesting using indigenous knowledge is familiar among people, including the Maasai pastoralists. However, rainwater harvesting practised by most of the pastoralists is primarily for household domestic use, and few allocate it for cattle production purposes. The implementation of rainwater harvesting by the pastoralists, even though it is for other uses, indicates the reason for the pastoralists to have a moderate knowledge level of rainwater harvesting. The majority of Maasai pastoralists (70%) do not have knowledge of the improved fodder production and conservation, such as cultivation and preservation of productive and nutritious grass varieties for cattle. An example of fodder grass is brachiaria grass (Njarui *et al.*, 2020) and improved fodder conservation technologies such as silage and hay making (Balehegn *et al.*, 2022). The study of Aderinoye-Abdulwahab *et al.* (2024), which was conducted in Nigeria, also found that 76.5% of the

pastoralists do not have knowledge of the cultivation of Napier grass. The majority of pastoralists feed cattle with poor-quality crop residues and natural pastures found in the environment, characterised by low productivity and not reliable in all seasons throughout the year, as the availability of pasture is mostly limited during the rainy seasons. Therefore, limited knowledge or information to encourage the Maasai pastoralists to shift from the use of poor-quality cattle feeds to improved feeds will continue to reduce cattle productivity, which will also affect the livelihood of the Maasai pastoralists.

Factors influencing the knowledge of pastoralists on CSA practices

The result of the multiple regression analysis in Table 3 shows the factors influencing the knowledge of the Maasai pastoralists on CSA practices in the study area. Table 3 reveals that 65% variations in the knowledge index (dependent variable) can be explained by the independent variables included in the model. Five (5) out of the eight (8) variables used in the model were significant: literacy (ability to read and write), access to extension services, household income, farm size and cattle feeding system, which were revealed to be the major factors influencing the knowledge level of the pastoralists on CSA practices.

Literacy was statistically significant ($p < 0.000$) with a

positive coefficient showing that the increase in the ability of the pastoralists to read and write increases the likelihood of the pastoralists to be able to access knowledge from both oral and other forms of printed media, such as pamphlets, compared to illiterate pastoralists who are limited to oral information sources. Literacy education empowers pastoralists to access, understand and apply knowledge of CSA practices in the adaptation process, which will enhance sustainable cattle production.

Access to extension services had a significant ($p < 0.001$) positive effect on the knowledge level of the pastoralists. In pastoral rural communities, pastoralists mostly depend on the agricultural extension experts to receive information regarding sustainable cattle management practices, such as rotational grazing, and other guidance related to production activities. The more the pastoralists have access to extension services increases the probability of the pastoralists to have knowledge on CSA practices. Through agricultural extension services, pastoralists are educated about the benefits and practical implementation of CSA practices, which will encourage informed decisions among pastoralists in the adaptation process of CSA practices in cattle production.

Household income had a positive significant ($p < 0.003$) effect on the knowledge level of the pastoralists. The increase in the household income, which includes both the farm income and off-farm income, increases the likelihood of the pastoralists to invest in learning opportunities such as workshops and training programs, which enhance their knowledge level on CSA practices compared to pastoralists with low income. The result is consistent with the study of Oli *et al.* (2025), whose findings showed that farmers with higher income are more likely to have better access to various resources and information. Knowledge obtained by the pastoralists about CSA practices through their ability to access different knowledge dissemination channels, because of high income, contributes towards the adaptation of CSA practices, fostering sustainable cattle production in the study area.

Farm size significantly ($p < 0.000$) influences the knowledge level of the pastoralists on CSA practices. Most of the Maasai pastoralists depend on the communal grazing lands, which they do not own, hence this limits them from adopting CSA practices on those lands. Therefore, the positive coefficient in farm size shows that the increase in the land holding size owned by the pastoralists increases the chances of having interest in seeking knowledge on CSA practices. Ownership of large farm size encourages pastoralists to seek information and provides the opportunity to adapt several CSA practices because of the availability of land. Adaptation of CSA practices will protect the environment, increase productivity and reduce social insecurities caused by the conflicts between pastoralists and farmers through open grazing.

The cattle feeding system had a significant ($p < 0.001$) positive effect on the knowledge level. The more the pastoralists practice an intensive cattle feeding system,

increase the probability of seeking knowledge about CSA practices compared to the pastoralists practising an open grazing cattle feeding system. The study of Aderinoye-Abdulwahab *et al.* (2024) also found that the method of feeding cattle, particularly intensive grazing, influences the knowledge level of the pastoralists on Napier grass cultivation in Nigeria. Implementation of intensive grazing encourages the pastoralists to seek practical knowledge of CSA practices, which is an important factor for increasing adaptation rate and enhancing sustainable cattle production in the Maasai pastoral communities.

Conclusion

The study found that the majority of the Maasai pastoralists have low and zero knowledge of CSA practices in cattle production, while only a few have high and moderate knowledge levels. Literacy, access to extension services, household income, farm size and cattle feeding system happen to be the factors influencing the knowledge level of the pastoralists on CSA practices. The low knowledge of the Maasai pastoralists on the benefits and practical implementation of CSA practices in cattle production will reduce the adaptation rate, which will hinder the sustainability of cattle production. If the Maasai pastoralists are well trained regarding CSA practices and adaptation is emphasised, the environment will be conserved, cattle productivity will increase and rising conflicts in the societies between the pastoralists and farmers will be minimised.

Recommendation

The study recommends massive campaigns for the government of the United Republic of Tanzania to increase knowledge dissemination of climate-smart agricultural practices to the Maasai pastoral communities, through improvement of the agricultural extension services and ensuring accessibility of most pastoralists to training regarding CSA practices. There is a need to support illiterate pastoralists through inventing knowledge dissemination channels which can enable the majority of the pastoralists to acquire knowledge on CSA practices. Furthermore, it is important for the agricultural extension practitioners to provide necessary training to the pastoralists on CSA practices in cattle production, while monitoring the implementation performance of each practice adapted by the pastoralists in case there is a need for corrective action to enhance social, economic and environmental sustainability in cattle production.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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