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Adoption Of Fodder Production, Livestock Husbandry, Climate Smart, And Integrated Landscape Management Technologies: A Case Of Agropastoral Economies Of Kenya

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Abstract
Consequences generated by climate change in the vulnerable agricultural system of Kenya could be disasters if effective adaptation strategies in the both agriculture and livestock sectors. There is growing evidence that improved fodder production technologies, holistic livestock husbandry practices, climate-smart agricultural practices and integrated landscape management for agro-pastoral economies of Kenya can be a potential adaptation strategy, but adopted on a limited scale
This paper documents their uptake and influencing factors in the counties of Narok, Kajiado, and Taita Taveta as efforts of various institutions to promote their adoption. A cross-sectional survey was conducted on 254 households around where these technologies were promoted using a semi-structured questionnaire. The data was fitted in a multiple logit regression equation to identify determinants of the adoption of the technologies. The result indicates that overall, the adoption levels for the technologies promoted was about 40%. The significant socioeconomic factors and farm characteristics of households in these regions raise questions as to whether the promoted fodder production and range management technologies are really affordable to poorer smallholder farmers. Therefore, successful dissemination of these knowledge-intensive fodder production and range management practices requires much more than the transfer of knowledge and germplasm; it involves building partnerships with range management stakeholders, assisting local communities in mobilizing resources, and purpose-targeting farmers' groups in evaluating the practice for enhanced adoption.
Keywords*: Adoption level, Climate Smart Agriculture, Integrated Landscape Management, Fodder production, Kenya, Pastoralists Household*

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I. Introduction

The livestock sub-sector in Kenya's economy is important not only at the national level but also at the household level. At the national level, the sector contributes about 11.9% and 43% to the Gross Domestic Product (GDP) and the agricultural sector's GDP, respectively (Farmer and Mbwika 2016; Behnke and Muthami 2011). At the household, the sector employs 50% of the agricultural labour force (Muthee, 2006). In the rangelands of Kenya, the livestock sector employs 90% of the labour force and contributes 95% of the household income (Otieno, et al., 2012; Onyango et al., 2019). Additionally, the sector provides most of the household animal products with an approximated average consumption of 15-16 kg of red meat per capita annually (Behnke and Muthami 2011). However, the rangeland ecosystems are continuously susceptible to climate viability and resource degradation that can be somewhat ascribed to lack of quality and quantity feed resources, low dry matter intake, input and output marketing problems, non-availability of credit facilities, limited extension services and inappropriate forage production technologies (Omore et al.**,** 1996; Staal et al**.,** 2002).

In an effort to mitigate these recurrent problems, SNV Netherlands Development agencies and Kenya Agriculture and Livestock Research Organisation (KALRO) in collaboration with County Governments of Narok, Kajiado, and Taita Taveta initiated a project on Integrated and Climate Smart Innovations for Agro-Pastoralists Economies and Landscapes (ICSIAPL) for ASALs of Kenya. The project was crafted around the grounded theory of change with an overall outcome of enhancing the resilience and livelihoods of agro-pastoralist communities through market-based solutions for improved fodder production and livestock husbandry practices, building on the commercialization of climate-smart innovations and integrated landscape management. In the process of implementing the project, several technologies and innovations/practices in fodder production, livestock husbandry, climate-smart agriculture, and integrated landscape management were promoted in the three counties.

Thus, an understanding of the factors affecting the adoption of these technologies and innovations is essential both to the researcher and investor of such technologies. Results obtained will assist in fine-tuning the technology and its transfer mechanism, hence enhancing farmer adoption.

The adoption theory suggests that when users are presented with a new technology, several factors influence their decision about how and when they will use it (Otieno, et al., 2016; Ali and Soar, 2018). The process follows several stages, usually categorized by the groups of people who use that technology which is often broken into five categories summarized as; innovators, early adopters, early majority, late majority, and laggards (Rogers, 1962). Rogers notes that these are ideal types and that reality shows, an individual's personal and resource characteristics can influence technology or innovation adoption. The adoption choice consists of all activities pertaining to problem perception, information gathering, attitude formation and evaluation, and resource development (Rogers, 1983). Therefore, technology developers and researchers must understand the underlying factors that influence the choice of technology in the decision-making process for their enhanced acceptability, acceptance, and adoption. This study aims to investigate the levels of adoption and drivers that influence the choice of fodder production technologies (FPT), livestock husbandry practices (that includes Livestock supplementary feeding, feed conservation and marketing (LSFFC&M), and Animal Health and breeding management (AHBM)), climate-smart agricultural practices (CSAP), integrated landscape management practices (ILMP) under the ICSIAPL project. The study posits that both the levels and drivers of adoption of these technologies may enhance researcher and investor effectiveness, their impact being improved farmers' welfare.

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II. Materials And Methods

Study site

The study sites are the counties of Kajiado, Narok, and Taita Taveta where KARLO in partnership with Netherlands Development Organization agencies (SNV) instituted the ICSIAPL project that was implemented for three years starting from 1st January 2021 to 31st December 2023. The three counties are found in the southern rangelands of Kenya and are climatically characterized by low, unreliable, and poorly distributed rainfall. They are located in the agro-climatic zones (ACZ) IV-V[1] and have an average annual rainfall and temperatures ranging from 300-1000mm, and 18.9°C - 25.44°C, respectively (Parry et al. 2012). Crop and livestock production are the main economic activities of these counties and therefore they were deemed representative of many arid and semi-arid lands of Kenya.

Data sampling and collection

The study employed a formative research approach in evaluation the adoption levels and drivers of the promoted technologies, therefore, quantitative research methods were applied. In this study, the quantitative method was employed for objective measurements and the statistical analysis of data was collected through questionnaires in order to systematically measure variables that influence adoption. The data sampling approach employed was purely simple random probability within the counties of Kajiado, Narok, and Taita Taveta and the technique used was the probability proportional to sample size (PPS). The PPS sampling involved assigning a unit being selected probability proportional to the size of the ultimate unit, giving larger clusters a greater probability of selection and smaller clusters a lower probability. The PPS involved in this study comprises two sequential stages; first, the determination of sample size for each county, and second, the distribution of the predetermined sample size in the first stage within each technology dissemination channel category[2]. Using the PPS approach, and after adjustment for the non-response factor of 20%, a sample size of 453.9 households was identified for the interview.

Prior to the actual data collection, the selection of households was done using an automatic dignitary-generated Excel random number table. Enumerators and data entry clerks were also recruited and trained on the survey instrument and a pre-test was done prior to the actual data collection. For quality assurance, the respondent was an adult member of the household – not a guest – and preferably the household head or his/her spouse. If nobody suitable is available, the household was skipped and moved to the next on the list, returning later to interview the household, if possible.

Data analysis

The qualitative data collected was first subjected to descriptive statistical analysis using frequencies, means, and percentages and tabulated using graphs, figures, and tables. The adoption levels of fodder production

[1] The two extreme ACZ includes IV that is characterized by semi humid to semi-arid and V that is characterized as semi-arid and

[2] Dissemination channel categories refer as the demo plots, Integrated Landscape Management, small investment funds and farmer field school

technologies, livestock husbandry practices, climate-smart agricultural practices, and integrated landscape management were determined by constructing an adoption index which was estimated by

$$\boldsymbol{Adoption\ index} = \frac{Respondents'\ total\ score}{Total\ possible\ score} \times 100 \quad (1)$$

The quantitative data was also used for investigating the adoption level and the drivers of adoption. Since adoption is a categorical variable with one implying adoption and zero otherwise, and again, several technologies were transferred, then several multivariate equations were estimated.

The commonly used models in adoption studies are the Logit, Probit, and Tobit models because they accommodate qualitative (categorical or discrete) responses (Cramer, 1991; Paap, and Franses, 2000). The Probit and Logit models are standard and have similar shapes, although the latter has the data concentrated in the tails. The Logit model was chosen because it gives a simpler approximation compared to other probability models that have complex relations (Amemiya, 1994; Theil, 2016). The Logit model was specified as;

$$\text{Log}\left[\frac{\text{Pro}(event)}{\text{Pro}(no-event)}\right] = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k, \quad (2)$$

Where X are the independent variables influencing the adoption of the technologies and β_{is} are estimated coefficients. Several factors are assumed to simultaneously influence the farmers' decision to adopt or reject FPT, LSFF&M, AHBM, CSAP and ILMP technologies, ***ceteris paribus,*** and, therefore, the model was specified as;

$$Y = f(SEXHH, AGEHH, EDUCHH, LO, LF, TECTR, YSSC, TFS, TFRMS, TNL, AFG) \quad (3)$$

Where Y was the probability of the farmer adopting the technologies (fodder production technologies, livestock husbandry practices (that include Livestock supplementary feeding, conservation and marketing, Animal Health and breeding management), climate-smart agricultural practices, and, integrated landscape management), with 1 = probability of adopting and 0 = not adopting any technologies, SEXHH=sex of household head, AGEHH=age of household head, EDUCHH=education level of household head (1=above primary level, 0=below primary level), LO=land ownership (1=individual, 0 otherwise), LF=Engaged in of Livestock farming, TECTR= technical training of fodder technologies, YSSC=year spent in school, TFS=total family size, TFRMS=total farm size under the fodder production, TNL=number of livestock and AFG =Affiliated to farmers group. It is hypothesized that these factors which can be grouped into farm and farmer characteristics, and technology-specific attributes positively influence the adoption decisions of p fodder production technologies, integrated landscape management practices, and feeding technologies at the farm level. Logit Regression Modelling techniques were constructed using the STATA package to determine the factors influencing adoption.

III. Results And Discussions

This section presents and discusses the levels and factors that influence adoption of the various technologies that were promoted during the implementation of ICSIAPL project. The section starts by presenting the demographic and farm characteristics of the survey respondents. This is followed by presenting the adoption levels of the various technologies categorized as fodder production technologies, (FPT), Livestock supplementary feeding, feed conservation and marketing (LSFFC&M), Climate-smart agriculture practices (CSAP), Animal health and breeding management (AHBM), and integrated landscape management practices (ILMP). The last section presents the factors influencing the adoption of these technologies, and the reason for not adopting them.

General demographic and farm characteristics of survey respondents

Demographic Characteristics

Tables 1 display the general household demographic as adopters or non-adopters of the FPT, LSFFC&M, CSAP, AHBM, and ILMP technologies. These characteristics are important in identifying recommendation domains for the development of technologies and dissemination approaches. As indicated in Table 1, on average, about 60.4% of the households were males while 39.6% were females. This finding concurred with Mutavi (2017) where about 80.0% of the households were found to be male-headed in a case study of Machakos County in the southern rangelands of Kenya. The highest age class mode of the household was observed to be 35 and above years. There were relatively small responses from the young (aged between 18-35 years) and ranges from 5.23-30.38% within the counties sampled. Generally, with regards to sex and age of the house, the study can arrive at a similar conclusion as observed by Mutavi (2017) that the responses were unbiased on gender and valid as they were obtained from responsible and rational persons in the areas of study.

The household size of respondents is also presented. Overall, the average family size was six with Taita Taveta County recording the lowest and Kajiado County the highest. The size of the household is another factor expected to positively or negatively influence household choice of adopting technologies such as FPT, LSFFC&M, CSAP, AHBM, and ILMP. Occasionally, a large household means having more assistance for the routine operation and frequent maintenance of the technology such as the ones mentioned above. In such a case, a larger household would be regarded as having a greater prospect of adopting these technologies. Contrary, a bigger household could also mean exerting a heavy dependence burden on the family's scarce resources to the level that there could barely be any reserves left to invest in these technologies, therefore, household size could negatively influence the decisions regarding adopting these technologies. According to the findings by (Kebede et al., 1990), if family relations are seen as additional sources of assistance, then new practices may be tried by the household, and, if they are regarded as dependents, then the opposite applies. In the study by Claessens et al**.** (2012), household size was identified as a mere measure of labour availability and financial commitment. The larger the household, the higher the financial commitment, and the lower the likelihood of adopting new technologies due to financial implications. In the study by Martínez-García et al. (2013), family members were also found not to be associated with farmers' intention to adopt the improved grassland management by small-scale dairy farmers in central Mexico.

The average level of education is relatively high with the majority having undergone primary and secondary school. Kimaro et al (2013) and Mutavi (2017) reported a comparatively higher level of literacy at a significant value of $p<0.05$ which indicates that education is a significant factor in facilitating awareness and adoption of fodder technologies. Years of schooling were measured in terms of the number of years spent by respondents in school. In this study, it was found that the number of years spent in school was 9.06 which indicates that the education level had been mainly elementary. This observation relates well with the finding by Martínez-García et al. (2016) in an adoption study of crop and forage-related and animal husbandry technologies by small-scale dairy farmers in Central Mexico. In addition, the number of years of formal education of the farmers was found to be positively related to diversification to non-farm activities (Obayelu et al., 2014) which implies that education creates great acceptance and an opportunity for pastoral and agro-pastoral households to diversify their livelihood sources, and therefore important in this study.

The result of household head affiliation to livestock or fodder producing and participating group is also presented in Table 1. Overall, the majority of the household heads interviewed responded belonging to livestock or fodder producing (80.28%). By belonging to group helps to increases the capacity of group members to access services such as credits, extension and information. Fenetahun and Yong-dong (2019) observed that participation in such groups is believed to strongly facilitate the adoption of new technologies. Further, Kinyangi, (2014), observed that a household membership of women's group showed a positive and very significant relationship with the women adoption of agricultural technologies. Based on these findings, this study hypothesized that membership to a group has a positive influence on the adoption of FPT, LSFFC&M, CSAP, AHBM, and ILMP technologies.

Results of household head's participation in the training on fodder production technologies before are also presented in Table 1. Overall, over 79.86% responded that their fodder production experience is the result of their cumulative knowledge about establishment, management, conservation and utilization. The promoted technologies, practically for fodder production-related technologies are knowledge-intensive practices requiring considerable training and facilitation, especially the first time farmers in the establishment and again at harvesting and utilization. Due to this knowledge requirement, previous experience in fodder production technologies together with sensitization on the importance of the practice is hypothesized to positively relates to the adoption of fodder production techniques.

Farm activities mostly carried out by the household head include crop and livestock farming with a small proportion that indicated engaged in other activities such as microbusiness and mining. Engaged in livestock farming in particular as was observed by Sinja et al (2004) facilitate the adoption of fodder production related technologies perhaps because they need more fodder materials to feed their animals following the frequent drought experienced in these areas.

Table 1: Household Demographic Characteristics

	Percent proportion			
Identifier variable	**Kajiado**	**Narok**	**Taita Taveta**	**Average**
Sex of the household head;				
Female	41.77	35.84	41.18	39.60
Male	58.23	64.16	58.82	60.40
Age of the household head;				
18-35	30.38	8.41	5.23	14.67
35 & above	69.62	91.60	94.77	85.33
Level of education;				
None	21.52	9.73	1.96	11.07
Primary	24.00	38.50	41.18	34.56
Vocational	2.53	3.98	5.23	3.91
Secondary	30.38	25.22	39.87	31.82
College	11.39	14.16	10.46	12.00
University	10.13	8.41	1.31	6.62
Years of schooling	9.06	9.88	10.12	9.81
Average size of the household	7.06	5.86	4.16	5.69
Household head group affiliation;				

Yes	92.41	60.18	88.24	80.28
No	7.59	39.82	11.76	19.72
Trained on fodder production before (%)	95.00	80.53	64.05	79.86
Household head farming activities;				
Crop Farming	17.72	80.53	86.93	61.73
Livestock Farming	72.15	59.73	86.93	72.94
Other (e.g. business, mining etc.)	12.50	4.42	15.03	10.65
Source: Authors' construction				

Farm Characteristics

Different levels of technology adoption across farmers have also been associated to farm characteristics such as farm size, land size, land ownership, and herd size (Mafimisebi et al**.,** 2006; Martinez-Garcia et al., 2013). Overall, the sampled farmers in the three counties had an individual form of land ownership (Table 2) with somewhat higher farm size ranging between 4.21 - 45.95 acres (Table 3) as compared to the central region with small average holdings being 2.25 to 5 acres per household (Sanyi et al., 2004).

Regarding land under fodder production, the findings were slightly above 20% of the land that was observed to be under pasture with the highest average recorded in Kajiado county (Table 3). Fenetahun and Yong-dong (2019) observed that among the pastoral communities in the Yabello rangeland, the total land size in acres of the household is directly related to the amount of land that is set aside for pasture or planned fodder production purposes. This implies that if the households have large land sizes as the result indicates for the case of Kajiado, the land size set aside for pasture and/or fodder production purposes too be large, and if it is small the land that is used for fodder production will be small. From this observation, the hypothesis indicates that the land size has a positive linkage with fodder production and its technology adaption. Land availability is a variable that can provide multiple feed sources for keeping livestock, as mentioned by Staal et al. (2002).

Table 2: Farm Characteristics

Parameters	**Kajiado**	**Narok**	**Taita Taveta**	**Overall**
Form of Land Ownership				
Individual	98.75	96.46	94.77	96.66
Communal	1.25	1.33	0.66	1.08
Hired	0.00	2.21	2.60	1.60
Leased	0.00	0.00	1.97	0.66
Individual land ownership (in Acres)	45.95	9.89	4.21	20.02
Land under fodder production	6.54 (14.23)	2.13 (21.54)	1.07 (25.42)	3.25 (16.23)

Note: in the parenthesis is the percentage of the average total land ownership
Source: Author's construction

Technology adoption rate/status

Several technologies were promoted during the implementation of ICSIAPL project and their adoption levels are presented in this section

Improve Fodder production technologies

Adoption of Improved Seed Varieties

Table 3 presents the different types of improved fodder-producing materials promoted and adopted by farmers in the three study areas of Kajiado, Narok, and Taita Taveta counties. The result revealed that the adoption status of the selected improved grass seed was variety and site-specific. Overall, for the grass varieties adopted, Boma Rhodes (*Chloris gayana*) was among the most preferred fodder varieties in the three counties. Improved Sugar graze (*Sorghum bicolor*) and African Foxtail varieties had also been planted by farmers within the study sites.

Table 1:Improve grass seed varieties adopted

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall**
Adopted improved grassed	**72.50**	**69.91**	**80.39**	**73.85**
Sugargraze	27.50	10.62	66.67	**34.93**
Nutrifeed	8.75	1.33	25.49	**11.86**
Camello	53.75	2.65	7.84	**21.41**
Bushrye	1.25	0.00	3.27	**1.51**
Maasai love grass	46.25	24.34	9.80	**26.80**
African Foxtail	3.75	0.44	13.73	**5.97**
Boma Rhodes	52.50	57.08	11.76	**40.45**
Cobra	6.25	8.41	9.15	**7.94**
Panicum *var* Siambasa	5.00	4.42	24.84	**11.42**

Cayman	0.00	2.65	13.73	**5.46**
Horsetail	6.25	3.98	2.61	**4.28**
Other (Nappier)	0.00	11.06	2.63	**4.56**
Source: Authors own construction				

Concerning legumes, again the adoption levels are species and site-specific (Table 4). Overall, the adoption level for the selected fodder legumes was about 48.36%. In general, improved legumes that were preferred by farmers across the three counties include Cowpea M66 (*Vigna Unguiculata*) and Desmodium. Majorly, farmers planted/adopted the improved varieties from seeds supplied by the ICSIAPL project. The reason for the high adoption of M66 may be because they are a bushy semi-spreading plant with an indeterminate growth habit and dual-purpose variety grown for both leaves and grain. Desmodium on the other hand is a superior legume that is commonly used as a protein supplement in dairy cattle, with many farmers growing it to cut production costs.

Table 2: Improved fodder legume varieties adopted

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall**
Adopted Improved Legumes	**60.00**	**33.18**	**64.70**	**48.36**
Dolichos lablab	16.25	1.33	18.95	**12.18**
Cowpea M66	46.25	4.42	40.52	**30.40**
Sunn hemp	1.25	0.88	7.84	**3.32**
Lucerne	8.75	8.41	7.89	**8.35**
Sunflower	5.00	11.95	4.58	**7.18**
Purple vetch	3.75	0.88	2.61	**2.41**
Lupin	1.25	11.06	3.27	**5.19**
Mucuna	3.75	11.06	4.58	**6.46**
Sweet potato vines	17.50	19.47	9.15	**15.37**
Desmodium	42.50	16.37	13.82	**24.23**
Source: Authors own construction				

Natural Pasture Improvement (NaPI)Technologies

Table 5, shows that over 65.0%, 50.9% and 27% of the farmers interviewed in Kajiado, Taita Taveta, and Narok counties, respectively, had adopted at least one of the components of the natural pasture improvement (NaPI) technologies. Out of the five technologies under NaPI technologies, surface water utilization, and bush management emerged as the most preferred strategies. This finding concurs with Manyeki et al (2013) finding that bush clearing was highlighted as the main strategy for natural pasture improvement. However, rangeland reseeding for pasture improvement emerged as the preferred strategy among the communities in Kajiado County which was also a prefer option among the Makueni community as was observed in the study by Manyeki et al (2013)

Table 5: Adoption rate of Natural pasture improvement technologies

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall**
Adopted NaPI	65.00	50.88	27.45	**47.78**
Rangeland reseeding for pasture improvement	35.82	3.70	10.96	**16.83**
Bush management	31.75	23.08	8.57	**21.13**
Invasive species management	12.70	25.79	5.41	**14.63**
Catchment rehabilitation	13.11	18.72	4.17	**12.00**
Surface water utilization	34.85	31.53	40.51	**35.63**
Overall	**25.65**	**20.56**	**13.92**	
Source: Authors own construction				

Climate-Smart Agriculture Practices

Climate-smart agriculture practices (CSAP) is an integrated approach to managing landscapes that comprise a set of agricultural practices and technologies that simultaneously boost productivity, enhance resilience, and reduce GHG emissions. CSAP encompasses a range of practices and technologies that are tailored to specific agro-ecological conditions and socio-economic contexts, therefore, for this project, the practices promoted include water harvesting for fodder production, intercropping fodder with food crops, manure utilization techniques, mulching, and minimum tillage strategies. Overall, the adoption of climate-smart agriculture was relatively high (above 87.61) implying the majority of the respondents are familiar with the role the CSAP plays as a holistic approach to end food security and promote sustainable development while addressing climate change issues. Table 6 also shows that in the three counties, the two most highly adopted CSA practices were mulching (63.0%) and intercropping (48.61%) while the least adopted practice was minimum tillage (22.16%). These results concur with Bitok et al. (2023) finding where a descriptive analysis revealed that on average 63.55% of the farmers were aware of the CSAP technologies while only 55.10% of farmers adopted them with intercropping being among the most adopted and utilized CSAP practice and minimum tillage was the least. Included in the "other" component in Table 6 are adoption of other practices such as growing of climate-resilient crop varieties, conservation agriculture techniques, agroforestry, precision farming, and improved livestock management practices.

Table 6: Adoption rate of climate-smart agricultural practices

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall**
Adopted CSA practices	97.5	87.61	92.16	**92.42**
Types of CSA practices adopted;				
Water harvesting for fodder production	78.75	14.60	29.41	**40.92**
Intercropping	30.00	51.77	64.05	**48.61**
Manure	53.75	53.54	81.70	**63.00**
Mulching	25.00	9.73	37.91	**24.21**
Minimum tillage	17.50	11.06	37.91	**22.16**
Other	0.00	3.10	0.65	**1.25**
Overall	**34.17**	**23.97**	**41.94**	

Source: Authors' construction

Livestock Supplementary Feeding, Feed Conservation & Marketing

The adoption of livestock supplementary feeding, dairy cattle nutrition, feed conservation, and marketing was also based on their importance, usefulness, productivity, and benefits to the farm. Table 7 presents the various livestock supplementary feeding, dairy cattle nutrition, feed conservation, and marketing promoted through training for wider adoption. Overall, the adoption levels of these animal husbandry practices was relatively low, averaging 45.17%. The results suggest that farmers need aid and support of extension services to reinforce the adoption of these technologies which were considered to be important by non-adopters. As argued by Adekoya (2007), the extension advice provides the technical bases for the use of new technologies and increased knowledge has been shown to have a positive impact on their adoption. The high adoption of feed conservation and storage was associated with the scale of operation of the farm since according to Manyeki et al (2013), herd size was shown to be a restriction to adoption.

Table 7: Adoption levels of livestock supplementary feeding, feed conservation and marketing

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall**
Adopted livestock supplementary feeding, conservation & marketing	60.00	37.67	37.84	**45.17**
Types of Supplementary feeding technology adopted;				
Feed conservation and storage	73.75	46.24	61.54	**60.51**
Feed ration formulation	23.75	22.33	12.40	**19.49**
Live weight measurements for growth monitoring & marketing	2.50	5.61	12.12	**6.74**
Total	**33.33**	**24.73**	**28.69**	
Source: Authors own construction				

Animal Health and Breeding Management

Under animal health and breeding management, a total of five technologies listed in Table 8 were disseminated under ICSIAPL project through trained trainers for adoption in the three counties. As presented in Table 8, there are notable similarities and some differences in the adoption levels of animal health and breeding management-related technologies within the county and across counties. Overall, the adoption levels of health and breeding management technologies across the counties were good ranging from 85,62 to 100.00% translating to an average of 92.7%. Table 8 also shows that in the three counties, the two most highly adopted health and breeding management technologies were disease prevention and control (92.39%) and housing (80.42%) while the least were manure management (68.87%) and breeding selection & management (72.35%). Generally, the result portrays that the three counties representing the larger southern rangelands regions of Kenya have similar animal health and breeding management technology adoption levels which range between 54.07% and 100%.

Table 8: Adopted animal health and breeding management technologies

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall**
Adopted animal health and breeding management	100.00	92.48	85.62	**92.70**
Breeding selection & management	73.42	72.00	71.62	**72.35**
Housing	100.00	65.91	75.35	**80.42**
Hygiene (Calves, kids and lambs)	73.75	90.48	67.88	**77.37**
Disease prevention and control	100.00	98.56	78.62	**92.39**
Manure management	81.33	54.07	71.22	**68.87**
Total	**85.70**	**76.20**	**72.94**	
Source: Authors' construction				

Integrated landscape management practices

Different integrated landscape management practices adopted by livestock farmers and producing organizations in the study area are shown in Table 10. Generally, adoption of integrated landscape management practices ranges from 26.67 to 61-86 percent, translating to an overall average adoption rate of 39.16%. Holistic grazing management of livestock as an integrated landscape management practice has been adopted by the largest number of respondents (17.8%) and the reseeding scheme was the least adopted integrated landscape management strategy, being adopted by just over 5.88% of the respondents. Holistic grazing management according to Lalampaa, et al. (2016) has the potential to improve animal performance, as well as the condition of range areas while agroforestry is proven to be highly impactful at improving the adaptive capacity of farmers, the resilience of local farming systems and in providing diversified livelihood benefits, hence both attracting high adoption rate as they are currently ubiquitous at the global scale

Table 10: Adopted integrated landscape management practices

	Percent proportion			
	Kajiado	**Narok**	**Taita Taveta**	**Overall average**
Adopted ILM practices	28.95	61.86	26.67	39.16
Integrated landscape management practices adopted;				
Reseeding	10.00	1.77	5.88	5.88
Holistic grazing management	17.50	33.19	3.27	17.99
Control of invasive weeds	11.25	14.16	3.27	9.56
Landscape planning	7.50	9.73	5.23	7.49
Agro-forestry	8.75	21.24	20.26	16.75
Carbon credit	12.70	14.81	12.50	13.34
Source: Authors own construction				

Factors influencing adoption of FPT, LSFFC&M, CSAP, AHBM, and ILMP

The multiple logit regression analysis was performed to determine the effect of eleven independent variables on levels of adoption of FPT, LSFFC&M, CSAP, AHBM, and ILMP technologies. The logit form of the regression model was chosen as the lead equation in terms of economic, statistical, and econometric criteria. The results of the factors influencing the adoption rate of FPT, LSFFC&M, CSAP, AHBM, and ILMP technologies among farmers using a multiple logit regression are presented in Table 11. The overall significance of the logit equation as measured by the log-likelihood chi-square (LR chi2(11)) which is greater than 10 is significant at the 1% level and increases the probability of 11 independent variables included in the model. The results in Table 11 also show the important factors influencing the adoption of FPT, LSFFC&M, CSAP, AHBM, and ILMP technologies in the study area. All the coefficients have the expected signs and seems to be robust and only those coefficients associated with statistically significant variables at the 10-percent level or better across the various technologies are considered.

Among the social factors included in the logit model, sex of the household, age of the household head, years of schooling, affiliated to association or groups, and livestock production were the major factors that influenced the adoption of various components of fodder production technologies, feeding integrated grazing management, and feeding innovations technologies. With regards to the sex of the household heads, the logit analysis found a positive and significant (***p***< 0.05) influence on households' participation in fodder production, livestock supplementary feeding, conservation & marketing, Integrated landscape management, and climate-smart agricultural practices implying that the male-headed households were more likely to participate than those headed by females. This could be explained as observed by Olila, (2014) study, by the fact that men have better access to and control over important resources such as livestock, land, and financial capital than women.

It is a well-established fact that farming experience is an important factor for success or failure in the farming business; towards this end, analysing the age of the household head with respect to adoption seems important. The age of the household head was found to be significantly associated with the rate of adoption across the five technologies disseminated in the study area. The positive relation, according to Sinja et al., (2004) can be associated with the interaction between the old farmers having experienced in particular with animal and fodder production-related technologies given that they may have been introduced some years back by other projects.

The adoption of the five disseminated livestock and fodder-related technologies was also positively and significantly influenced by access to formal education by the household head. The educational level of farmers is assumed to increase their ability to obtain, process, and use agriculture-related information and technologies in a better way. This hypothesis collaborates with the finding by Boateng (2008), where a high level of literacy rate would increase technical efficiency and decrease conservationism among farmers.

Engaged in livestock farming was positively and significantly (at $p < 0.05$ or better) associated across the five disseminated technologies, which suggests that households that had more years in livestock farming were 2.69, 2.97, 2.71, 1.93, and 1.60 times more likely to adopt fodder production technologies, livestock supplementary feeding, conservation & marketing, integrated landscape management, climate-smart agricultural practices, animal health and breeding management technologies, respectively than households that had fewer years in livestock farming. A similar finding was reported by Njarui et al (2017) and the rationale behind this finding was that farmers who had been involved in livestock farming for many years might have gained more knowledge than those with a few years of experience in keeping livestock and therefore had a higher probability of adopting fodders.

Farmers who participated before in the training on either fodder production-related technologies or animal husbandry practices were also likely to adopt the various training components because of their experience with fodder production and animal husbandry information through various projects in the past. The coefficient for this variable was strongly positive and significant at a 1% level. The variable implies that farmers who had attended training on fodder production before were more than 1.3865 times more likely to adopt the Fodder Production Technologies, Livestock supplementary feeding, conservation & marketing, Integrated landscape management, Climate Smart Agricultural Practices, Animal health, and breeding management technologies. This result implies that enormous efforts in fodder and livestock production technical training and provision of adequate information, communication, and skills for innovation are necessary for enhanced technology adoption (Sanni et al**.,** 2007).

Belonging to or affiliated with group(s) can have a positive effect on the adoption of technology since farmers are likely to share ideas as they meet in those groups or associations. The results in Table??? indicate that belonging to group(s)/association(s) was positive and significant in determining the rate of adoption of the five technologies disseminated at the 5% level or better. This is expected as observed in the study by Fenetahun and Yong-dong (2019) in that, groups or associations whether farmer-based or otherwise serve as platforms where farmers interact and share ideas, and this may include new technologies. Dissemination through farmers' groups instead of individual farmers also economises on scarce training skills and resources. In addition, working with groups ensures greater farmer-to-farmer dissemination and exchange of information. Therefore, there is need for technical support to the pastoralist households towards starting and/or joining existing social groups, through which extension and training services aimed at enhancing fodder production in the Kenya rangeland can be offered.

Each of the five fodder or animal-related technologies was also further associated with different variables; for example, farmer's education, education level of HHH, Age of HHH, Years of Schooling, and form of land ownership by HHH played an important role in the adoption of fodder production technologies, livestock supplementary feeding, conservation & marketing, integrated landscape management and animal health and breeding management technologies; however, the adoption of climate-smart agricultural practices and animal health and breeding management technologies was also highly associated with the variable such as the size of land under fodder, since this variable showed the highest coefficient value. For instance, Fayama et al (2022) argued that the availability of land and hence form of land tenure is undoubtedly the main factor determining the adoption of five livestock and fodder production-related technologies.

Overall, the marginal effects indicate that encouraging participation of gender, enhancing Education level, the form of land ownership, engaging in livestock farming, and group affiliation by HHH among others can increase the chance of fodder and livestock production-related technologies disseminated uptake by 46.07%

IV. Conclusion And Recommendations

This study provides insights into levels/status and factors that influence the adoption of Fodder Production Technologies, Livestock supplementary feeding, conservation and marketing, Integrated landscape management, Climate Smart Agricultural Practices, Animal health and breeding management technologies among the livestock production communities of Kajiado, Taita Taveta, and Narok counties of the southern rangelands of Kenya. Concerning the levels of adoption of the transferred Fodder Production Technologies, Livestock supplementary feeding, conservation and marketing, Integrated landscape management, Climate Smart Agricultural Practices, Animal health and breeding management technologies, a descriptive analysis was employed. The fodder production was found to be an attractive alternative to the expensive protein concentrates that farmers feed their livestock cows and goats as the adoption levels was fairly high (over 40%) for most of the fodder production technologies. The adoption status of integrated landscape management, climate-smart agricultural practices, Livestock supplementary feeding, conservation and marketing, and animal health and breeding management technologies were also relatively high (above 39%) implying these new animal and agronomic for fodder production enhancement practices are picking in the drought-prone rangelands of Kenya. This call for mechanisms to enable government extension services and other development partners, such as nongovernmental organizations (NGOs) and private enterprises, to incorporate successful new practices, such as integrated grazing management and climate-smart agricultural practices, from localized projects

Although adoption status was fairly good, factors such as socioeconomic (sex, age, level of education, and the possibility of belonging to a pasture or livestock-producing group) and farm variables (form of land ownership, engagement in livestock production, participation in the training on fodder production before, number of livestock owned) were important together with reasons given by farmers including knowledge and capital intensive practice requiring considerable training, facilitation, and some start-up resources, especially the first time farmer's establishment, during weeding and again, about three months later, at harvesting. The sex, age, level of education, form of land ownership, engagement in the livestock production, engaged in training on fodder production before, number of livestock owned, and the possibility of belonging to a pasture or livestock producing group of the household raise questions as to whether FPT, LSFFC&M, ILMP, CSAP and AH&BMT technologies are really affordable to poorer small scale farmers. The policy implication is that extension approaches are needed to enable farmers' groups, on their own, to access information on new practices. Governments and development partners should not see their role as simply transferring technology and information to farmers, but rather, they should also focus on assisting farmers' groups to mobilise their own resources and enhance their ability to obtain information on improved practices from within or outside their locality. Further, farm-oriented policies that consider the promotion of important technologies that demand low-cost investment by farmers, and where capital support is offered that this is through a simple and fast procedure.

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