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Integration and adoption of climate resilient management practices for enhanced productivity of sheep and goats in pastoral communities of Northern Kenya

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Abstract

Interventions to improve productivity in pastoral livestock systems of northern Kenya focus on the management of the rangeland resources and grazing areas with few initiatives on changes related to the livestock assets. However, changing climatic conditions with high frequencies of droughts have increased the vulnerability of pastoral communities and necessitate prompt interventions in animal management practices. In 2018, the Ministry of Agriculture, Livestock, Fisheries and Irrigation in collaboration with the International Livestock Research Institute commenced a programme to build the resilience of pastoral holdings using their animal assets rather than depending on humanitarian emergency responses. Interventions necessitated changes in management practices related to sheep and goat production. Core innovation groups (CIG) each comprising 30 pastoral households in select communities were established to model new practices for wider adoption using participatory processes in Isiolo, Marsabit and Turkana Counties. CIG members went through a 3-year phased training programme on animal management practices for more efficient, resilient and productive animals. The adoption of new practices in CIG flocks was monitored by extension personnel. Data were analysed using logistic regression techniques to assess household-level adoption of livestock breed improvement, feeding and disease control interventions. The 3 years of the programme (2018–2021) were relatively satisfactory in terms of pasture availability; hence, communities pursued strategies to enhance their flocks. All CIG adopted more than one of the introduced technologies concurrently. Prevention of diseases was the most readily adopted, followed by crossbreeding using indigenous breeds of sheep and goats from other arid areas of Kenya. Turkana County had the lowest probability of adopting any of the technologies as previous devastating droughts have resulted in an increased emphasis on animals for survival rather than productivity. The study shows that pastoral communities are open to technological interventions for animal productivity. Adoption of the technologies was enhanced by the experiential capacity development activities adapted to the education level of the different communities.

Keywords Pastoralists, Technology interventions, Community-based animal improvement

Introduction

Pastoral communities raise livestock under extensive conditions using natural rangelands as the main source of forage for their animals and manage grazing through traditional institutions (Degen 2007). The lands used by these communities are generally semi-arid to arid with low and highly variable rainfall (< 600 mm) per year and

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are not suitable for crop farming purposes (Otte and Chilonda 2002). The livestock practices adopted by the communities take advantage of the characteristic instability of rangeland environments, where key resources such as grazing pastures and water for livestock are available in short-lived and largely unpredictable distributions (Nyariki and Amwata 2019). In Kenya, pastoralists occupying the arid and semi-arid lands (ASAL) cover long distances with their animals along traditional grazing areas according to pasture availability and watering points. The livestock in these systems are reported to contribute up to 92% of the household incomes, with meat production estimated to contribute to 28% of the nationally consumed meat (Nyariki and Amwata 2019). Documented information on pastoral systems indicates an intimate relationship between the pastoralists and their environment and a rich knowledge of the terrain that enables them to exploit the varying characteristics of rangelands (Opiyo et al. 2015).

In recent times, traditional rainfall patterns in the ASAL have been greatly disrupted by extreme climatic conditions. Annual reports from the National Drought Management Authority (NDMA 2018) indicate that most counties in the ASAL of Kenya experienced a series of major droughts in the years 2000, 2005/2006, 2010/2011, and 2016/2017. This high frequency of droughts alongside changes in land ownership patterns has reduced areas for the movement of animals by nomadic pastoralists and has greatly impoverished the pastoral communities (Nganga and Robinson 2017; Akall 2021), with some households losing more than 50% of their livestock (Akall 2021). Other challenges that pastoralism faces include insecurity resulting from efforts to protect community-owned resources, land fragmentation and fencing of grazing reserves, diseases and refugee settlements that have increased the population pressure in the ASAL (UNHCR 2020). Pastoral livestock keepers are also often marginalized and have limited access to adequate market facilities for their animals. Alternative practices alongside coping strategies and support systems are required to reduce the vulnerability of pastoral communities in the East African rangelands. However, pastoral livestock keepers tend to resist the introduction of changes in livestock management practices from external sources as past development interventions resulted in the loss of strategic grazing areas in different communities (Stave et al. 2007; Akall 2021).

The adoption of participatory community-based breeding programmes (CBBP) for animal improvement provides an effective and practical way of conserving and improving small ruminant genetic resources. CBBP integrate community involvement in poverty reduction using their own livestock resources while stemming the erosion of domestic animal diversity (Kaumbata et al. 2021; Mueller et al. 2015; Haile et al. 2019). Through integrating the interests of the livestock keepers, CBBP increase the accuracy of information collated and the adoption of technological interventions by livestock-keeping communities. Following a prolonged drought in the arid lands of Kenya in 2017, the Government of Kenya through the Ministry of Agriculture, Livestock and Fisheries and Irrigation (MALFI) in collaboration with different development partners introduced the "Regional Pastoral Livelihoods Resilience Project" (RPLRP 2019) to implement activities that would enhance climate resilience in the pastoral and agro-pastoral communities in cross-border drought-prone areas. In collaboration with the International Livestock Research Institute (ILRI), one intervention of the RPLRP would necessitate changes in management practices related to sheep and goat production by the different communities to build holdings' resilience through household animal assets rather than depend on humanitarian emergency responses. The focus was to improve the local sheep and goat populations that were adapted to the arid environments using a CBBP approach. This paper presents results from the introduction of interventions to enhance productivity through changing management practices for the indigenous sheep and goats in the pastoral communities of Isiolo, Marsabit and Turkana Counties of Northern Kenya; the resultant changes in management practices; and factors that influenced the adaptive capacity of the pastoral households.

Methodology

Study area and household characteristics

The project was implemented in three counties of northern Kenya participating in the RPLRP programme: Isiolo, Marsabit and Turkana (Fig. 1) between 2018 and 2021. The three counties are classified as mainly arid to semi-arid, with a mean annual rainfall of less than 800 mm in most areas. More than 80% of the land is owned by communities that practise nomadic pastoralism rearing cattle, goats, sheep, camels and donkeys (Ojango et al. 2021). The three counties host large populations of sheep and goats that are mainly unimproved indigenous breed types with low potential for milk and meat production (KNBS 2010).

Through a multi-stage sampling process that involved the county-level leadership and the livestock departments, four sites were selected to implement activities aimed at improving goat and sheep productivity. Site selection was based on the county priorities for livestock development, the population density of the wards, accessibility, security within the community and availability of markets for livestock. Two sites were in Turkana County (Napeikar and Kapua sub-locations), one site in Isiolo

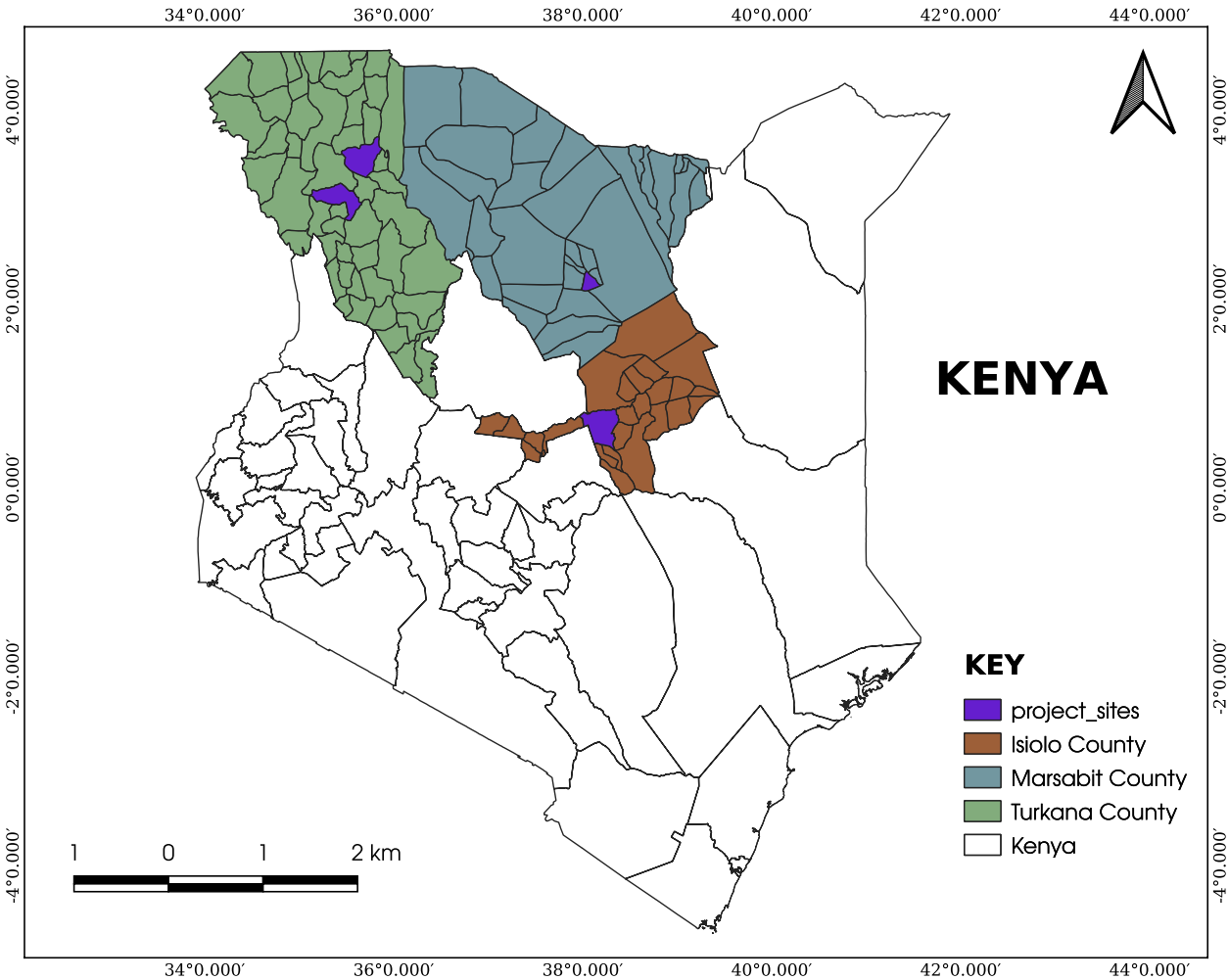

Fig. 1 Map of Kenya indicating the location of Counties involved in the project

County (Nakuprat-Gotu Conservancy) and one site in Marsabit County (Songa Conservancy). In each site, local leaders and community members were engaged in joint meetings through which they identified 30 households to form community-based "core innovation groups" (CIG) through which the RPLRP team would collaboratively work with the county livestock departments and the pastoralists to identify needs, develop and strengthen capacity and introduce transformative innovations for improving sheep and goat productivity under the local environment (Ojango et al. 2017). Households identified to form a CIG were those open to learning and able to influence other households within their community. CIG members were required to give their consent to participate and were at liberty to withdraw from the programme at any time. Each household in a CIG was mandated to share the information and practices learned through the programme with a minimum of ten other households within their community. Those they trained were also expected to train others and thus expand the adoption of the practices learned across their community. Data on the practices adopted was only collected from the CIG households.

The location of each CIG household was georeferenced with Global Positioning System (GPS) under the Universal Transverse Mercator (UTM) coordinate system and Google Earth software, to enable monitoring of any migration by the households during the course of the programme. Demographic characteristics of the CIG households at the start of the interventions (2018) have been outlined for the 102 members (21 in Isiolo, 28 in Marsabit and 58 in Turkana County) by Oyieng et al.

(2021). Community engagements beginning in 2018 enabled the pastoralists to specify reasons for keeping sheep and goats and critically examine the conditions necessary for them to attain desired products from their animals. The CIG members subsequently took part in a targeted training programme over 3 years (2018 to 2020) as outlined in an impact pathway developed by the project team (Ojango et al. 2017). Community focus group discussions (FGD) involving both CIG members and other households within their communities were organized twice each year to review and share information on the new practices introduced, challenges in the interventions, and opportunities for implementing a CBBP for goats and sheep within the sites.

Data collection and analysis

Monitoring of the CIG and collation of data on the sheep and goat flocks were implemented every three months by extension personnel engaged and trained through RPLRP using survey tools developed for the Open data kit (ODK) mobile data collection system (Audho et al. 2021; Gitau et al. 2021). Details on the sheep and goat breeds kept, flock structures, traits and behavioural characteristics considered to be important in the animals, management practices adopted for sheep and goats and management practices adopted for all animals during drought periods were collected from the households in 2018 (baseline) and again in December 2021 (monitoring) after the households had participated in the project's training activities. The software package of STATA 17 (2021) was used for data processing and analysis. Descriptive and inferential analyses were carried out to assess changes in flock sizes, structures, animal disease and husbandry management used by the CIG households in 2021 relative to baseline, and tests for statistical significance on parameters were carried out using either the chi-square (χ^2) or *t*-test. In assessing breed and trait preferences, the respondents were requested to rank their choices. The relative importance of each trait and breed based on their ranking was derived using the index of Bett et al. (2009).

$$I_i = \sum_{j=1}^{n} r_j X_{ji} / \left(\sum_i \sum_{j=1}^{n} r_j X_{ji} \right) \quad (1)$$

where X_{ji} is the number of respondents giving rank j ($j=1, 2, 3, 4, 5$, highest to lowest) to trait I, where $i=$ trait (age, sex, size, body condition and breed). r_j is the weight corresponding to rank j ($r=5, 4, 3, 2, 1$). The weights given for each rank are based on the order of preference, with the highest rank receiving a higher weight, and the lowest rank a lower weight.

Logistic regression analyses were used to assess the adoption at the household level of the following livestock management practices: (i) crossbreeding, (ii) early castration of males not selected for breeding, (iii) feeding using crop residues and improved forages and (iv) preventive disease management practices. Variables were coded as yes (1) for households practising a particular technology and no (0) for households not practising the technology. A logistic model was fitted to predict the probability (p) of a household applying each of the technologies (crossbreeding-1, castration of young male animals-2, improved feeding-3, disease prevention-4) within a county, in the survey period (baseline-1, monitoring-2) and depending on the gender of the household head (man-1, woman-2) as follows:

$$\ln \frac{\widehat{p}}{(1-\widehat{p})} = \exp(\beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} \ldots \beta_p x_{pi})$$

where $\ln \frac{\widehat{p}}{(1-\widehat{p})}$ is the expected log of the odds of applying the technology, β_0 is the model intercept, and β_i are coefficients of the respective predictor variables.

Following the initial regression analyses, an ordered logistic regression was fitted to estimate the probability of a household using a combination of the different technologies.

Results

Characteristics of the participating households were outlined in detail by Oyieng et al. (2021) and are summarized in Table 1. A majority of the household in all the counties were headed by men (73%). The education level in the communities was higher in Isiolo and Marsabit Counties relative to Turkana County in which the highest level of education reported for the household head was primary education. Additionally, in Turkana County, the average age of 78% of the household heads was over 45 years, whereas in Isiolo and Marsabit, most of the household heads were 31–45 years old.

Flock size and structure

The average flock size for both sheep and goats at baseline (2018) and during monitoring (2021) are presented in Table 2. In all the counties, flock size increased between baseline and monitoring (Table 2). The most significant increase in the number of goats and sheep owned per household was observed in Marsabit County where flock sizes more than doubled ($p<0.001$). There was a notable change in the breed composition for both goats and sheep in the Isiolo and Marsabit Counties, with a higher proportion of the households rearing crossbred animals in their flocks at monitoring relative to the baseline (Table 2). There were significantly more goats of Galla × Small East African (SEA) in Isiolo County ($p<0.001$).

Table 1 Demographic characteristics of pastoral households at the start of the project in 2018

		County		
		Isiolo	**Marsabit**	**Turkana**
Number of households (*N*)		21	28	53
Average household size		7	8	7
Gender of household head (% of *N*)	Male	81	79	66
	Female	19	21	34
Age category of household head (%)	Young adult (21–30 years)	0	0	2
	Middle age adult (31–45 years)	73	58	20
	Elder (> 45 years)	27	42	78
Education level of household head (%)	None	33.3	46.15	93.5
	Primary education	33.3	50.0	6.5
	Secondary and tertiary education	33.3	3.85	0

The relative proportion of the different categories of goats and sheep in the CIG member's flocks at baseline and monitoring are presented in Table 3.

At monitoring, the livestock keepers reported a significantly higher proportion of bucks and rams in their flocks ($p < 0.001$) than what was reported during the baseline study (Table 3). In Isiolo and Marsabit Counties, there were also a significantly higher proportion of castrated goats ($p < 0.001$) and sheep in the flocks in 2021 than at the baseline, though the proportion of castrated sheep in Marsabit was lower than in Isiolo County. In Turkana County, the proportion of both castrated goats and sheep in the flocks was lower in 2021 than at the baseline (2018). Amongst all the counties, livestock keepers in Turkana retained the highest proportion of mature female animals in their flocks (52% does, and 49% ewes, Table 3).

Disease management practices and grazing patterns

Management of different diseases in the sheep and goat flocks was through the adoption of measures for preventing diseases which included deworming, vaccination against diseases as guided by government extension personnel and the use of acaricides to control ticks. The proportion of households adopting the different measures in the three counties at baseline and following participation in the training programme is presented in Table 4.

In all the counties, more households adopted deworming and tick control following the training programme by the project. The highest change in adopting deworming and vaccination was in Marsabit County, while the use of acaricides for tick control was adopted by a higher proportion of households in Isiolo County. It was notable that no households in Isiolo County indicated that they had vaccinated their animals at monitoring (Table 3).

The systems for grazing animals that were adopted in dry and rainy seasons in the three counties are presented in Table 5.

There was a change in grazing patterns for both sheep and goats in Isiolo and Marsabit in the dry and rainy seasons from mainly free-range grazing at baseline to mainly transhumance at monitoring (Table 5). The grazing pattern did not change in the rainy season in Turkana County; however, in the dry season, some of the livestock keepers in the county adopted transhumance.

Traits of importance in the sheep and goats for the different communities

The relative importance of different traits for communities in Isiolo and Marsabit did not change significantly between the baseline and monitoring surveys (Table 6). In Turkana County, however, the age of the animal was rated to be most important followed by the breed of the animal at monitoring yet at baseline these two traits were rated as least important.

Adoption of improved management practices in different communities

Preliminary logistic regression analysis showed that there were significant differences in the adoption of recommended technologies by the pastoralists depending on the county, year of survey, and number of animals owned (Table 7). However, there were no significant differences in adoption depending on the gender of the household head. The data used in subsequent analyses of the adoption of technologies was thus not disaggregated by the gender of the household head.

Following the training provided through the RPLRP programme, the probability of adoption of the different technologies (castration, crossbreeding, improved feeding (crop residues) and disease prevention) in the

Table 2 The main breeds of goats and sheep and the average number owned by households at baseline (2018) and monitoring (2021) in the three counties

Category (S)	Breed (*N*)	The average number of animals owned (with standard deviation) (county)															
		Isiolo					Marsabit					Turkana				
		2018		2021		*p*-value	2018		2021		*p*-value	2018		2021		*p*-value
		N	S	N	S		N	S	N	S		N	S	N	S	
Goats																
Purebreds	Galla	0	*0*	3 (8)	*4 (8)*	ns	1 (8)	*24 (19)*	8 (11)	*12 (11)*	***	0	*22 (19)*	0	*30 (18)*	ns
	Small East African	0		1 (1)		ns	23 (19)		4 (7)		***	22 (19)		30 (18)		*
Crosses	Galla cross other	30 (45)	*37 (42)*	18 (34)	*62 (36)*	ns	0	*1 (8)*	25 (20)	*39 (20)*	***	0	*2 (7)*	0	*0*	
	Galla × SEA	7 (14)		44 (42)		***	1 (8)		14 (17)		**	2 (7)		0		ns
Total		**37 (42)**		**66 (36)**		*	**25 (19)**		**51 (20)**		***	**24 (15)**		**30 (18)**		**ns**
Sheep																
Purebreds	Blackhead Persian	17 (23)	*17 (23)*	28 (48)	*34 (50)*	ns	7 (8)	7 (8)	20 (26)	*22 (26)*	*	8 (7)	*9 (7)*	14 (11)	*14 (11)*	***
	Dorper	0		6 (14)		ns	0		2 (6)		ns	0		0		
	Red Maasai	0		0			0		0			1 (3)		0		ns
Crosses	Blackhead Persian × Dorper	5 (11)	*10 (12)*	17 (21)	*39 (30)*	*	0	0	14 (18)	*31 (18)*	***	1 (2)	*2 (3)*	0	*0*	ns
	Blackhead Persian × Red Maasai	5 (13)		1 (4)		ns	0		1 (4)		ns	1 (3)		0		ns
	Red Maasai × Dorper	0		7 (15)		**	0		7 (12)		**	0		0		
	Blackhead Persian × Red Maasai × Dorper	0		14 (28)		**	0		9 (14)		***	0		0		
Total		**28 (27)**		**73 (52)**		**	**7 (8)**		**53 (28)**		***	**11 (8)**		**14 (11)**		*

p-value indicating significant differences in the numbers of animals from 2018 to 2021

ns not significant

*** $p < 0.001$

** $p < 0.01$

* $p < 0.05$

Table 3 Different categories of goats and sheep owned by the community innovation group households at baseline (2018) and monitoring (2021)

	The relative proportion of different categories of goats/sheep in a household flock (county)								
	Isiolo			Marsabit			Turkana		
	2018	2021	*p*-value	2018	2021	*p*-value	2018	2021	*p*-value
Goat category									
Buck	0.10	0.29	***	0.08	0.25	***	0.17	0.29	***
Doe	0.30	0.13	***	0.39	0.10	***	0.30	0.52	***
Castrates	0.03	0.15	***	0.05	0.15	***	0.11	0.01	***
Buckling	0.06	0.19	***	0.14	0.18	ns	0.06	0.01	***
Doeling	0.19	0.17	***	0.18	0.15	*	0.21	0.02	ns
Kid female	0.16	0.04	***	0.08	0.06	ns	0.05	0.09	*
Kid male	0.09	0.02	***	0.07	0.10	ns	0.10	0.06	ns
Sheep category									
Ewe	0.2	0.11	ns	0.2	0.17	ns	0.47	0.49	ns
Ram	0.08	0.32	***	0.03	0.29	***	0.1	0.27	***
Castrates	0.02	0.14	***	0.03	0.09	*	0.06	0.02	ns
Ram lamb	0.09	0.17	ns	0.12	0.1	ns	0.04	0	***
Ewe lamb	0.31	0.14	*	0.27	0.09	***	0.12	0.01	*
Lambkin female	0.09	0.06	ns	0.1	0.11	ns	0.02	0.05	ns
Lambkin male	0.09	0.07	ns	0.07	0.12	ns	0.06	0.04	ns

p-value indicating the level of significance

ns not significant

*** $p < 0.001$

** $p < 0.01$

* $p < 0.05$

Table 4 Measures adopted to control diseases in the different counties

Disease control measure	Survey	Per cent of households adopting measure in each county		
		Isiolo	Marsabit	Turkana
Deworming	Baseline	38.1	17.86	13.21
	Monitoring	47.62	90	71.15
Vaccination	Baseline	9.52	7.14	1.89
	Monitoring	0	26.67	19.23
Tick control	Baseline	9.52	7.14	1.89
	Monitoring	85.71	73.33	21.15

different counties evident at the time of monitoring using logistic regression analyses is presented in Fig. 2.

The technology with the highest probability of adoption in all three counties was the prevention of diseases in the animals and most notably Isiolo County which showed the highest probability of adoption (65%, Fig. 2). Crossbreeding and castration of male animals were adopted differentially in the counties. Adoption of cross-breeding for both sheep and goats was higher in Marsabit County (45% for sheep and 60% for goats) relative to Isiolo County (30% for sheep, 50% for goats), while adoption of castration in the two counties differed depending on the species with a 60% and 50% probability of castration in sheep and goats, respectively, in Isiolo and a 50% and 60% probability of castration in sheep and goats, respectively, in Marsabit. Amongst the three counties, Turkana County had the lowest probability of adopting any of the technological interventions with a 40% probability of adopting disease prevention; 21% and 12% probability of adopting improved feeds in goats and sheep, respectively; less than 10% probability of adopting crossbreeding in any species; and a 35% and 10% probability of adopting castration in goats and sheep, respectively (Fig. 2).

The probability of the households in all the counties using more than one technology is illustrated in Fig. 3. When the baseline was conducted, the probability of households using more than one technology was negligible in all three counties. However, following training, the probability of households using three or more technologies at a given time increased to over 30% (Fig. 3). Ordinal logistic regression coefficients show

Table 5 Grazing systems adopted in the different counties in the dry and rainy seasons of the year

County		Per cent (%) of households adopting the feeding system			
	season	Rainy		Dry	
	Type of feeding system	2018	2021	2018	2021
Isiolo	Only grazing (free-range or tethering)	100	1.25	80	2.5
	Transhumance	0	98.75	0	97.5
	Mainly grazing with some stall feeding	0	0	12	0
	Mainly stall feeding with some grazing	0	0	8	0
Marsabit	Only grazing (free-range or tethering)	100	4.63	96.83	4.63
	Transhumance	0	95.37	0	95.37
	Mainly grazing with some stall feeding	0	0	3.17	0
	Mainly stall feeding with some grazing	0	0	0	0
Turkana	Only grazing (free-range or tethering)	97.06	100	8.98	56.12
	Transhumance	0	0	0	13.27
	Mainly grazing with some stall feeding	2.94	0	90.7	30.61
	Mainly stall feeding with some grazing	0	0	0	0

that Marsabit had the highest probability of households using all the recommended technologies (0.42) compared to Isiolo (0.31) and Turkana Counties (0.15) (Fig. 3). During the monitoring survey, the household heads in all the counties reported that they were using more animal breed improvement technologies than at baseline.

Discussion

The adoption of interventions in different communities is highly influenced by leaders within pastoral households. When introducing interventions that require changes in existing practices, an understanding of the characteristics of the household leadership guides the adaptation of training approaches and helps in managing expectations. In the three counties of this study, the diverse characteristics of the household heads in Turkana County relative to Isiolo and Marsabit necessitated the training approach in Turkana to enable more experiential learning.

Flock dynamics and breeds adopted

The goat and sheep numbers owned by the CIG households in Marsabit, Isiolo and Turkana increased between 2018 and 2021 (Table 2). The increase in flock sizes was attributed to better rainfall in the 3 years and a desire by the communities to rebuild and multiply their livestock population that had been greatly reduced in the preceding years when the droughts were severe. When environmental conditions are good, pastoral households generally acquire goats and sheep which are known to have a faster rate of reproduction than the larger ruminants, with the aim of selling them later to purchase cattle (Little et al. 2014). The pastoralists in Eastern Africa tend to pursue strategies that enhance herd production and reproduction rather than culling unless there is an increased demand for cash for expenditure purposes (Little et al. 2014; Zonabend König et al. 2016). Sheep and goats are traded easily amongst pastoral communities for either cash or in exchange for other commodities through barter trade (Abdilatif et al. 2018).

Table 6 The relative importance of different traits in both sheep and goats for the pastoral livestock keepers at baseline (2018) and monitoring (2021)

Trait	Year	Isiolo			Marsabit			Turkana		
		Weighted score	Index	Rank	Weighted score	Index	Rank	Weighted score	Index	Rank
Age	**2018**	52	0.2	2	101	0.3	1	38	0.1	4
	2021	94	0.3	2	158	0.3	1	266	0.2	1
Breed	**2018**	51	0.2	3	13	0.0	5	13	0.0	5
	2021	61	0.2	3	72	0.1	5	262	0.2	2
Conformation	**2018**	50	0.2	4	46	0.1	4	149	0.3	1
	2021	52	0.1	5	118	0.2	3	258	0.2	4
Nutrition status	**2018**	40	0.2	5	86	0.3	3	140	0.3	2
	2021	61	0.2	3	115	0.2	4	260	0.2	3
Sex	**2018**	72	0.3	1	90	0.3	2	92	0.2	3
	2021	107	0.3	1	133	0.2	2	256	0.2	5

Table 7 Results from the logistic regression analysis of factors influencing the adoption of technologies

Fixed effect (reference in bracket)	Coefficient ± SE	*p*-value
Gender of household head (male)		
Female household head	0.26 ± 0.29	0.371
County (Isiolo)		
Marsabit	1.20 ± 0.43	0.005
Turkana	−0.64 ± 0.43	0.135
Year of survey (2018)		
2021	1.86 ± 0.31	0.000
Number of sheep owned	0.05 ± 0.01	0.000
Number of goats owned	0.03 ± 0.01	0.000

With the improved rainfall experienced during the RPLRP programme, CIG members in all three counties reported in the FGD that if conditions further improved, they would readily sell off their goats and sheep and buy cattle. They however noted that the mortality of cattle was high hence goats and sheep were a better option. High mortalities of larger animals in arid areas of Eastern Africa following droughts have resulted in a rapid increase in the sheep and goat populations (Muigai et al. 2017; Opiyo et al. 2015).

The higher proportion of crossbred goats (Indigenous × Galla) and sheep (Indigenous × Dorper and Indigenous × Red Maasai) in pastoral flocks of Isiolo and Marsabit Counties in 2021 relative to when the baseline was conducted could be attributed to the training on measures to improve productivity, together with the slightly improved rainfall which resulted in increased flock sizes. In Turkana County, however, the households generally retained the Small East African goat and the Blackhead Persian sheep. Devastating droughts in Turkana County that negatively affected the livelihood and security of communities have resulted in adaptive and coping strategies that emphasize the exploitation of the existing resources (Opiyo et al. 2015). The high frequency of droughts also reduces recovery periods for the livestock populations in households, leading to a higher focus on survival of the animals rather than reproduction and growth as was noted in the ranking of traits in animals by the different CIG members (Table 6). Limited recovery periods for livestock could also contribute to the increased caution by the Turkana pastoralists in adopting new breed types for their flocks. Caution in crossing different breeds by pastoral communities was also reported in a study on breeding practices adopted by pastoralists in the Isinya and Amboseli regions of Kenya (Zonabend Konig et al. 2017). The study reported that in more arid conditions, the communities retained purebred indigenous breed types with good reproduction and mothering ability rather than faster-growing crossbreds.

Breeding programmes developed for arid environments should have a higher focus on within-breed selection implementing mating strategies to ensure diffusion of both productive and resilient lines within the populations.

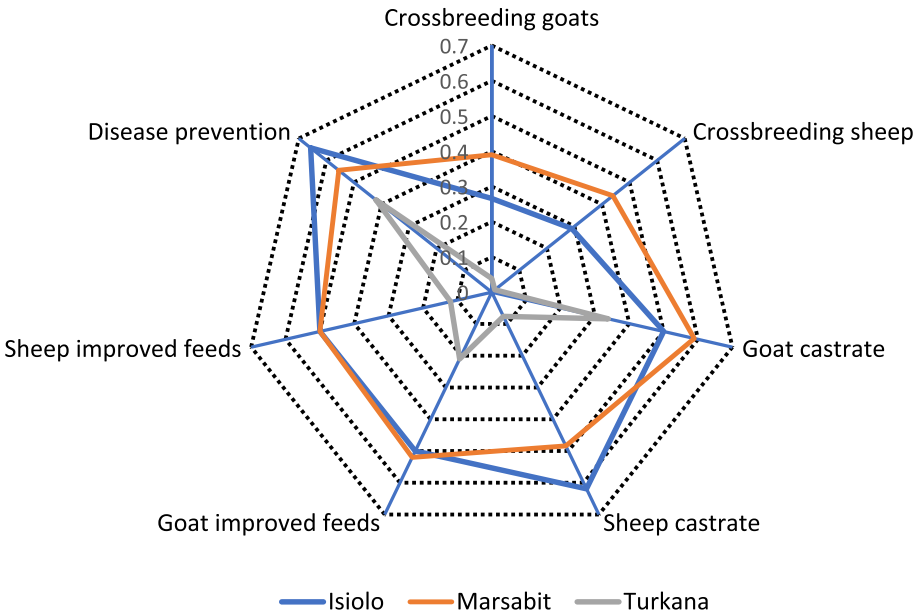

Fig. 2 The probability of adoption of different technologies (castration, crossbreeding, improved feeding and disease prevention) in the 3 counties

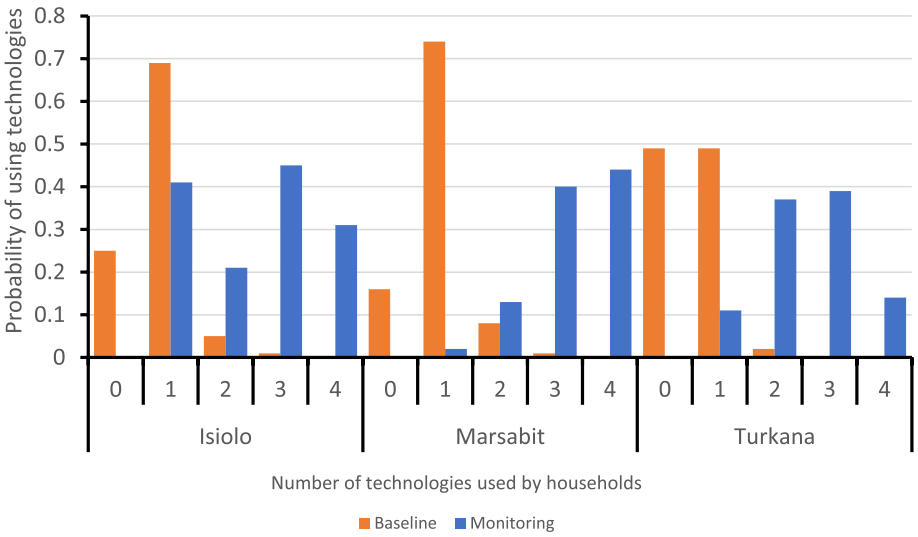

Fig. 3 The probability of households adopting different numbers of technologies recommended through project (0 = no technology adopted, 1 = 1 technology adopted… 4 = 4 technologies adopted)

Adoption of management practices

The number of animals owned by individual households appeared to be few (Table 2); however, all animals of a community were grazed and moved together in large flocks. In Isiolo and Marsabit Counties, during the monitoring of practices adopted, it was notable that the communities adopted grazing their flocks in fields from which crops had been harvested by other farmers in addition to the mobile free-range grazing (Table 5). This enabled more optimal use of the range resources and facilitated the co-existence of the pastoral livestock keepers with the more sedentary farming communities growing crops. As in other arid regions of Kenya (Kosgey et al. 2006, 2008), the pastoralists use mobility to counter uncertainties in the rainfall distribution and hence the availability of forages and to counter disease incidences.

RPLRP programme interventions that helped control or reduce incidences of diseases were readily adopted by the different communities. Studies on other communities in the arid areas of Kenya indicate that diseases and drought are key challenges in rearing sheep and goats (Abdilatif et al. 2018; Nkedianye et al. 2011; Omondi et al. 2008; Zonabend König et al. 2016). Training pastoral communities in livestock health management has been reported to reduce risks associated with livestock diseases as the pastoralists more readily accept veterinary products and services for their flocks (Opiyo et al. 2015).

It was notable through the FGD that no household adopted any of the interventions introduced across their whole flock but at a measured level in only a portion of their animals. The communities of Isiolo and Marsabit that had larger flocks than those in Turkana had a higher tendency of adopting the technologies introduced (Fig. 2). The CIG members indicated through the FGD that they had previously adopted the practice of separating male and female flocks when grazing to reduce the random mating of animals; however, this was not very successful as haphazard mating would occur when the male and female flocks met. The most readily adopted practice was the early castration of male animals not earmarked for breeding (Fig. 2). Interestingly, castration was more readily adapted for goats across all the counties. Castration of male goats at an early age reduces tainting of meat when the animals are slaughtered. In Turkana County, male rams were not so readily castrated. Additional information on reasons for failing to castrate rams was not obtained in this study.

Leveraging community practices in technology interventions

When monitoring the adoption of technologies relative to the baseline, the adoption of technology interventions increased to over 30% following the training, demonstrating that changing long-established practices can be achieved in pastoral communities using inclusive community-based methods. Community involvement enables clarity when defining objectives in breeding livestock, creates a sense of ownership of the improvement envisaged and facilitates adaptation and adoption of technologies for the targeted environment (Mueller et al. 2015; Haile et al. 2019). It was notable that the adoption of the different technologies introduced was not dependent on the gender of the household head (Table 7). This indicated that in the communally managed flocks, animals

owned by both men and women benefited from technological interventions. A previous study on the pastoral communities in five counties of Kenya including Isiolo, Marsabit and Turkana, indicated that women often had limited access to agro-veterinary services due to their home-based roles (Kariuki et al. 2022). The targeted engagement of both men and women as CIG members in the RPLRP programme enabled equitable adoption of the different technologies. Development interventions need to integrate indigenous management practices and socio-ecological dynamism of the pastoral communities (Akall 2021) in order to promote nature-based solutions to restore and enhance adaptable ecosystem services under the changing climatic conditions.

Conclusion

Results from this study illustrate the willingness of pastoral communities to adopt new management practices and technologies in their sheep and goat flocks. When climatic conditions are favourable, the communities are receptive to technological interventions that help enhance herd productivity and expansion. However, where climatic conditions are harsher and education levels lower, households adopt changing practices more cautiously. More effective adoption of technologies is achieved through adapted experiential capacity development in line with the exposure level of the communities. Innovative strategies using community groups should be expanded with supportive monitoring and evaluation to benchmark change in each community.

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Authors' contributions

J.M.K.O. conceptualized the study and analyses required and lead the preparation of the manuscript. J.G. developed the data capture tools, followed up on field data capture and management and contributed to the statistical analyses. N.N. provided critical input in the statistical analyses of data. J.G. and A.W.T.M. contributed to the study design, data capture tool development, implementation of field activities and revision and editing of the manuscript. J.W.R. reviewed the analysis methodologies and revised and edited the manuscript. The authors read and approved the final manuscript.

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Availability of data and materials

Data used in this study is available through the ILRI data portal at https://data.ilri.org/portal/dataset/monitoring-pastoral-flock-dynamics.

Declarations

Ethics approval and consent to participate

The study was approved by the ILRI institutional research ethics committee: ILRI-IREC2017-31/2. All respondents provided their informed consent to participate in the RPLRP project, knowing that the information generated would be shared with global audiences through various publications.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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