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POLICY RECOMMENDATIONS FOR PROMOTING THE VIABILITY OF HAY PRODUCTION IN THE ARID RANGELANDS OF KENYA

Kimaru J[1]*, Mutembei H[2] and JM Kaunga[2]

Judy Kimaru

*Corresponding author Email: judykimaru@gmail.com

[1]The University of Nairobi, Department of Climate, Earth and Science, Nairobi, Kenya

[2] The University of Nairobi, College of Agriculture and Veterinary Studies, Nairobi, Kenya

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ABSTRACT

Hay production in arid and semi-arid areas of Kenya is a flagship program under drought risk reduction and climate change adaptation strategies like the Kenya Climate Smart Agricultural Project, the Agricultural Sector Transformation and Growth Strategy, and the Range Management and Pastoralism Strategy. In Kajiado County, the roll-out of the hay production flagship program began in 2018 without precise data on the financial viability of producing hay as a private enterprise. To inform the implementation of the hay flagship project, planners need a cost-benefit analysis of the hay enterprise and the challenges around hay production. The study undertook a literature review, a knowledge, attitude, and practice survey on 354 pastoralists, and a cost-benefit analysis of 23 hay-growing farms in Kajiado Central, Ololiloi and Mashuru sub-counties. The findings showed that proximity to hay farms and availability of hay resulted in livestock keepers increasing the hay fed to their livestock from 23 % to 62 % during the droughts of 2015 and 2017, respectively. However, 35 % of the hay farms having less than 90 acres and 8 % of the hay farms producing less than 4,250 hay bales (15 kgs per bag) were not profitable. Despite only two farms of over 400 acres accounting for 73 % of all hay production, they need more tangible support from the government. Furthermore, farms owning machinery and irrigation facilities were unprofitable, while rain-fed farms hiring machinery were profitable after three years. Other factors affecting profitability were cropping practices, herder-farmer conflicts, hazards like fires, and capital expenditure like building hay stores and purchasing irrigation equipment. Decision-makers need to address the inadequate seasonal hay market worsened by pastoralists' hay-buying behaviour, which was 86 % influenced by animal deaths at the peak of the drought. This paper recommends actionable policy frameworks to establish public-private-producer partnerships, promote stable markets, set up strategic hay reserves, promote low-technology production methods, and train commercial hay producers. In addition, policies should encourage pastoralists to diversify their livestock feeding options during droughts and use hay vouchers for drought response. Furthermore, the policy frameworks should be expanded to provide cash subsidies to hay farmers, address the high costs of machinery and promote drought-based insurance policies.

Key words: hay, drought, cost-benefit analysis, climate-smart agriculture, pastoralists, livestock

INTRODUCTION

The livestock sector in Africa suffers from several natural and human-made disasters, such as drought, storms, floods, landslides, animal diseases, pests, locusts, earthquakes, urban and forest fires, poisoning and power outages in animal production units [1]. The connection between droughts and livestock production points to drought's impact on animals directly and indirectly. Droughts directly affect animal growth, the quality of animal by-products, and reproduction. Indirect effects include reduced quantity and quality of grasses and increased livestock disease and parasites [1]. Climate change has intensified droughts in arid and semi-arid lands (ASAL), where pastoralism is the main livelihood [2]. Traditional pastoralism, where livestock moves through vast areas, enables the rangeland ecosystem's carbon sequestration capability more efficiently [2]. However, socioeconomic pressures like changes in land tenure, agricultural expansion, extractive industries, and real estate have reduced rangelands for livestock mobility in traditional pastoralism [2].

Several sub-Saharan African countries have invested in hay production to help pastoralists save their livestock during droughts and sustainably use marginal rangelands [3]. In addition, hay production in rangelands also provides ecosystem services and supports wildlife conservation [3]. Furthermore, hay production utilises several good rangeland management practices that promote soil health, like growing and maintaining healthy, vigorous grass, manuring and weeding invasive species. Therefore, hay production is a crucial climate-smart agricultural (CSA) strategy for addressing droughts in pastoralism livestock systems [3].

A 2018 study by the International Livestock Research Institute suggests that for Kenya to bridge its approximately 3.6 billion bales of annual hay deficit, an additional 15 million acres of land under fodder crops and pasture will be needed [4,5]. This acreage of land is only available in the ASAL. Kenya has initiated several projects to support fodder production to meet this demand, especially commercial fodder production [6]. However, although providing animal feed during droughts is crucial, there is insufficient robust financial and economic data to support the upscaling of hay production, especially by the private sector, towards attaining CSA targets and the United Nations Sustainable Development Goal (UN-SDG) 2.4.1 [7].

The study assessed the viability of hay production as a drought-resilient climate-smart option in the pastoralist systems of Kajiado County to inform policy recommendations and implement existing hay flagship projects in Kajiado County and other arid areas in Kenya.

MATERIALS AND METHODS

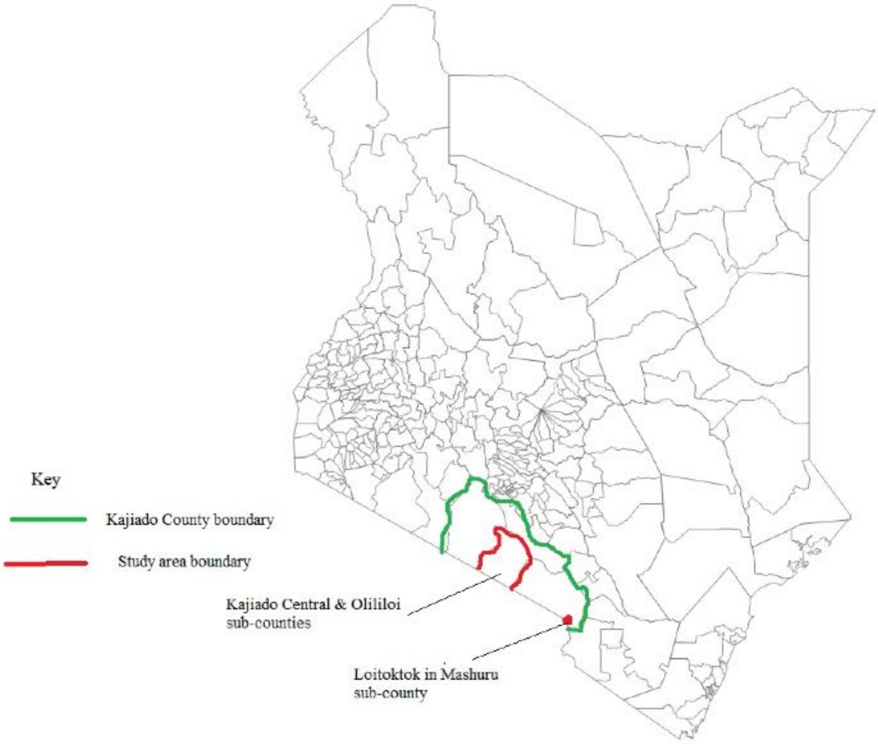

Figure I: Map of the location of the study in Kajiado County

Kajiado County is one of Kenya's arid and semi-arid lands (ASAL), covering 19,600 square km with 1.8 million animals, with rainfall averaging between 300 to 800 millimetres yearly [8, 9]. Kajiado County has seven sub-counties: Kajiado East, Kajiado West, Kajiado North, Kajiado South, Kajiado Central, Ololiloi and Mashuru. The study area covers Kajiado Central sub-county locations with the following coordinates: From Isinya (1.6727° S, 36.8425° E) to Kajiado Town (1.8421° S, 36.7919° E); continues into Oloililoi sub-county from Ibissil (2.0940° S, 36.7873° E) to Namanga town (2.5521° S, 36.7839° E). The study also included Loitoktok 2.9248° S, 37.5081° E in the Mashuru sub-county.

This study used a mixed-method approach of a literature review of published and unpublished reports and a field survey collecting data from 2005 to 2021. A purposeful sampling method selected pastoralists and hay growers. According to Cochran 1977 recommendations on sampling techniques when the population residing in the study area is over 100,000, the sample size should be at least 204 at a 7 % precision and 95 % confidence rate [10, 11]. In line with Cochran, the study selected 354 livestock keepers and hay farmers and interviewed them using a structured and semi-structured knowledge, attitude, and practice (KAP) questionnaire and focused group discussions (FGDs) on the farm's cropping and business practices. In addition, the researcher collected market data from traders selling hay in the Ibissil town market.

A total of 23 hay farms ranging from 5 to 400 acres were selected, accounting for 23/26 (88 %) hay farms in the study area. The 23 farms were selected based on the availability of farm owners and managers. The 23 hay producers were categorised as follows: eight large producers (400 - 135 acres of hay), seven medium producers (20-50 acres of hay) and eight small producers (3-15 acres of hay). Farms growing over 350 acres accounted for 73 % of total hay production.

The study limited itself to hay growing, on-farm hay storage, and on-farm hay sales within the hay value chain. The processors (feed manufacturing industry), aggregators (retailers or wholesaler traders and industry), and distributors (transporters) within the hay value chain were not accessed. The study also limited itself to pastoralists buying hay at gate prices and living within the study area.

Based on the UN-SDG Target 2.4, which focuses on productive and sustainable food production systems that are resilient and adaptive to climate change, the UNFAO recommends measuring agricultural production sustainability using farm surveys under the indicator UN-SDG 2.4.1. Surveys are flexible across different agricultural geographies and provide comparable data to measure sustainability across economic, environmental, and social factors [7]. Under indicator UN-SDG 2.4.1, the economic values to measure include, (1) Land productivity (farm output value per hectare) and, (2) Profitability (net farm income) because profitability can be a standalone measure to determine agriculture sustainability [7].

Following FAO guidelines, a cost-benefit analysis (CBA) was carried out on 23 hay farms to establish the profitability and sustainability of hay production in Kajiado. Specifically, (i) establishing the optimal hay output that will make hay farming profitable, (ii) determining how fluctuations in demand for hay from pastoralists and supply of hay from farms affect the price of a hay bale (price sensitivity) and (iii) identifying the major cost centres of hay production.

The CBA values used were (a) Net Present Value (NPV), (b) The Payback Period, (c) Internal Rate of Return (IRR), (d) Return on Investments (ROI), and (e) Price Sensitivity Analysis [11].

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Net Present Value (NPV) is the difference between the total discounted benefits minus the total discounted costs. Projects with positive net benefits are viable, while those with negative net benefits are not viable. The higher the positive NPV, the more benefits the project provides.
The formulae below were used to calculate the Net Present Value (NPV):

$$NPV = \sum \left(\frac{C_t}{(1 + K)^t}\right) = IO$$

Where:
C = Cash flow in time t (C_t)
t = time period of investment (summation of years 1, 2, 3, 4 & 5)
K = Discount rate
IO = Cost of investment/ initial cash outlay

When NPV > 0, accept the project and when NPV < 0 reject the project and when NPV = 0 be indifferent.

The Internal Rate of Return (IRR) aims for the period (month or year) when the discounted benefits minus the initial capital investment gives an NPV equal to zero. In other words, the project has paid back its initial capital and can now be considered viable. The higher the IRR (above zero), the more desirable the project.

The formulae used were:
IRR= NPV = discounted benefits − Initial Investment (IO) = 0
If IRR ≥ 0, the enterprise is profitable and accepts the project. If IRR < 0 enterprise is loss-making; therefore, reject the project, and if IRR = 0, this is the enterprise's break-even year.

The Return on Investment (ROI) is the total benefits of the entire project. When ROI is positive, then total returns are higher than total costs. The formula used was:

$$\text{ROI} = \frac{\text{Cost of investment}}{\text{Net Return on Investment}} \text{ X } 100\%$$

When ROI is positive, accept the enterprise as viable; when ROI is negative, reject the enterprise.

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The Payback period is the time (month or year) when a project's total discounted costs surpass the total discounted benefits. In other words, the project will see net profits or benefits in the year following the project payback period.

RESULTS AND DISCUSSION

Implementation of drought-supporting strategies

From the landscaping of 30 national policy instruments, two strategies, namely, the Agricultural Sector Transformation and Growth Strategy (ASTGS) and Kenya Climate-Smart Agriculture Program (KCSAP), have hay production as flagship projects. On review of the Kajiado County Integrated Development Plan (CIDP) 2018-2022, it was found that the ASTGS and KCSAP are stated in the plan. The CIDP, under the KCSAP project, has a hay flagship project aiming to increase livestock resilience to recurring droughts by investing in hay production, reducing post-harvest losses, expanding irrigation, encouraging modern technologies, and reducing climate change impacts [12].

The Kajiado CIDP has implementation gaps in designing and rolling out the hay flagship project. For instance, the involvement of the private sector could be more substantial, and the direct support to hay farmers to ensure a vibrant hay production enterprise could be much better. As currently implemented, the CIDP's budgetary allocation goes to government institutions for fencing, buying farm machinery for demonstration farms, and targeting hay production training to the existing pastoral field schools [13]. The study found that only 6% of the pastoralists took up hay farming. In addition, the hay farmers in the study all cited that they had yet to receive training from the government. Furthermore, hay farmers do not utilise the County's balers because they need to be more efficient in service delivery. This lack of direct government support for existing hay farms has led to low uptake of cost-effective cropping technologies resulting in low hay productivity.

Determinants of demand for hay from pastoralists

Migrating livestock in search of grass and water is the primary traditional drought mitigation strategy used by pastoralist communities in Kenya. Migrating animal results in high monetary losses. For instance, emaciated animals sold at throw-away prices account for 54% of losses incurred by pastoralists during drought migration. Another 36% of drought migration losses are attributed to livestock death, 4% are from the cost of treating sick animals, and 6% are from wildlife predation, as illustrated in Figure 2.

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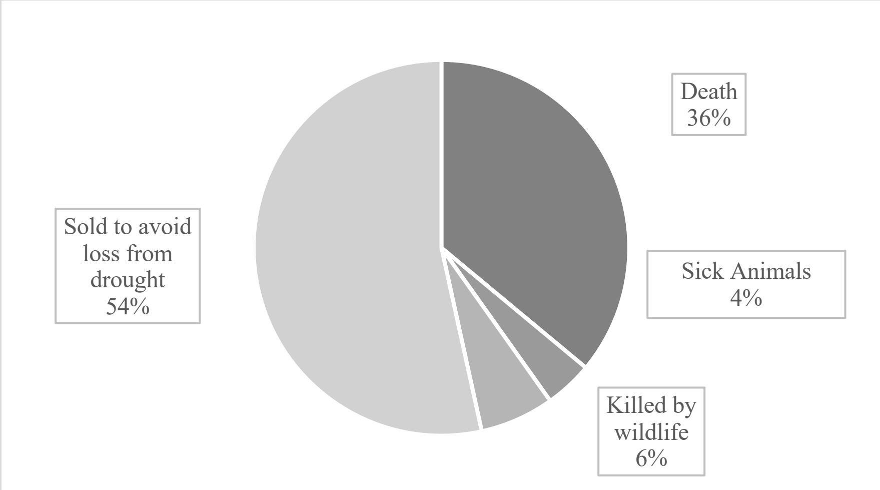

Figure 2: Livestock (cattle, sheep and goats) losses during migration due to droughts (2005, 2009, 2015 and 2017)

Hay bought accounted for 60% of the feed for livestock, commercial feeds accounted for 22%, other forages accounted for 10%, own-grown hay 19% and purchased 49% during the droughts of 2005, 2007, 2009 and 2017, as illustrated in figure 3.

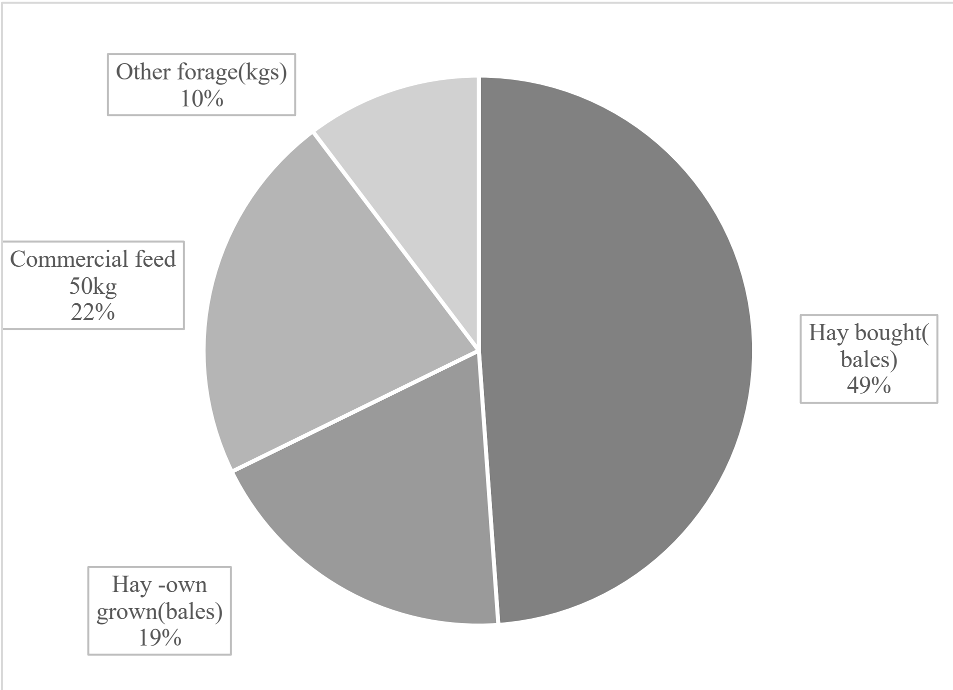

Figure 3: Livestock Feeding Options used by pastoralists in drought years of 2005, 2007, 2009 and 2017

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The regression analysis results shown in Table 1 indicate a strong positive coefficient of correlation R=0.93 between the livestock losses that pastoralists incur during droughts and their tendency to buy hay to sustain their animals. Another crucial correlation indicator is the R square value (0.8617) which shows that 86% of pastoralists' decision to purchase hay was triggered by the losses they incurred from the drought. However, this is only significant at a p-value ($p<0.005$), n=10. The remaining 14% (100% - 86%) reasons farmers bought much hay can be explained by other factors (proximity of hay market to livestock, quality of hay, access to credit, alternative income sources) that are not captured in this model.

Land to migrate animals over vast areas is shrinking due to land use changes. Drought is the primary driver of demand for hay among pastoralists. However, pastoralists need to improve their adaptation to new technologies like growing hay forage.

Determinants of supply and profitability in hay production

Farm Size

The study analysed farms ranging from 3 acres to 400 acres. Hay production per acre was the most significant determinant of profit. To be profitable, farms need to optimise productivity per acre to produce at least 4,250 bales annually at the sale price of USD 1.8 per 15 kg bale, with optimal cultivation practices such as weeding, manuring and clearing invasive weeds. Farmers can harvest 4,250 bales of 15 kg each with 90 acres under the hay; farms producing below this quantity are unprofitable irrespective of the farm size because the operational costs exceed the income for hay sales. Farms smaller than 100 acres were unprofitable, as illustrated in Table 2.

Buying versus Hiring Machinery

The 400-acre farm that bought and maintained its machinery was not profitable. The 400-acre farm that hired machinery was profitable by the third year, with a significantly higher NPV of 25,100 (Table 3). The machinery evaluated in this study were balers, cutters, and tractors. Machinery is a high capital expenditure item with high operating and maintenance costs, making these farms unable to recoup initial investments within five years.

Irrigation versus rain-fed

The 400-acre Boma Rhodes farm had an irrigation setup that allowed for three crops per year, one legume crop and two Boma Rhodes grass crops. Although using irrigation can enable the production of three crops per year, the high costs of buying, setting up and maintaining the irrigation system resulted in the farm taking well over five years to recover the initial capital costs, as indicated in their negative NPV (-88,484), IRR (-0.17) and ROI (-40%), refer to Table 3. In contrast, the rain-fed farm had a payback period of three years.

The farm growing Boma Rhodes grass uses an overhead rain-gun irrigation system that costs USD 5500 per acre, compared to a drip-type irrigation system that costs USD 1200 per acre [14]. Extension officers should carefully consider the appropriate irrigation system relative to the farm's size before farmers are encouraged to set them up. The study showed that irrigating pastures resulted in negative NPV, IRR and ROI and should not be used in hay pasture cropping practices in ASAL.

Hay stores

Depending on the construction material used, a store with a 20,000 hay bales capacity costs about USD 20,000 (Table 4). Although expensive, building hay stores was a necessary capital expenditure because storing hay for 1-2 years cannot be avoided. The demand for hay depends on the drought cycle, with the highest demand during a severe drought. The low hay demand during good rains forced farms to store the hay.

To offset losses incurred from harvesting hay only to store it for more than one year, the 400 acres farm chose not to harvest in 2020 and 2021. Instead, this farm increased its income by renting out the land for grazing in 2020 and 2021. In the other years, from 2015 to 2017, renting grazing was only one-month post-hay harvest. The results in Table 4 illustrate the dynamics of harvesting on profits.

Hay market

Demand for hay is negligible in years of average or abundant rainfall. However, when droughts occur, the market is excellent. Droughts deplete grass on rangelands resulting in livestock dying of starvation, triggering pastoralists to buy hay in desperation, as results in Table 1 show. However, when there is good rainfall, pastoralists have free grazing resources to feed their livestock. Despite the years when there have been no hay sales, farms still have recurring annual overheads and costs to pay. After one to three years in storage, the income from sales does not offset the cumulative yearly operating expenses. Table 4 illustrates that during the study period, farms sold hay in 2015, 2016, 2017 and 2018. However, in 2019 and 2020, until November of 2021, there were no hay sales as rains were average, providing adequate forage for livestock in the communal free rangelands.

To address the drought-driven demand for hay, the government should consider establishing a national feed and fodder strategic reserve that would buy hay from private farmers during good rainy seasons and redistribute it to pastoralists during droughts under humanitarian aid. At the sub-national level, ASAL Counties like Kajiado should also consider setting up strategic feed and fodder reserves. Alternatively, Kajiado County can create public-private-producer partnerships (4Ps) engaging the government, large feed-utilising businesses, export abattoirs and commercial hay farms. The government can facilitate seasonal bulk buying and storing of hay during good rain years through export abattoirs, fodder bulkers, or strategic animal feed and fodder reserves. Alternatively, the government can subsidise the farms to store the hay and then sell it at controlled subsidy prices to pastoralists during droughts, as an example of the 4Ps described by IFAD [15].

Challenges in setting up hay production enterprise

Lack of insurance for the hay

Although the 400-acre farm had insured the farmhouse against fire, the insurance coverage did not extend to the open farmland. After the 2018 fire, the insurance company offered a very high premium fire cover that needed to be more attractive to farmers. The hay enterprise is predisposed to wildfires, accidental fires, flood damage, and post-harvest losses due to moisture mould, locusts, armyworms, and insect infestation. These hazards can happen during the stages of growing, harvesting or storage. Hay growing is considered high risk by insurance companies in Kenya like Old Mutual/ UAP and Britam and, therefore, do not cover hazards like fire or floods. Table 4, under costs, includes the USD 2000 cost of reconstruction and loss of potential (2018) hay sales incurred by the farmers after losing the store and hay harvested in early 2018 to a fire in late 2018. Table 4 shows the NPV was positive, therefore profitable, in 2016, 2017, and 2019 for the 400 acres of farms growing the local indigenous grasses. The farm's cropping practice, additional grazing income, and the fire hazard in 2018 illustrate what a typical farm is likely to experience. The profitability of hay farms is very sensitive to sale dynamics and hazards.

Illegal livestock grazing

From the survey interviews, the farmers elaborated on the issue of illegal grazing by neighbouring pastoralists that regularly resulted in farmer-herder conflicts, leading to insecurity. Farms also noted that the illegal grazers also damage fencing when driving their herds onto the farms. As a result, hay farms incur losses on fence repair, hiring security personnel to patrol the farms, and time spent in court cases at the local chief office. Illegal livestock also feeds on the growing grass leading to reduced harvest and profits for the farmer. The costs inTable 4 show that fencing repair is an annual recurring cost due to these illegal grazers.

Lack of relevant training and extension services
Interviews found that half the farmers cited the need for more relevant government support for the hay value chain, leaving them to figure things out. Despite hay being a priority flagship project in Kajiado County, farmers have yet to report attending a meeting between hay growers and the County government. Due to this lack of interaction, the hay producers' issues and potential solutions need to be represented in the CIDP implementation. These findings are similar to those reported by Mohamed Sala et al. [16] for Isiolo County.

Ineffective cooperatives for the hay farmers
From the key informant interviews, all the farmers rejected setting up hay cooperatives, citing corruption as the main reason. Interestingly, creating cooperatives is crucial under the Kajiado County CIDP and the Agricultural Sector Growth and Transformation Strategy. These findings are similar to those Mohamed Sala et al. [16] reported in a study in Isiolo County.

CONCLUSION

Farmer-responsive implementation of the strategy: Kenya has adequate policies, strategies, and structures to address drought risk reduction, including emphasising hay production at national and county levels through the ASTGS, KCSAP, and the CIDP. However, the action plans under implementation still need to translate to a tangible increase in hay production in targeted counties. There is a need to revisit the activities planned under the hay production flagship project to ensure that private hay producers are supported.

Establish public-private-producer partnerships (4Ps): The government should consider establishing 4Ps that address the challenges of hay farmers, such as the unstable hay market, expensive capital assets and machinery, poor quality forage seeds, and inadequate education by extension services. A 4P should stabilise the hay market, maintain good quality hay, and provide a fodder-drought response.

Establish strategic hay fodder reserves: To address post-harvest losses, strategic public or private hay fodder reserves can be established under its existing KCSAP strategy.

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Promote low-technology production methods: Low technology in hay farming includes using readily available livestock manure, weeding, and fencing that achieve better hay output. Extension officers should refrain from encouraging the uptake of expensive technology like irrigation and purchasing tractors and balers. It is crucial to decide what kind of irrigation system is appropriate to a farm's size before advising farmers to invest in a scheme to irrigate pastures that would lead to negative NPV, IRR, and ROI.

Hay farmer training: Training commercial hay producers should be prioritised. The current projects under KCSAP focus on encouraging pastoralists to grow hay. The government must address the mismatch of training pastoralists who have yet to show much interest in growing hay instead of training the current hay growers.

Pastoralists trained on hay feeding: Encourage the uptake of hay as a regular feeding option during droughts and dry seasons to improve livestock productivity. The study found that pastoralists preferred to purchase hay during droughts, with hay as a feeding option growing from 23% (2015) to 62% (2017). Pastoralists did not utilise hay during periods of average rainfall, even in the months between the rainy season.

Hay vouchers for drought response: To increase access to hay and support private hay producers, humanitarian actors should consider voucher-based interventions for pastoralists to access hay during drought. Hay is in very high demand during drought, and the price can increase from USD 1.8 to USD 3.5 per 15 kg bale, making it out of reach for vulnerable households. Government drought interventions can provide vouchers to low-income families to access hay.

Introduce hay subsidies for farmers: The hay enterprise is still in its infancy as a climate change adaptation strategy and needs support. One solution is to subsidise hay producers to ensure enough hay supply during drought. As part of drought risk reduction strategies, the government should consider cash subsidies directly to hay farmers. Hay farmers will benefit from subsidies for the years they need to store hay when the rains are good and free grazing pasture is readily available. In Kajiado Central, only eight farms cultivate over 100 acres, accounting for 73% of all the hay produced in the sub-county. For example, an annual cash subsidy for a 400-acre farm is USD 22,000 to cover the storage, capital purchases, and hazards. To protect the eight farms, total cash subsidies of between USD 120,000 and USD 150,000 per year would keep the hay farmers in business. Existing KCSAP budgets can easily accommodate this money.

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Insurance for hay enterprises: The insurance sector needs to expand drought-based insurance policies for farmers and pastoralists. For example, Kajiado County signed an agreement with Kenya Risk Transfer Services to incentivise farmers to take out hay insurance policies.

Table 1: Correlation between feeding and livestock losses

Regression Statistics	
Multiple R	0.9283
R Square	0.8617
Adjusted R Square	0.8444
Standard Error	3813156.5190
Observations	10.0000

	Coefficients	Standard Error	t Stat	P-value
Intercept	1418410.8873	1380476.7202	1.0275	0.3343
Hay bought (bales)	1628.8208	230.7116	7.0600	0.0001

R-regression
t-stat - hypothesis test statistic
p-value - number, calculated from a statistical test, describing the likelihood of a particular set of observations if the null hypothesis were true. P-values are used in hypothesis testing to help decide whether to reject the null hypothesis [17]

Table 2: Profitability of 10-to 200-acre Farm sizes without hay stores

Farm Size	Net Present Value (NPV)	Return on Investment (ROI)
200	(3,133,650)	(0.79)
150	(2,034,386)	(0.79)
50	(323,496)	(0.46)
10	(1,087,873)	(0.74)

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Table 3: Comparison between rain-fed/ machinery hiring versus irrigation/ machinery buying farms

400 acres that hired machinery & rain-fed		400-acre that bought machinery and irrigation	
NPV of project	25,092	NPV of project	-88,484
IRR	38%	IRR	-0.17
ROI	23%	ROI	-40%
payback period	3 years	payback period	beyond 5 years

NPV – Net Present Value IRR – Internal Rate of Return ROI – Return on Investments

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Table 4: Profitability of 400-acre farm (growing local variety grasses, hiring machinery and rain-fed)

The initial cost of the capital cluster (USD)	
Store construction cost	20,000
Fencing Cost	10,000
Bush Clearing Cost	12,000
	42,000

No of the bales sold	Years	Price per bale (USD)	Revenue in USD	Cultivation strategy
6000	2015	3	18,000	Harvest
8000	2016	2.5	20,000	Harvest
15000	2017	3	45,000	Harvest
19200	2018	0	0	Harvest
10500	2019	0	0	Fire destroying hay store & hay 2018 hay; 2019 hay harvest
0	2020	0	0	no harvest; increased grazing hires
10,500	2021	3	31,500	no harvest; sold hay stored; increased grazing hires

Discount rate 10%
The initial cost of capital 42,000

		2015	2016	2017	2018	2019	2020	2021
Cash in-flows	Year	0	1	2	3	4	5	6
Sale of Hay		18,000	20,000	45,000	0	0	0	31,500
Grazing income		1,500	1,500	1,500	1,500	1,500	6,000	6,000
Cash inflows		19,500	21,500	46,500	1,500	1,500	6,000	37,500
PV of cash inflow		19,500	19,545	38,430	1,127	1,025	3,726	21,168
Cumulative cash inflow		19,500	39,045	77,475	78,602	79,627	83,352	104,520
Costs								
Reconstruction Fire hazard – hay stores					2,000			
Tractor & Baler harvesting cost		4,800	6,400	12,000	15,360	8,400	0	0
Gen Utility Cost		300	300	300	300	300	300	300
Fencing Repair Cost			100	100	100	100	100	100
Permanent staff cost		6,000	6,000	6,000	6,000	6,000	6,000	6,000
Weeding Cost		300	300	300	300	300	300	300
Temporary staff for hay		210	210	210	210	210	210	210
Cash outflow		11,610	13,310	18,910	24,270	15,310	6,910	6,910
PV of Cash Outflow		11,610	12,100	15,628	18,234	10,457	4,291	3,901
Cumulative cash outflow		11,610	23,710	39,338	57,573	68,029	72,320	76,221
Discounted total cash outflow								76,221
Net Cash flow/Benefit		-34,110	8,190	27,590	-22,770	-13,810	-910	30,590
PAYBACK (CUMULATIVE PV)		-34,110	-25,920	1,670	-21,100	-34,910	-35,820	-5,230

NPV of project	-13,701
IRR	-4%
ROI	-18%

Notes:
PV of cash inflow-Is the Present value of cash inflows i.e. yearly cash inflow discounted at a discount rate of 10%
PV of cash outflow-Is the Present value of cash outflows yearly cash outflow discounted at a discount rate of 10%
Payback Period, i.e. the project starts to get positive net benefits in year 3 with USD 1670
2018 hay stored – stacking method and fire destroyed it.
2019 hay stored and sold in 2021
No sales saw profits drop to negative within one year

NPV – Net Present Value
IRR – Internal Rate of Return
ROI – Return on Investments
PV – Present Value

REFERENCES

1. **Food and Agricultural Organisation (FAO).** The impact of Disasters and Crisis on agriculture and food security, 2017; pp. 16-19.

2. **Food and Agricultural Organisation (FAO).** Review of evidence on drylands pastoral systems and climate change, FAO, 2009.

3. **Mganga K, Musimba N, Dickson N, Mwang'ombe M and K Agnes** The choice of grass species to combat desertification in semi-arid Kenyan rangelands is greatly influenced by their forage value for livestock. *Grass and Forage value for livestock*, 2013; vol. **70.**10.1111/gfs 12089.

4. **Auma J, Omondi I, Githinji J, LukuyuJ and I Baltenweck** Feed and Fodder Value Chain Assessment Report, USAID-Kenya Crops and Dairy Market Systems Activity, Nairobi. 2018; **201:**10.13140/RG.2.2.14770.66249.

5. **Mininstry of Agriculture.** Re-positioning the Fodder Value Chain in Kenya. The First National Fodder Commercialization, Nairobi. 2017.

6. **Auma J, Omondi I, Githinji J, Lukuyu J and I Baltenweck** Feed and Fodder Value Chain Assessment Report, USAID-Kenya Crops and Dairy Market Systems Activity, Nairobi. 2018; **201:**10.13140/RG.2.2.14770.66249.

7. **Food and Agriculture Organisation (FAO).** Sustainable Development Indicators, 2020; [Online]. Available: http://www.fao.org/sustainable-development-goals/indicators/241/en/ *Accessed September 2021.*

8. **Kenya Bureau of Statistics**. 2009 National Population Census: Livestock by County, 2009.

9. **Kenya Bureau of Statistics.** 2019 Kenya Population and Housing Census Volume I: Population by County and Sub-County, 2019.

10. **William Cochran.** Sampling Techniques third edition, New York,1977;72-86.

11. **Pan American Health Organization.** "A Practical Guide Cost Benefit Analysis," A practical guide for hospital administrators, health disaster coordinators, health facility designers, engineers and maintenance staff to achieve Smart Health Facilities by conserving resources, cutting costs, increasing efficiency in operations and red, 2021; p. Section IV CBA methodology.

https://doi.org/10.18697/ajfand.118.23045

12. **County of Kajiado.** County Integrated Development Plan, County Government of Kajiado, Kajiado, 2018.

13. **County of Kajiado**, Dept of Livestock, fisheries and Cooperatives "Agriculture Sector FY 2017/2018," Kajiado, 2019.

14. **Grekkon**. "Rain gun sprinklers," 2020; [*Online*]. Available: https://grekkon.com/rain-gun-sprinklers-2/ *Accessed April 2021.*

15. **IFAD.** "How to do public-private-producer partnerships (4Ps) in agricultural food chains," 2016.

16. **Sala M, Otieno S and J Nzuma** Determinants of pastoralists' participation in commercial fodder markets for livelihood resilience in drylands of northern Kenya: Case of Isiolo. *Pastoralism* 2020; **10(18).** https://doi.org/10.1186/s13570-020-00166-1

17. **Kimaru J, Mutembei H and J Muthee** Analysis of Hay Demand from Pastoralism Systems on Viability of Hay Production as a Climate Adaptation Strategy in Kajiado County, Kenya. *Agricultural Sciences,* 2021; **12:** 1089-1102. https://doi.org/10.4236/as.2021.1210070

18. **Kenya Agricultural and Livestock Research Organization (KALRO).** Climate Smart Agricultural Technologies, Nairobi: Kenya Agricultural and Livestock Research Organization (KALRO), 2020.

19. **Sala O, Yahdjian L, Havstad K and M Aguiar** Rangeland Ecosystem Services: Nature's Supply and Humans' Demand. In: Briske, D. (eds) Rangeland Systems. *Springer Series on Environmental Management*. 2017 Springer, Cham. https://doi.org/10.1007/978-3-319-46709-2_14