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Assessment of seasonal availability and variability of rice straw as livestock feed in smallholder production systems in Ahero, Kenya

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Abstract

This study evaluated the seasonal pattern and variability of rice straw for feeding livestock within smallholder farming systems in Ahero, Kenya. This study adopted both qualitative and quantitative research methodology, data collected from smallholder farmers. Demographic analysis focused on gender with 62.86% of the respondent being male while age distribution revealed 39.18% of the respondent fell within the 45-54 age bracket. Education levels were modest, with 70.85% completing primary or secondary school. All respondents were farmers, growing rice in one to five acres of land (85.71%). The respondents had over ten years of rice farming experience for 24.29% of respondents. The most adopted rice variety was the IR 27 (88.89%). Rice straw was identified as the leading rice by-product used in feeding livestock (71.21%) and its utilization includes baling (34.65 %) and mulching (30.69%). Nevertheless, advanced utilization methods, such as silage production, were minimally adopted (0.99%). The survey revealed that livestock systems were largely based on extensive grazing (50%) and tethering (47.14%) in both the wet and the dry season, thus limiting intensification. Seasonal feed accessibility remained a major challenge, with crop residue (55.2%) and pasture (42.4%) being the main feed sources. The dry season supplements included rice straw at 56.86%, and maize stovers at 43.14%. Among the respondents, 48.57% indicated that they used value-addition techniques; drying was the most prevalent method (97.06%), and the grinding method was rarely practiced (2.94%) in the region. Knowledge about value-addition techniques knowledge was low, 54.26% of respondents expressed no knowledge about the practices. There was also minimal effort on feed conservation techniques, with no respondents reporting the use of barns, silos, or concentrate supplements in the study area. Therefore, enhanced awareness and adoption of value-added feed technologies and conservation strategies across the study area will bolster feed accessibility as well as livestock productivity.

Keywords: Rice straw, feed utilization, smallholder farming systems, seasonal production, Ahero, Kenya, crop residue, value addition

Introduction

Rice straw, a by-product of rice cultivation, holds significant potential as an alternative livestock feed, particularly for smallholder farming systems constrained by limited resources (Kaur & Singh, 2024) ^[11]. Despite its availability, rice straw remains underutilized in Kenya, where smallholder dairy farmers face recurring challenges in accessing affordable, nutritious feed, particularly during the dry season. Smallholder farmers face persistent challenges in accessing affordable, high-quality livestock feed, especially during the dry season (Cooke *et al.*, 2024) ^[5]. Factors such as the perceived low nutritive value of rice straw, its high fiber content, and limited data on its seasonal availability and variability hinder its widespread adoption (FAO, 2017; Maclean *et al.*, 2013) ^[7, 12].

The Ahero Irrigation Scheme, a prominent rice-growing area in Kisumu County, provides an ideal setting to explore the potential of rice straw as a sustainable feed source. Understanding the patterns of rice straw availability and its variability could enable better utilization of this by-product, thereby addressing feed shortages, reducing agricultural waste, and supporting the livelihoods of smallholder farmers (Rossi & Srail, 2024) ^[23].

Rice production is an important crop globally for food and feed, providing approximately 21% of global human per capita energy and 15% of per capita protein (Abbade *et al.*, 2021) ^[1]. According to FAO (2017) ^[7], rice produces water- and land-efficiently, generating food and feed from otherwise marginal land and using less water per calorie than other major crops. Rice farmers typically harvest the most productive grain and leave or burn the remaining straw as waste (Singh *et al.*, 2021) ^[26]. However, rice straw has potential nutritive value as livestock feed if handled and treated properly (Abo-Donia *et al.*, 2022) ^[2].

This research seeks to shed light on the seasonal dynamics of rice straw availability, the environmental and agricultural factors influencing these dynamics, and the feasibility of integrating rice straw into livestock feeding systems in Kenya's rice-producing regions.

Materials and Methods

Study Design

This study adopted a longitudinal approach to check on rice straw availability and utilization patterns as livestock fed, across seasons with a focus on Kisumu County, specifically the Ahero Irrigation Scheme, a key rice-producing area.

Sampling

A purposive sampling method was employed to select a representative sample of 0 smallholder rice farmers who also manage livestock. The sample included farmers from different sections of the Ahero irrigation scheme to account for potential variations in farming practices, soil conditions, and water access.

Data Collection

Bi-weekly surveys were conducted with farmers to document the quantities of rice straw harvested, stored, used as livestock feed, sold, or discarded. Farmer perspectives on the usability and value of rice straw as fodder will also be gathered. Key informant interviews were conducted with agricultural officers, livestock extension agents, and local leaders to provide insights into seasonal trends, management challenges, and the market dynamics affecting rice straw utilization.

Field measurements with the use of a quadrant-based sampling method were used to estimate rice straw yield per hectare accurately. Environmental data, including rainfall, temperature, and soil conditions, was recorded to understand the ecological impacts on straw production.



Plate 1: Photo during rice straw harvesting in Ahero



Plate 2: Photo of animals feeding on rice straw fields

Data Analysis

Quantitative data on rice straw volumes will be analyzed to assess seasonal trends and presented using descriptive statistics and graphical formats. Qualitative data from farmer perspectives and key informants was analyzed to identify barriers, opportunities, and trends in rice straw utilization in

the rice-producing area. This comprehensive methodology ensures a detailed understanding of rice straw availability and its utilization for livestock feed in the Ahero region.

Results and Discussion

Table 1: Demographic Characteristics

Characteristic	Category	Frequency (n)	Percent (%)
Gender	Female	26	37.14%
	Male	44	62.86%
Age	18 - 24 years	2	1.17%
	25 - 34 years	13	7.60%
	35 - 44 years	14	8.19%
	45 - 54 years	67	39.18%
	55 - 64 years	40	23.39%
	65 & above years	35	20.47%
Educational background	None	7	10.00%
	Primary	32	43.71%
	Secondary	19	27.14%
	Vocational	6	8.57%
	College	5	7.14%
	University	1	1.43%
Main Occupation	Farming/Agriculture/Livestock	70	100.00%
	Informal Self Employment	0	0.00%
Total Farm area	< 1 acre	10	14.29%
	1 - 5 acres	60	85.71%
	6 - 10 acres	0	0.00%
	> 10 acres	0	0.00%

Results on the demographic characteristics are presented in Table 1. Majority of the respondents (62.86%) comprised of males, while females represented 37.14%. The largest age group is 45-54 years, making up 39.18% of the respondents. Significant proportions also belong to the 55-64 years (23.39%) and 65 and above (20.47%) age groups. Younger individuals aged 18-34 years are less represented, accounting for only 16.96% of the sample.

Most respondents had attained primary or secondary education, collectively making up 70.85% of the sample.

Smaller proportions have vocational training (8.57%), college education (7.14%), or university education (1.43%), while 10.00% reported having no formal education.

Farming, agriculture, or livestock is the sole occupation for 100.00% of respondents, reflecting the agricultural dependency of the study population.

The majority (85.71%) owned farms ranging between 1 and 5 acres, while 14.29% had less than 1 acre of land. There were no respondents with farms larger than 5 acres, underscoring the smallholder nature of the agricultural operations.

Table 2: Rice Farming Practices

Characteristic	Category	Frequency (n)	Percent (%)
Land under Rice cultivation	< 1 acre	11	15.71%
	1 - 5 acres	59	84.29%
years of rice farming	< 1 year	5	7.14%
	1 - 5 years	24	34.29%
	6 -10 years	24	34.39%
	> 10 years	17	24.29%
Rice Varieties	IR27	64	88.89%
	Pishori	7	9.72%
	Tapki	1	1.39%

The results of the rice farming practices are presented in Table 2. Most respondents primarily practice rice cultivation on land areas of 1-5 acres (59.41%), followed by those who cultivate rice on less than 1 acre (29.70%). Only a small percentage cultivates rice on 6-10 acres (8.91%) or more than 10 acres (1.98%). Additionally, most participants (42.57%)

have more than ten years of experience in rice farming. A substantial number have been farming rice for 6-10 years (22.77%) or 1-5 years (20.79%), while a smaller percentage have less than 1 year of experience (13.86%). Moreover, IR27 was the most-grown rice variety in the area (88.89%), followed by Pishori (9.72%) and Tapki (1.39%).

Livestock Ownership and Breeds

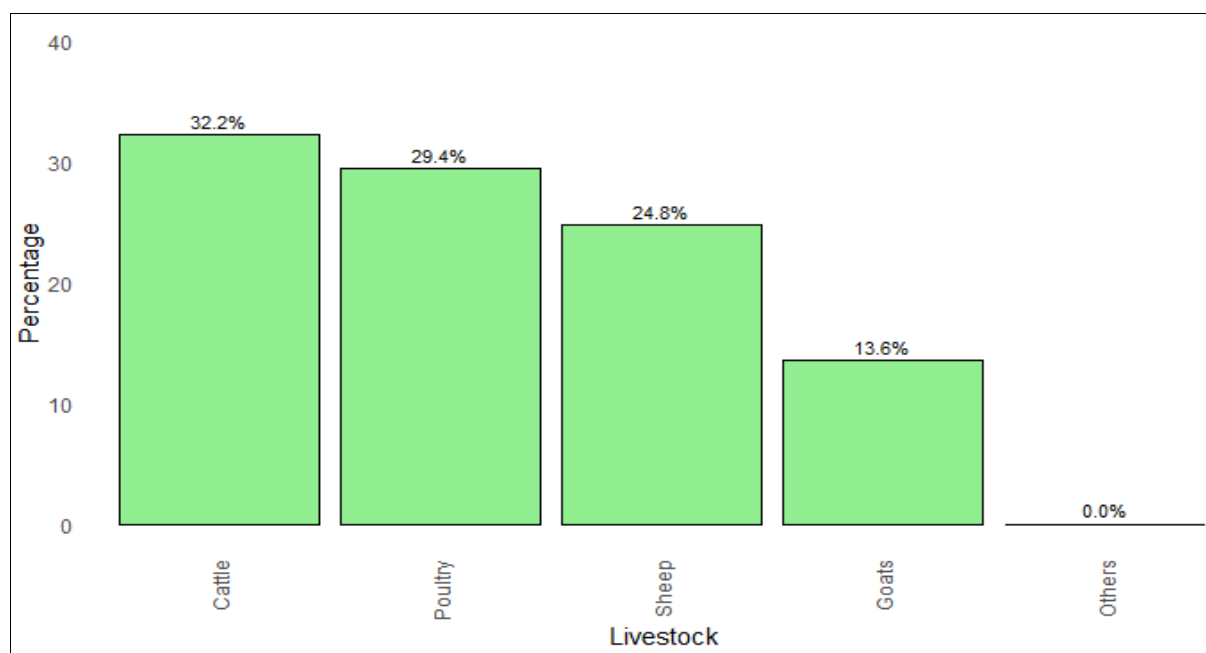


Fig 1: Livestock kept in Ahero.

From Figure 1, it was observed that cattle were the most kept livestock, reported by 32.2% of respondents. Poultry followed as the second most common, with 29.4% of respondents indicating they kept poultry. Goats were kept by 24.8%, while sheep accounted for 13.6%. Notably, no respondents indicated keeping any other types of livestock beyond those mentioned. Among cattle keepers, it was observed that the Sahiwal cattle breed was the only breed kept for dairy purposes, as reported

by 100% of the respondents. For poultry, respondents indicated that they exclusively kept pure indigenous chickens. Among sheep keepers, the Dorper sheep was the only breed raised in the area. Regarding goat breeds, the majority (75%) reported keeping the Small East African goat, followed by 20% who kept Galla goats, and a small proportion (5%) who kept Boer goats.

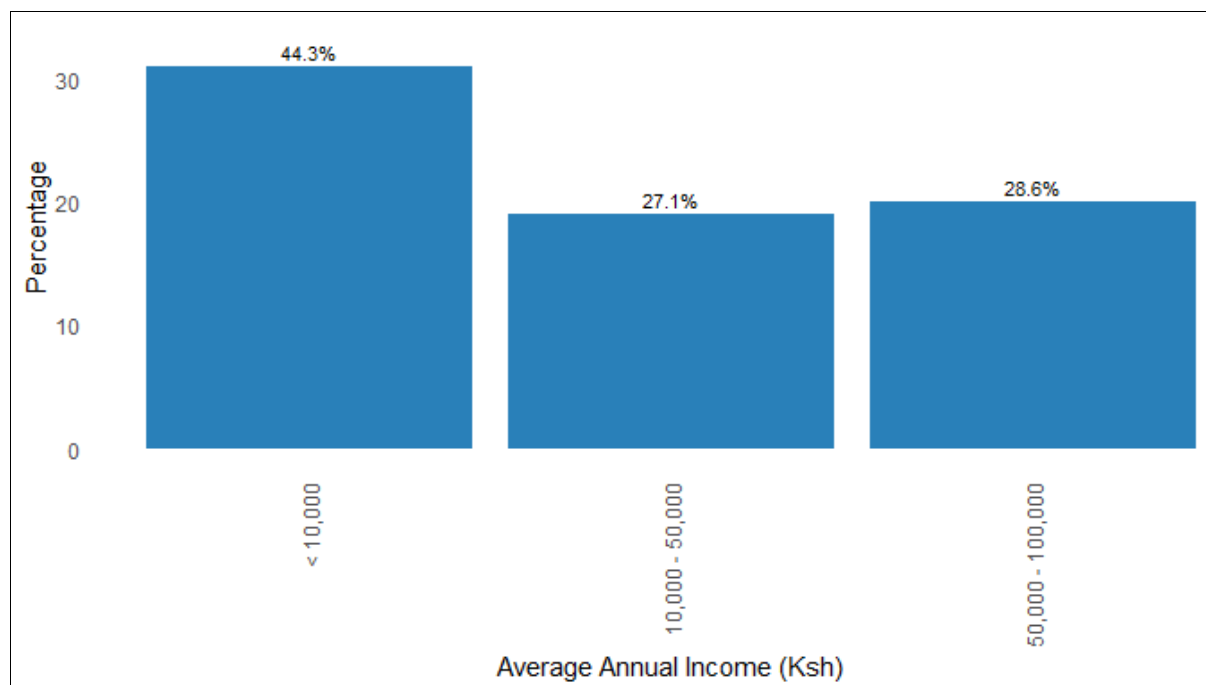
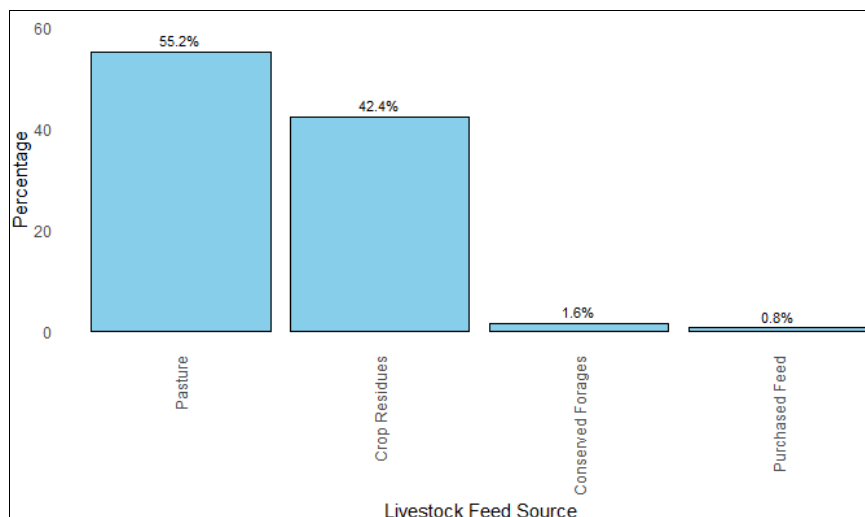


Fig 2: Average Annual income from livestock farming

From Figure 2, most respondents (44.3%) reported an average annual income of less than Ksh 10,000 from livestock farming.

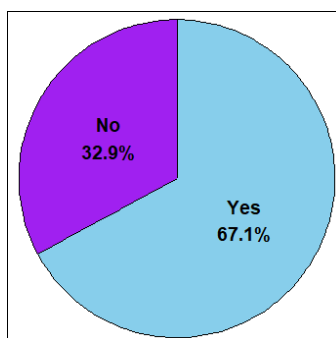
This was followed by 28.6% who earned between Ksh 50,000 and 100,000, while 27.1% reported earnings in the range of Ksh 10,000 to 50,000.

**Fig 3: Main Source of Livestock Feeds**

Crop residues and pasture were the primary sources of livestock feed, used by 55.2% and 42.4% of respondents (Figure 4), respectively. Conserved forages were reported as a feed source by 1.6% of respondents, while purchased feed

was the least utilized, at just 0.8%.

Use of Rice By-products and Seasonal Variation in Feed Availability

**Fig 4: Use of Rice By-product as Livestock Feed**

Most respondents (67.1%) reported utilizing rice by-products as livestock feed, while the remaining 32.9% did not use rice by-products for this purpose.

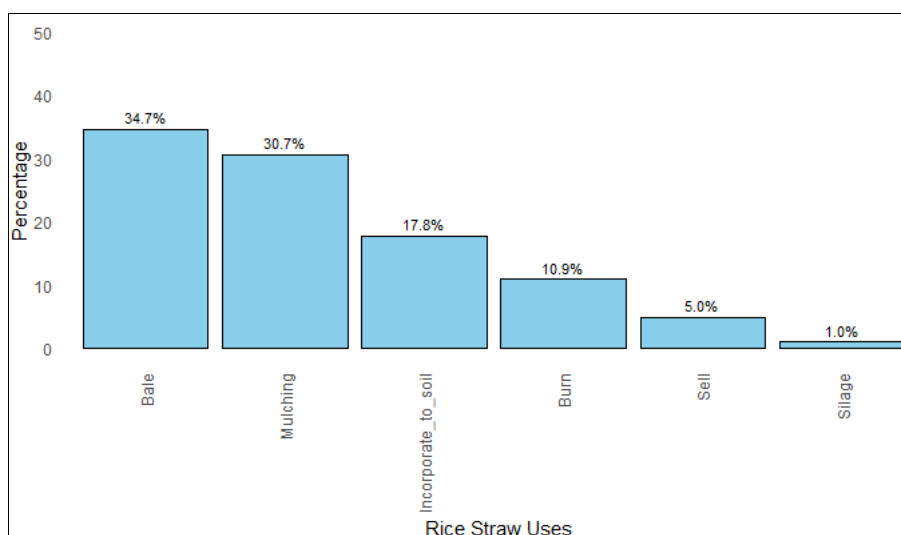
respondent reported using rice germ as livestock feed.

Table 3: Rice by-product as livestock feed

Rice By-product	Frequencies(N)	Percentage (%)
Rice straw	47	71.21%
Broken Rice	17	25.76%
Rice bran	2	3.03%

Rice By-product used as livestock feed

Rice straw (Table 3) was the most used rice by-product as livestock feed, reported by 71.2% of respondents, followed by broken rice at 25.76% and rice bran at 3.03%. Notably, no

**Fig 5: Main Uses of Rice Straws**

The main uses of rice straw among respondents were baling (34.65%) and mulching (30.69%). About 17.82% incorporated it into the soil, while 10.89% burned it (Figure

5). A smaller proportion (4.95%) sold rice straw, and only 0.99% used it for silage. This indicates limited adoption of value-added practices like silage production.

Table 4: Main livestock production system for both dry and wet season

Main production system	Dry season (N & %)	Wet Season (N & %)
Extensive grazing on communal land	35(50%)	35(50%)
Semi zero grazing	2(2.86%)	2(2.86%)
Tethering	33(47.14%)	33(47.14%)

Most respondents practiced extensive grazing on communal land (50%) and tethering (47.14%) as their main production systems in both dry and wet seasons, with only a small proportion (2.86%) practicing semi-zero grazing (Table 4). Additionally, all respondents (100%) unanimously agreed that feed availability varies significantly across different seasons. When asked about their current methods of livestock feed

storage, respondents indicated that they primarily used haystacks, with no one reporting the use of barns or silos. Additionally, respondents stated they faced no challenges in feed conservation as they did not practice it. Moreover, none of the respondents used concentrates, minerals, or vitamins as supplements for their dairy cattle.

Table 5: Value addition for crop residues

Characteristics	Categories	Frequency(n)	Percent (%)
Aware of the value addition for crop residues	Aware of value addition	32	45.71
	Not aware	36	54.26
Use of value-addition techniques	used	34	48.57
	Never used	36	51.42
Value-addition techniques used	Drying	33	97.06
	Grinding	1	2.94

Awareness of value addition for crop residues was slightly lower, with 54.26% of respondents indicating they were not aware, compared to 45.71% who were aware (Table 5). Despite this, nearly half (48.57%) of respondents reported

using value-addition techniques. Among these, drying was the predominant method, employed by 97.06%, while grinding was minimally used (2.94%). This highlights a significant reliance on drying for enhancing crop residue utilization.

Table 6: Feed Supplements used during the dry season

Characteristic	Category	Frequency (n)	Percent (%)
Feed Supplements	Grasses	37	52.11
	Crop Residues	32	45.07
	Conserved Hay	2	2.82
Crop residues used as feed supplement during dry season	Rice Straw	29	56.86
	Dry maize stover	22	43.14

The results of the feed supplements used during the dry season are presented in Table 6. Among the respondents, grasses were the most frequently used feed supplement during the dry season, reported by 52.11%, followed by crop residues at 45.07% and conserved hay at 2.82%. No respondents reported using concentrates or agro-industrial by-products. Rice straw and dry maize stover were reported as the only crop residues utilized as feed supplements during the dry season, with 56.86% of respondents indicating the use of rice straw and 43.14% reporting the use of dry maize stover.

Discussion

The findings of this study offer valuable insights into the demographic characteristics, farming practices, and utilization of rice straw as livestock feed among smallholder farmers in Kenya's Ahero region. These results are consistent with previous research, thereby providing a comprehensive understanding of the challenges and opportunities in the region.

The demographic analysis revealed a predominance of male respondents (62.86%), with a significant portion in the age group of 45-54 years (39.18%), indicating that middle-aged men are the primary decision-makers in the agricultural sector. The limited representation of younger individuals aged 18-34 years (16.96%) highlights a potential gap in youth

engagement in farming activities. This aligns with the findings of Makate & Mango, (2017) ^[14] who observed a similar trend of low youth participation in agriculture in sub-Saharan Africa, attributing it to migration to urban areas for education or non-agricultural employment. Bringing young people into farming operations helps enhance sustainability in smallholder systems (Zulu *et al.*, 2021) ^[30].

Furthermore, the educational background of respondents showed that most had attained primary or secondary education (70.85%), which is essential for understanding and adopting improved agricultural practices. However, the low percentage of respondents with a college or university education (8.57%) suggests a need for greater emphasis on educational opportunities. This finding supports Mucheru-Muna *et al.* (2021) ^[16] who indicated that while basic education is common among rural farmers, it limits their ability to adopt more advanced agricultural innovations. In line with Njenga *et al.* (2021) ^[18] who reported that middle-aged men dominate agricultural decision-making, and Okello *et al.* (2024) ^[20] who emphasized the challenges of low tertiary education in improving agricultural productivity, these findings underscore the need for targeted interventions in education to enhance farming practices in the region.

The study population is entirely dependent on farming, agriculture, or livestock as their main occupation. Most

respondents own small farms ranging between 1-5 acres (85.71%), underscoring the smallholder nature of agricultural operations in the region. Rice cultivation is a significant activity, with most farmers cultivating rice on 1-5 acres (84.29%) and having substantial experience in rice farming, with many having farmed rice for over ten years (24.29%). The IR27 variety is the most-grown rice variety (88.89%), reflecting its adaptation to local conditions.

These findings are consistent with the observations of Devendra & Leng, who reported that rice straw is often the most accessible by-product for smallholder farmers in Asian and African regions. The predominant use of rice straw over other by-products such as rice bran (67.54% vs. 19.30%) highlights its importance as a readily available feed resource (Singh & Patel, 2022) [27].

Cattle are the most kept livestock (32.2%), followed by poultry (29.4%), goats (24.8%), and sheep (13.6%). The preference for specific breeds, such as Sahiwal cattle for dairy, indigenous chickens, Dorper sheep, and Small East African goats, indicates a reliance on locally adapted livestock breeds that meet environmental conditions and market demands (Ahmad *et al.*, 2024) [4]. Most respondents reported an annual income of less than KSh 10,000 from livestock farming (44.3%), highlighting the economic challenges faced by smallholder farmers. Crop residues (55.2%) and pasture (42.4%) are the primary sources of livestock feed, with minimal use of conserved forages (1.6%) and purchased feed (0.8%).

Rice straw burning practice (10.89%) increases greenhouse gas emissions because of the open field burning of rice residues and its direct effect on the environment, eventually contributing to climate change (Singh *et al.*, 2021; Romasanta *et al.*, 2024) [26, 22].

This reliance on crop residues, particularly rice straw (71.21%), underscores its importance as a feed source during the dry season when natural forage is scarce (Saharan *et al.*, 2024). These findings are in line with Afzal *et al.* (2024) [3] and Sharma *et al.* (2024) [5], who identified the high fibre content and low nutritive value of rice straw as barriers to its widespread adoption. Farms need to learn about ammoniation and value-addition techniques which can make their livestock feed better (Kabinda *et al.*, 2022) [10]. Farmers use traditional drying techniques more often than other methods (97.06%) even though they need training to learn innovative options such as urea treatment and ensilage practices (Madzingira *et al.*, 2021) [13].

Seasonal variability significantly impacts feed availability, with all respondents acknowledging this challenge. Extensive grazing on communal land (50%) and tethering (47.14%) are predominant production systems, reflecting practices noted by the (FAO, 2019) [8] on livestock management in Kenya. The reliance on haystacks for feed storage, without barns or silos, highlights inadequate infrastructure for feed conservation. This agrees with the findings of Mburu, (2015) [15] who identify storage alternatives like barns and silos as key successful practices. Additionally, the lack of supplements such as concentrates, minerals, and vitamins, as observed by Njarui *et al.* (2016) [17], underscores missed opportunities to improve livestock nutrition and productivity.

Awareness of value addition for crop residues is relatively low, with 54.26% of respondents unaware of such practices. Despite this, nearly half (48.57%) of the farmers engage in value addition, predominantly through drying (97.06%), which is the simplest and most cost-effective method. This finding aligns with Thornton and Herrero (2010) [28], who

noted that drying is the most used technique among smallholder farmers due to its accessibility and low cost. Similarly, Hilmiati *et al.* (2024) [9] observed that drying is widespread in resource-limited systems, but advanced techniques like ensiling or urea treatment are underutilized due to low awareness and resource constraints.

Van Soest (2006) [29] emphasized that while methods such as alkali treatment could significantly enhance the nutritive value of crop residues, limited farmer awareness and training restrict their adoption. These observations suggest a considerable opportunity to improve the adoption of advanced value-addition techniques by addressing knowledge gaps and providing targeted extension programs (Prasara & Gheewala, 2017) [21]. Finally, by building awareness and demonstrating the benefits of enhanced practices as suggested by Dejene *et al.* (2014) [6], farmers could optimize the use of crop residues, increasing their value for livestock feed and other uses.

Conclusion

The study highlights the critical role of rice straw as a livestock feed in smallholder production systems in Kenya's Ahero region, especially during periods of forage scarcity. However, the findings also point to challenges such as limited youth engagement in farming, low educational attainment, and inadequate infrastructure for feed conservation storage and supplementation. Rice straw burning practice increases greenhouse gas emissions that have a direct effect on the environment, contributing towards climate change. Addressing these challenges through targeted education, infrastructure development, and the promotion of value-addition techniques can enhance the sustainability and productivity of smallholder farming systems. Future research should focus on developing and disseminating affordable technologies for processing rice straw to improve its nutritional value, thereby supporting smallholder farmers in making the most of this readily available resource.

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Conflict of Interest: The authors declare no competing interests

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