

Analysis of potential sources of feed improvement for livestock in the Kasungu and Mangochi districts of Malawi

Analysis of livestock feed options in Kasungu and Mangochi

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Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

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Abbreviations and acronyms

ADMARC	Agricultural Development and Marketing Corporation
AEDOs	Agricultural Extension Development Officers
AEZs	Agroecological Zones
APES	Agricultural Census Production Survey
ASF	Animal-Source Foods
CEAs	Community-Based Extension Agents
CIMMYT	International Maize and Wheat Improvement Centre
CP	Crude Protein
DM	Dry Matter
FGD	Focused Group Discussion
FISP	Farm Input Subsidy Programme
g CP DM/ d	Gram's crude protein per day (Dry matter basis)
g/ kg	Grams per kilogram
GDP	Gross Domestic Product
GHG	Greenhouse gas
IPC	Integrated Food Security Phase Classification
MFS	Mixed Farming Systems
MJ/ kg	Megajoules per kilogram
NDF	Neutral detergent fibre
NGO	Non-Governmental Organisations
R & D	Research and Development
SDG	Sustainable Development Goal
SI-MFS	Sustainable Intensification of Mixed Farming Systems
SSA	Sub-Saharan Africa

Introduction

Livestock farming plays an integral part in the vulnerable and economically constrained livelihoods of smallholder farmers in Malawi, contributing to food and nutrition security, ecosystem services and overall economic resilience (Banda and Tanganyika, 2021; Herrero et al., 2013, 2009). As these communities navigate the challenges posed by climate change, land degradation, and economic constraints; the availability and often inconsistent supply, and quality of livestock feed, particularly protein, emerge as pivotal factors in ensuring the optimum productivity and resilience of their herds (Dzowela et al., 1990; Thornton and Herrero, 2015). The significance of livestock feed transcends mere nutrition for animals; it stands as a basis for the well-being and prosperity of entire communities (Alonso et al., 2019; Banda and Tanganyika, 2021; Duncan et al., 2023). Against the backdrop of a delicate balance between traditional practices and modern agricultural methods, the quest for sustainable and nutritious livestock feed becomes not only a necessity for the well-being of the animals but also a cornerstone for the overall development of rural communities.

Most smallholder farmers in Malawi, particularly in the south and central regions, rely on mixed farming systems (MFS) that integrate crops, livestock and/ or agroforestry (Chimonyo et al., 2023; Rogé et al., 2016). The combined output of crop-agroforestry-livestock MFS surpasses the aggregate of individual components due to interdependence, that is, the output from one land unit serves as input for another segment of the system, enhancing overall farm efficiency and enhances productivity in both crop and livestock production if properly managed (Sekaran et al., 2021). This promotes the concept of a closed-loop nutrient cycle system. For instance, livestock manure contributes nutrients and organic matter to enhance soil fertility, while crop residues serve as feed for livestock and can be utilised as organic material to enhance soil health. The synergy degrees vary spatially and temporally, even within the same agroecological system and can be affected by farmers' socio-economic conditions (Dhehibi et al., 2023; Sekaran et al., 2021). Apart from the benefits of the production systems, MFS is more likely to expand household diet diversification and empower smallholder producers to actively access local markets for high-value products (Dhehibi et al., 2023). Despite the many potential synergies this system offers (i.e., sustainable, climate-resilient, and productive agricultural systems), it is not without its trade-offs and challenges.

The inherent nature of MFS is that it can be complex to operate and manage as it demands a greater knowledge of diverse production systems. In addition, competition for resources could arise, for example, crop residues are not only used as livestock feed but are also required as mulch or fuel for households. Agricultural production volumes can be increased by expanding the farm area (i.e., extensification), but, in Malawi, farm sizes are shrinking due to the increasing population density (Anseeuw et al., 2016; Sekaran et al., 2021; Timler et al., 2023). While some regions may have abundant natural resources suitable for livestock feed, others may face constraints such as the risk of climate-induced feed gaps, land degradation and scarcity, climate variability, and limited access to inputs.

Furthermore, the socio-economic dynamics and farming practices differ between regions, necessitating tailored interventions to maximise impact.

The integration of crops, agroforestry and livestock components that sustain food, and nutritional security with regular and periodic income to farmers is vital for improving the livelihoods (Paramesh et al., 2022; Sekaran et al., 2021). To address this, there is an urgent need to identify and capitalise on opportunities for sustainable intensification of MFS (SI-MFS), all while navigating the myriad of challenges faced by these farmers. Among the key elements is the need to improve the feed resource base by augmenting both the quantity and quality of available feed, along with implementing improved feeding practices (Salmon et al., 2018). A pivotal factor for maximising animal productivity lies in the accessibility and efficient utilisation of local feed resources. Through this targeted research, the aim is to provide practical insights that can drive sustainable agricultural development among smallholder farmers forward. The objectives of this study were to identify the potential sources of feed improvement for livestock in the Kasungu and Mangochi districts.

Methodology

Study Site Description

The survey was conducted in two districts in Malawi, that is, Kasungu in the central region and Mangochi in the southern region between 24 and 31 January 2024. These districts were selected purposively based on the presence of a vibrant (Consultative Group on International Agricultural Research) CGIAR Initiative: Sustainable Intensification of Mixed Farming Systems (SI-MFS) for smallholder farmers. These districts were selected due to their distinct agroecological zones with Kasungu being a medium altitude and Mangochi, being a low altitude. According to Kumbuyo et al. (2014), the mean annual rainfall in Kasungu and Mangochi is 784 and 805 mm, respectively. Kasungu district experiences a cool to warm tropical climate, with minimum and maximum average temperatures around 12°C and 30°C, respectively. Its topography features little fluctuation in altitude; the district's lowest point at 800 m above sea level, while its apex reaches 1451 m atop Kasungu Mountain. Mangochi lies adjacent to the southwestern shore of Lake Malawi, at a lower altitude of approximately 500 m (Bruce et al., 2008).

Participant Selection, Sample Sizes and Data Collection

Focused Group Discussion

For the FGDs, participants (i.e., smallholder farmers; Fig. 3.1) were purposively selected from the two districts based on their participation in the CGIAR Initiative: SI-MFS with assistance from local Agricultural Field officers. Three FGDs from one Extension Planning Area (EPA) were conducted per district. Due to population disparities, Mangochi has densely populated communities, therefore, three sections were selected as opposed to Kasungu where three clusters comprising three sections were selected. In Kasungu, Mtunthama was selected and comprised of three clusters [(Cluster 1: Liziri, Livwezi and Mchezi sections), (Cluster 2: Nthema, Chambwe, and Kadifula sections) and (Cluster 3: Mthuthama, Kasikidzi, and Wimbe sections)]. Each section was represented by four farmers,

two male and two female making a total of 12 farmers for each FGD, which falls within the 10 – 12 members as recommended by Creswell and Creswell (2023). In Mangochi, Mithi, Chimwala and Mpinganjira sections were surveyed for the FGD in the Nasenga EPA. A facilitator moderated the discussions in the Chichewa language. Krueger and Casey (2014) have suggested that three to six different focus groups are adequate to reach data saturation and/or theoretical saturation, with each group meeting once or multiple times.

The discussions began with an understanding of the farmers' current farming practices in terms of crop and livestock production systems. Farmers' knowledge and understanding of SI-MFS, its benefits and opportunities, synergies and trade-offs of MFS, challenges and strategies for adoption of SI, market access, challenges and opportunities and lastly knowledge and resource gaps were also collected. An interview guide was developed to facilitate the discussions and ensure that the discussions' in-depth views and opinions are explored. In total, six FGDs were conducted for this study, and each lasted approximately 90 minutes.

Key Informant Interviews

Key informant interviews were conducted with agricultural professionals to capture in-depth information and insights about the interactions of soils, forages, and nutrition, with livelihoods in contrasting landscapes (i.e., Kasungu and Mangochi districts) in Malawi, to identify opportunities to maximise synergies and reduce/ minimise trade-offs agricultural practices. A semi-structured questionnaire was used to collect quantitative and qualitative data on demographics, production practices, available livestock feed resources, SI-MFS practices, adoption and the reluctance of technology in SI-MFS systems and community participation and capacity building needs. A total of 36 informants (i.e., 25 in Kasungu and 11 in Mangochi) were chosen by employing the snowball sampling technique. A pre-test of the questionnaire was conducted on five respondents in Lilongwe to reduce bias. The questionnaire was in English but was administered in Chichewa using trained enumerators. During interviews, multiple responses and overlaps were observed because the key informants were all from the same agricultural discipline. The sample size adopted was therefore sufficient to ensure data saturation.

Feed Sample Collection

Five farmers were randomly chosen from each FGD, and the surrounding feed resource area of their farms underwent nutrient profiling through sampling. None of the farmers utilised commercial feed, and the absence of crop residues during the sampling period (summer) was noted. Consequently, the sampled feed resources exclusively comprised grasses, herbs, and foliage sourced from multipurpose shrub/ tree legumes. For the identification and collection of fodder grass, herb and shrub/ tree foliage samples, several site visits where animals graze or browse were made with some farmers. Within each location, apical portions from three plants of the same species were cut with a garden pruner plucked and mixed to get a representative sample of that species. Each fodder grass sample was identified by comparing their morphological characters with already available grass specimens in the Guide to Grasses of Southern Africa (Fish et al., 2015), online available plant databases like Flora of Malawi

(<https://www.malawiflora.com/>) and using Google Image search. The samples were bagged and transported to Chitedze Agricultural Research Station where they were air-dried before being ground and then transported to Lilongwe University of Agriculture and Natural Resources (LUANAR) for nutrient profiling (DM, CP, EE, Ash, CF, NDF, ADF and ADL).

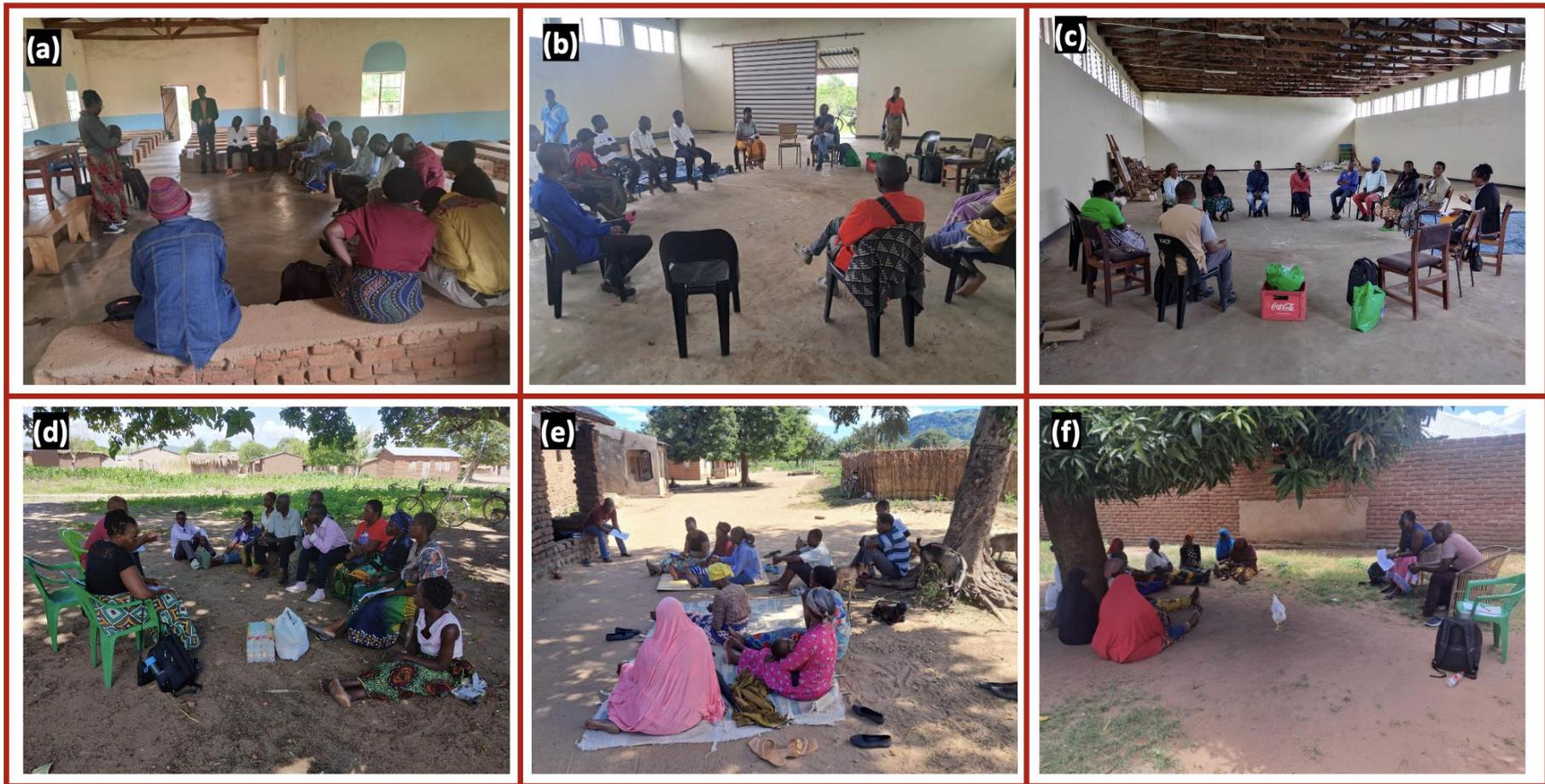


Figure 0.1 Focused group discussions held in the Kasungu (a, b and c) and Mangochi (d, e and f) districts.

Data analysis

During the interviews, the Chichewa local language was used and then translated to English using an independent back-to-back translation system. The audio recordings from the FGD were translated transcripts were transcribed verbatim. Subsequently, thematic analyses were conducted, adhering to Braun and Clarke's (2006) framework using the Atlas-ti 24.0.1 Mac software. From the transcripts, 26 different code categories were generated from the Atlas-ti 24.0.1. Once coding was completed, emerging themes were drawn from the tree nodes which would assist in answering the research objectives. Extracted direct quotations from study participants were included to convey critical findings from FGDs. All quantitative data were analysed using SAS Institute Inc. 2014. SAS[®] OnDemand for Academics: User's Guide. Cary, NC: SAS Institute Inc. Thus, using the PROC FREQ of SAS, descriptive statistical analysis was used to analyse and summarise the KII demographic profiles, farm characteristics and agricultural practices, and information on knowledge, experiences and challenges of sustainable intensification in mixed farming systems. For feed samples that were collected from the two districts, only 4 were common to both districts, hence, PROC GLM of SAS (SAS[®] OnDemand for Academics: User's Guide. Cary, NC: SAS Institute Inc.) was used to evaluate the effect of district and species as the main fixed factors and farmer as a random factor to evaluate the nutrient profiles [dry matter (DM), crude protein (CP), crude fat (ether extract, EE), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF), crude fibre (CF) and acid detergent fibre (ADL)]. The rest of the samples which were not common to both districts were evaluated using PROC MEANS of SAS (SAS[®] OnDemand for Academics: User's Guide. Cary, NC: SAS Institute Inc.).

Results

Key Informant Interviews

Demographic Profiles

It was observed that a majority of the interviewed key informant (KI) participants in both Kasungu and Mangochi were male, with females comprising less than 30% in both districts (Fig. 3.2). The dominant age group was 41-50 years, with Mangochi having 45.5% and Kasungu having 38.5% participants in this age group. All the KIs in Mangochi were employed by the government, while in Kasungu, 19.2% and 15.4% of KIs were employed by NGOs and the private sector, respectively, with the rest employed by the government. In both districts, the interviewed KIs were working on a full-time basis, with 11.5% and 3.9% working either on a contract/part-time or volunteer basis in Mangochi. In Mangochi, 63.6% of the KIs had a diploma qualification as their highest education level, while the rest held a bachelor's degree. On the other hand, 42.3% of the KIs in Kasungu had a diploma followed by 38.5% with a bachelor's degree, while those with a certificate and master's degree were 11.5% and 7.7%, respectively. More than half (54.6%) of the KIs in Mangochi were Extension officers and the rest were Crop Officers. A diverse profile of KIs were interviewed in Mangochi with the majority being Extension Officers (46.2%) followed by those in a supervisory position (19.2%) and administrators (15.4%). The rest were less than 10% and these were either Crops Officer, Nutritionist, Veterinarian and a Trainer. Mangochi had more people

in their current position compared to Kasungu with those in the 11 – 20-year category having the greatest proportion in the former district, while the latter the first three categories were higher at 26.9% each.

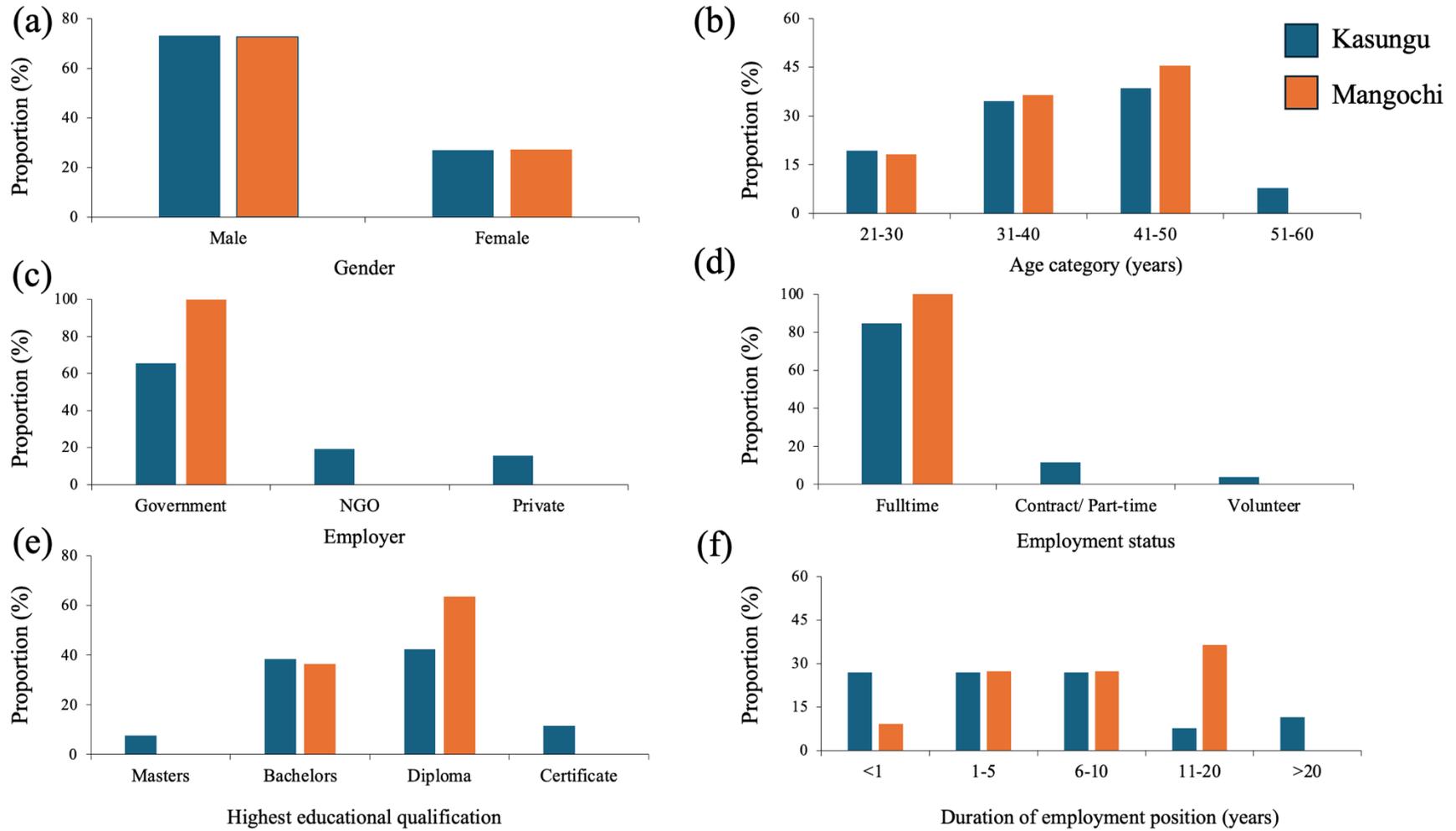


Figure 0.2 Demographic profile of key informants in Kasungu and Mangochi districts.

Farm Characteristics and Agricultural Practices

According to the Key Informants (KIs), all the respondents indicated that the maize-based system was the dominant practice among farmers in the two districts. This was followed by crop-livestock mixed farming, which accounted for four-fifths of the respondents from either district. However, there was no significant association between the farming system and the district ($P > 0.05$). It is worth noting that the chi-squared (χ^2) test revealed a correlation between the district and mixed cropping, livestock, and irrigation systems. The proportion of respondents indicating that these systems were practised in Kasungu was higher ($P \leq 0.05$) than in Mangochi. Maize and soybeans were the dominant crops cultivated in both districts (Table 3.1). Interestingly, Mangochi district had more respondents reporting that farmers cultivate more diverse crops than Kasungu (Table 3.1; $P \leq 0.05$).

The analysis revealed no association between livestock breeds and districts ($P > 0.05$). In Kasungu, 91% of respondents were able to identify the Malawian Zebu as a breed, with 4.5% mentioning Brahman and crossbreeds, while in Mangochi, all respondents identified local Zebu. The predominant dairy breed in Kasungu was Holstein-Friesian (55%), followed by Malawian Zebu (27.7%), Jersey (11.1%), and crossbreeds (5.6%). Conversely, in Mangochi, two-thirds of respondents named Holstein-Friesian as the primary dairy breed, with the remaining naming local Malawian Zebu. Over 96% of Kasungu respondents and all Mangochi respondents mentioned that farmers in that area reared local goats (i.e., small East African), with some in Kasungu keeping crossbreeds. A similar trend was observed with sheep with 90.9% of Kasungu respondents naming the local breed, which is the fat-tailed hair sheep. Indigenous pigs were prevalent in both districts with 72.7% in Kasungu and 82.3% in Mangochi, along with minor contributions from exotic breeds (i.e., Landrace, Large white and Tristar) and crossbreeds. Dominant chicken breeds were local in both districts, with 78.6% in Mangochi and 65.6% in Kasungu, while 18.8% of Kasungu respondents identified Black Australorp compared to 7.1% in Mangochi. Some respondents mentioned exotic poultry chicken breeds but were only able to identify them as either layers or broilers and not the actual breed. Regarding rabbits, only one Kasungu respondent mentioned the California Black and Flemish Giant breeds, with no names mentioned for the rest of the poultry species (guinea fowl, ducks, and turkeys) in either district.

Table 0.1 Farming systems, crops and livestock in Kasungu and Mangochi districts.

Parameter	District		χ^2	P value
	Kasungu	Mangochi		
<i>Farming system</i>				
Maize-based	100 (26)	100 (11)	1.14	0.2850
Mixed crop	56.0 (14)	9.1 (1)	6.92	0.0085
Livestock	32.0 (8)	0	4.53	0.0334
Mixed crop-livestock	80.0 (20)	81.8 (9)	0.02	0.8985
Conservation Agriculture	24.0 (6)	9.1 (1)	1.08	0.2978
Irrigation	40.0 (10)	0	6.09	0.0136
Horticulture	16.0 (4)	18.2 (2)	0.03	0.8715
Aquaculture	12.0 (3)	9.1 (1)	0.07	0.7981
<i>Field crops</i>				
Maize	100 (26)	100 (11)		
Sorghum	0	81.8 (9)	28.1	<0.0001
Sweet potatoes	53.9 (14)	100 (11)	7.5	0.0061
Rice	7.7 (2)	72.7 (8)	16.6	0.0001
Common beans	50.0 (13)	54.6 (6)	0.1	0.8004
Irish potatoes	46.2 (12)	27.3 (3)	1.1	0.2850
Bananas	42.3 (11)	81.8 (9)	4.0	0.0453
Cassava	53.9 (14)	90.9 (10)	4.8	0.0275
Soybeans	80.8 (21)	81.8 (9)	0.01	0.9406
Tobacco	65.4 (17)	54.5 (6)	0.4	0.5344
Groundnuts	69.2 (18)	81.8 (9)	0.6	0.4307
Horticultural crops	53.9 (14)	100 (11)	7.5	0.0061
Pigeon peas	7.7 (2)	72.7 (8)	16.6	<0.0001
Velvet beans	3.9 (1)	63.6 (7)	16.3	<0.0001
Cowpeas	30.8 (8)	90.9 (10)	11.2	0.0008
<i>Lablab purpureus</i>	3.8 (1)	68.6 (7)	16.3	<0.0001
Millet	7.7 (2)	54.6 (6)	10.0	0.0016
<i>Livestock</i>				
Cattle (beef)	76.9 (20)	100 (11)	3.0	0.0817
Cattle (dairy)	53.9 (14)	27.3 (3)	2.2	0.1320
Goats	100 (26)	100 (11)	0.4	
Sheep	42.3 (11)	90.9 (10)	7.4	0.0064
Pigs	65.4 (17)	45.5 (5)	1.3	0.2591
Chicken	100 (26)	100 (11)	0.9	0.3443
Rabbits	42.3 (15)	62.6 (7)	1.4	0.2355
Guinea fowl	34.6 (9)	63.6 (7)	2.7	0.1034
Turkeys	7.7 (2)	36.4 (4)	4.7	0.0306
Ducks	38.5 (10)	100 (11)	11.9	0.0006

Integrated Nutritional Strategies

From the two districts, just over 50% of the respondents indicated that farmers in the respective communities used some form of bought-in feed supplement for their livestock. Of these, 57% were from Mangochi and the remainder from Kasungu (Fig. 3.3a). Most (36%) of the respondents in Kasungu indicated that salt lick block supplement was used in their district by farmers. One-third of the respondents indicated that none of the farmers use any supplements (Fig. 3.3b). Mangochi had the highest number of respondents who attributed the usage of energy supplements in their district (Fig. 3.3b). Napier grass was reported as the most dominant improved grass, used in both districts by two-thirds of the respondents (Fig. 3.4). Rhodes grass was mentioned almost by the same proportion of KIs with Kasungu higher at 40% and 33% in Mangochi (Fig. 3.4). Except for Lucerne and unidentified tropical grasses, which were noted by 50% of respondents in Mangochi, the remaining enhanced fodder varieties were scarcely mentioned, with none of the participants identifying either smuts finger grass or *Brachiaria* spp. in either district (Fig. 3.4). The chi-square test revealed an association between the district and Lucerne with Mangochi having greater ($P \leq 0.05$) respondents who indicated farmers are more likely to grow Lucerne than in Kasungu. The rest of the improved grasses did not show an association with the district ($P > 0.05$).

The two communities surveyed reported that farmers mainly use maize stover, bran, and groundnut haulms as supplementary feeds for their livestock. However, these crop residues used were not associated with any district ($P > 0.05$). More than 88% of respondents confirmed using maize stover and bran in both districts, while groundnut haulms varied from 66 to 68%. In Mangochi, 55.6% of respondents reported using soybean straw, while 44.4% reported using sorghum stover. Other crop residues or oilseed cakes were reported by less than 30% of the participants in both districts.

It was found that the most used tree legume species for livestock feed were *L. leucocephala* and *G. sepium*. Just below 60% and above 40% of the respondents reported that farmers use *L. leucocephala*, while *G. sepium* was reported by 44% and 33% of the respondents in Kasungu and Mangochi, respectively. Additionally, participants (over 40%) from Kasungu reported that farmers in that district use *Tephrosia* spp. than respondents from Mangochi (0%) ($\chi^2 = 5.1$, $P = 0.0239$). Despite the absence of an association, 62.5% of the respondents in Mangochi reported that farmers in their area conserved feed as hay versus 40% in Kasungu. However, more respondents (48%) indicated that farmers in Kasungu did not practice any forage conservation methods compared to 37.5% in Mangochi. Only 12% of the respondents mentioned that farmers in Kasungu conserved feed as silage whilst none reported this in Mangochi.

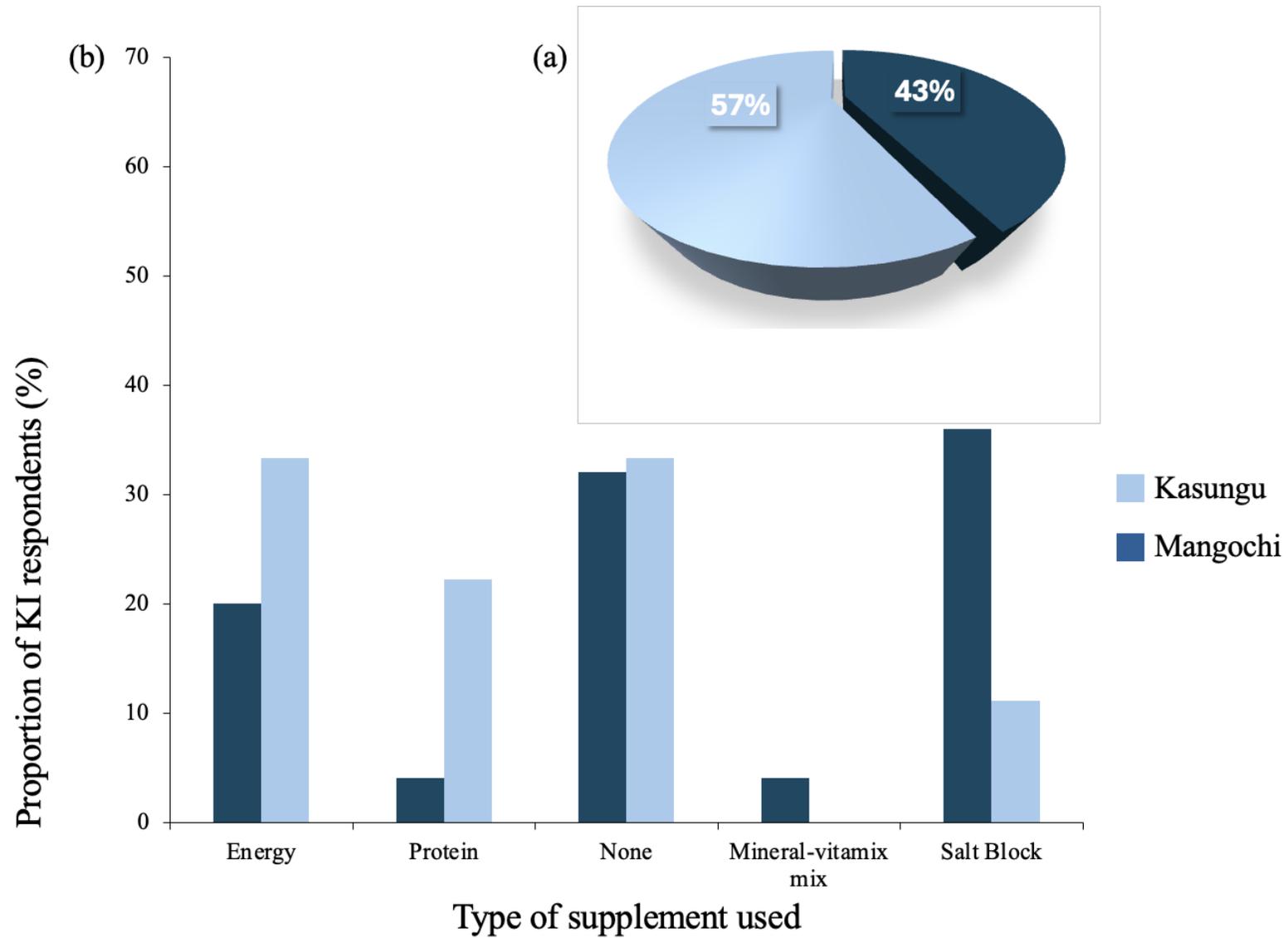


Figure 0.3 The use of (a) bought-in supplement and (b) the type of supplement used in Kasungu and Mangochi districts.

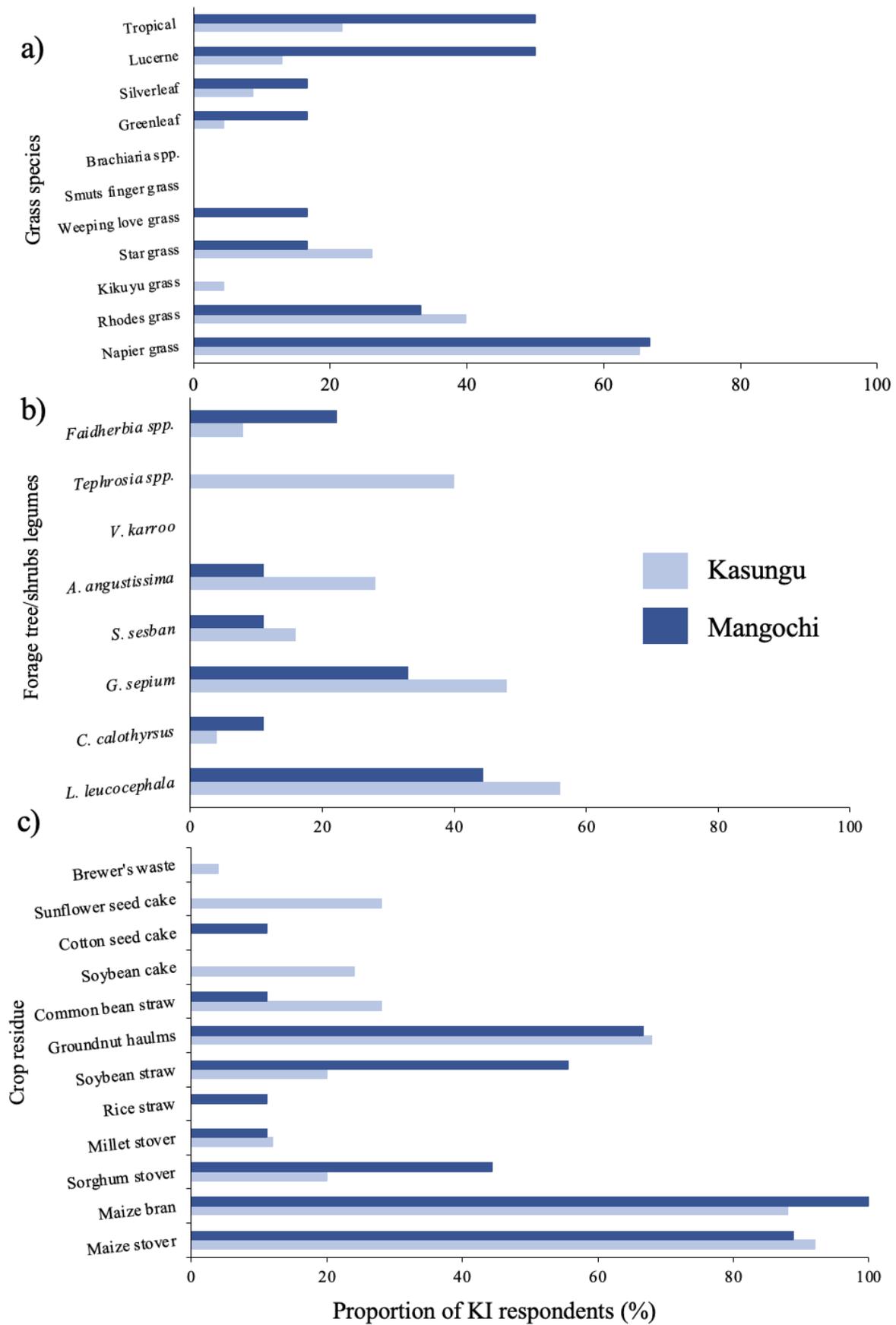


Figure 0.4 Feed resource options available to smallholder farmers in Kasungu and Mangochi districts.

Focus Group Discussion Qualitative Findings

The following themes emerged from the FGD study analysis:

Theme 1: Lack or high cost of farming inputs.

Theme 2: Financial Constraints.

Theme 3: No Access to Reliable Markets.

Theme 4: Lack of Technical Skills.

Theme 6: Potential of Adopting Sustainable Intensification in Mixed Farming Systems.

Theme 1: Lack or high cost of farming inputs

Smallholder farmers who participated in the FGD discussions in both districts highlighted several challenges that impede their agricultural endeavours, both within the two production enterprises, Crops and Livestock. Figure 3.5 shows some of the challenges experienced by the farmers. It also highlights suggestions raised to mitigate some of the current impediments that the farmers are currently experiencing. Among these challenges within the cropping production system was the struggle with agricultural inputs, mainly seeds and fertilisers, which are expensive, thus hampering their ability to optimise crop production. The following quote is evidence captured from one of the farmers during the discussion who said:

“Fertiliser is not scarce and can be found everywhere, however, many of us cultivate the land and plant our crop seeds but do not harvest any crops during the harvest season because we lack the finances to buy fertiliser”.

The situation is quite bad in that most farmers use seeds from previous harvests, which further compromises the yields considering that most of these seeds are hybrid type. One farmer from Kasungu said the following:

“If we don’t have the money to purchase seeds, we use the old seeds. For the recycled maize, they don’t do well when we grow the old seeds but for the groundnuts, they do well”.

Climate change and its impact on the variability impacting rainfall patterns, more so, the delay of the onset of the rain is further compounding the challenges of seeds and fertiliser. Farmers in Mangochi complained that their rice crops were being eaten by hippopotamuses near Malombe Lake, whilst monkeys from nearby mountains were also consuming their crops. Although some of the farmers in Mangochi are situated near a lake, they are unable to make use of the water body because they do not have access to irrigation facilities like pipes and water pumps. Both communities complained about the ubiquity of pests and diseases. The impact of diseases is not only affecting crops but also livestock.

“We have veterinary officers, but they stay away from our area, so it becomes hard and expensive for us to call the veterinary people to come and treat our livestock. The government does not provide free medicine...”.

Livestock management was a major issue among the farmers. In addition to diseases, the lack of capital to purchase stock and feeds was among the main impediments faced by these farmers. The issue of capital had implications on the quantity of manure available for them to use in their fields. Almost all the farmers who participated in the FGDs indicated that the free range system was their main feed for animals, both ruminants and non-ruminants. For ruminants, natural pastures supplied the bulk of the feed and there were major feed gaps during the dry season as indicated by the following quotes:

“During the rainy season, it is easy for our animals to graze/ feed anywhere but during the dry season when all the grass has dried, we like to feed our livestock closer to the river banks and water. This becomes a problem for us because our livestock can sometimes be found eating someone’s crops on their farm and we get charged a very high fee for this”.

Additionally, farmers were grappling with land scarcity, coupled with the persistent issue of stock theft. The shortage of grazing lands further exacerbates the already dire inadequate nutritional needs of their livestock and disease burdens. For farmers who move their animals to river banks, if they consume other farmers’ crops, they will be fined. This puts a further burden on the already resource-strapped farmers.

“Limited space for grazing. In our area we do have river banks as the only grazing area so due to the high population, the space is limited. And sometimes when we try to release these livestock for grazing on free range, we are fined MK35000”.

However, for non-ruminants (chickens and pigs) there was a feed-food competition between them and humans. The situation is even worsened by the poverty levels amongst these communities, instead of feeding maize by-products such as maize bran to chickens and pigs, some farmers indicated that they use this as a source of food.

“For some of us who keep pigs, feed especially maize bran is very expensive and there is high competition between people and pigs this is because we also depend on maize bran for food”.

Financial constraints add to the complex web of challenges faced by smallholder farmers in the surveyed who are striving for sustainability and resilience within mixed farming systems.

Theme 2: Financial Constraints

Financial challenges among smallholder farmers in Kasungu and Mangochi can never be overemphasized because lack of finances affects all facets of their livelihood, including their attainment of optimum productivity. This is disastrous to these farmers whose entire livelihood is based on agriculture for income generation. As highlighted above, lack of capital restricts farmers’ ability to invest in essential resources (e.g., seeds, fertilisers, feed, vaccines, equipment) and the adoption of sustainable practices that could improve their production efficiencies

and resilience in the face of environmental challenges, such as climate change and land degradation. Without adequate funds, the farmers are limited in terms of access to education and training, which could be used for improving agricultural productivity and adapting to changing market demands. Due to the lack of adequate government extension services, education and training are critical for farmers to acquire necessary agricultural management skills. The multifaceted nature of the lack of funds is summed up well by one of the FGD participants who says,

“We are currently not facing any new challenges that we have not encountered in the past. Our challenges remain the same in the sense that we do not have the financial means to buy farming necessities such as fertiliser and seeds for our fields”.

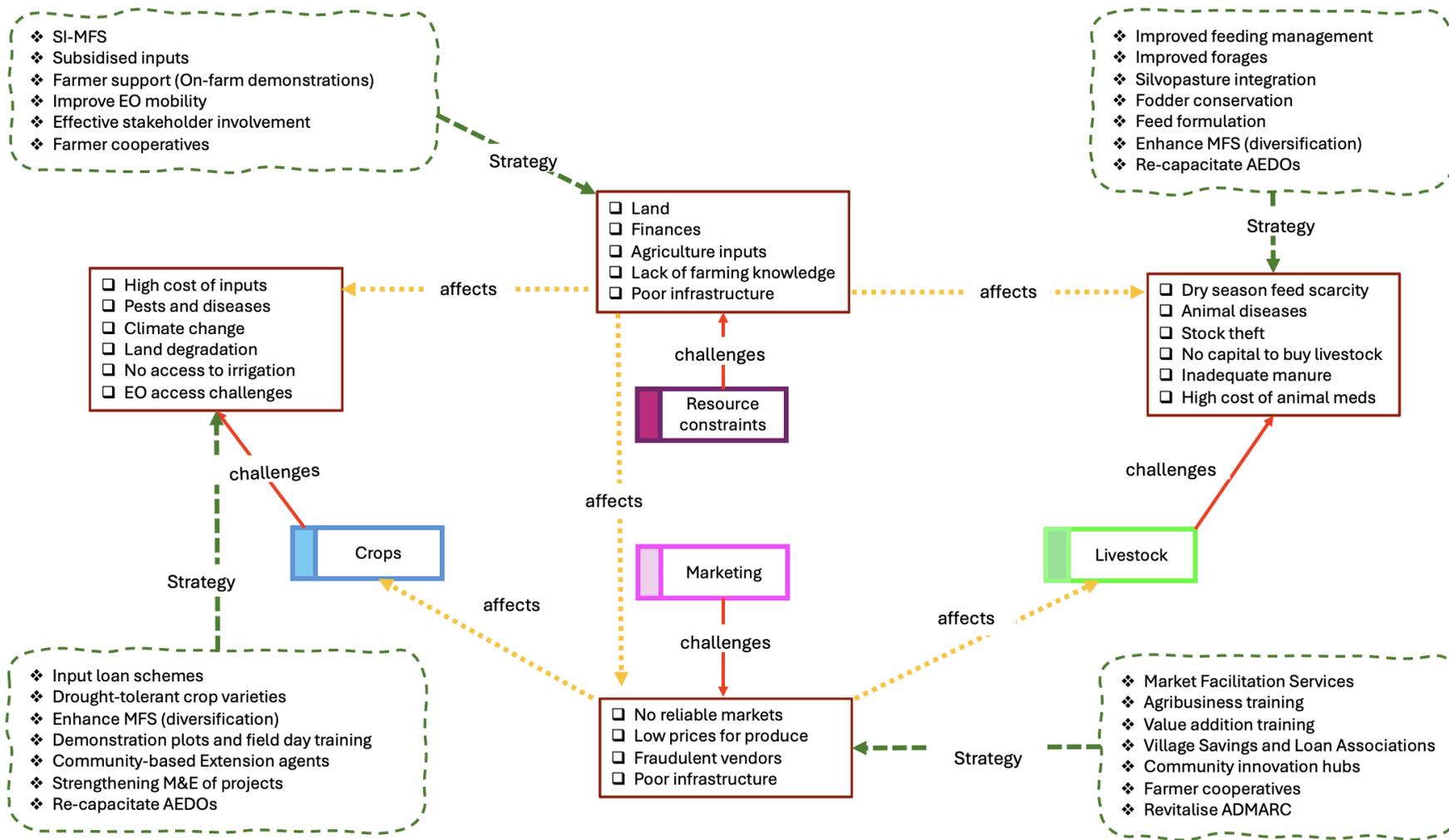


Figure 0.5 Challenges and mitigation strategies raised during the FGDs and KII.

Theme 3: No Access to Reliable Markets.

The absence of well-organised and dependable markets threatens the success of farmers who face difficulties in selling their agricultural produce. The unavailability of reliable avenues to sell agricultural produce exposes farmers to the mercy of vendors (i.e., middlemen) who exploit their vulnerability, offering meagre prices for their hard-earned harvests. Due to pressing hunger needs, farmers have indicated that most of them are even compelled to sell their produce directly from the fields when the crops have not matured. The prices that they are offered are not even close to what the produce would have fetched on the market had they waited for harvesting. The farmers have highlighted that this practice undermines their potential earnings but also perpetuates a cycle of poverty because every growing season they find themselves in a similar situation. Below are some of the quotes which came up during the FGDs with farmers from the two districts:

“We do not have any marketplaces here where we can sell our produce and livestock, so we sell it in and amongst ourselves... or we do get vendors that come and buy our livestock such as goats”.

“We also receive money in advance from vendors so that when we harvest produce such as maize, we give them a bag at a much cheaper price than that of the commercial market”.

“The markets are the crucial factor here, so please assist us in locating trustworthy markets where we may sell the produce from our farm”.

The farmers also accused the vendors of having “fake” weighing scales. They believe their weighing scales have been manipulated because they feel that their produce is much heavier than what the scales will be showing. This results in them receiving less money than what they deserve. Additionally, lack of transport to the available markets prevents them from getting fair prices for their produce. The following quote encapsulates their transportation challenges:

“Transporting our farm produce to markets is a very difficult task. We stand along the roadside and wait for people to buy from us”.

In Mangochi, all the communities that we visited were close to the main tarred road, but due to a lack of finances, they could not transport their produce to the main trading centres, hence they ended up opting for selling their produce along the roadside.

Theme 4: Lack of Technical Skills

A recurring topic in the FGDs revolved around the deficiency in practical expertise, specifically in areas such as livestock management, value addition, agribusiness, and marketing. When farmers receive good rains on the rainy, they acknowledge that the harvests are even on the limited arable lands, yet they face limited opportunities to add value to their produce, ultimately limiting their potential for maximising income. Furthermore, the limited technical skills regarding livestock management, particularly diseases are hindering them from

providing the necessary treatments. Farmers are grateful for the help they receive from various stakeholders. However, they point out that the training they receive is often insufficient. Some organisations offer handouts, but the farmers fail to continue with the project after its completion because they lack the necessary training.

“For us to progress as farmers we would like the government and other organisations to provide us with more information and training workshops so that we learn and attain knowledge so that we can do things for ourselves and not solely depend on the government or NGOs to give us handouts but rather do things independently such as how to treat sick animals, how to keep away pests/insects and how to make our fertiliser”.

The above quote indicates the willingness of farmers to be independent and not always rely on external organisations. The farmers' lack of technical skills significantly undermines productivity. The farmers acknowledge that since the inception of the SI-MFS by CIMMYT they have learnt quite a lot on the principles of the systems. However, there is still much they do not know, and the technical knowledge inadequacy may be a handicap in their effectively implementing some of the appropriate technologies. This is more pronounced concerning livestock management as one of the participants pointed out:

“Regarding training and information, we would like to be taught how to treat and prevent different livestock from catching diseases. We would also like to receive information and training on the conservation of forage for livestock feed as well to learn how we can conserve and look after our soil”.

Most of the assistance they received from extension officers was mainly related to soil and crop management and few officers are competent with some of the practices that can assist the farmers improve animal production. This was further compounded by the fact that few extension officers are serving many people, and most of them rarely get an opportunity to interact with some officers.

“Extension workers/ advisors from different organisations much like yourselves as well as from the government do reach out to us to offer their advice and impart knowledge however, one of the problems we are facing with extension workers is that nowadays extension workers are scarce, and the help/ advice we are receiving from them is communicated through different channels such as phones as opposed to in the past where extension workers would be physically present with us when teaching and advising us”.

Theme 6: Potential of Adopting Sustainable Intensification in Mixed Farming Systems

Although most farmers were in their first year of implementing SI-MFS, the project held prospects of better yields.

“We learnt that we could harvest more crops on a small piece of land. We learnt about ridge alignment, reducing ridge spacing and rows, this means the high population of crops on a small piece of land and more yield at the end”.

“Our fellow farmers from other sections started this project last year and they are testifying that ridge alignment, reduced ridge and row space enabled them to harvest more crops on a small piece of land”.

When farmers were asked if they would continue practising sustainable intensification even after the project has been phased out, this is what one farmer responded by saying:

“Yes, we will continue since we have been trained, so we are going to continue practising SI”.

“We will continue, even if the project phases out because we have seen the benefits and we have been well-trained on how to use the technology”.

Interaction with the farmers showed a lot of enthusiasm and hope that they are likely to benefit from implementing SI-MFS because they can optimally utilise the available resources, which not only improves farm productivity leading to increased yields and incomes for their households.

Chemical Composition of Feed Resources Surveyed in Kasungu and Mangochi Districts

Table 3.2 shows the chemical composition of fodder plant species collected from Kasungu and Mangochi districts. *Hyparrhenia* spp., signal grass and wandering jew were the only species collected in both districts. The rest were only collected from either district. There was no significant interaction between the district and four plant species for all the parameters, except for ether extract. Wandering dew (*Tradescantia fluminensis*) collected from Mangochi had the highest ether extract compared to all the other interactions. Species were significant for ash, NDF, ADF and lignin. Overall, wandering jew had higher ash contents and the lowest NDF, ADF and lignin than the other three common plant species in both districts. There was a significant difference in the CP and NDF contents for species with Kasungu having higher CP and lower NDF for Guinea grass, *Hyparrhenia* spp., and signal grass compared to those collected in Mangochi.

In general, *L. leucocephala* had the highest protein (> 35%) in the Kasungu district with moderate levels (20 – 24%) in Guinea grass, *Bambusa balcooa*, *G. sepium* and snot apple tree (*Azanza garckeana*) leaves. Except for *Nabe nawo* (common Yao name), all the fodder plans had a CP content above 10%. In Mangochi, wondering jew, cassava leaves, *Khaya nyasica* (known locally as *Khobo*) and *M. oleifera* had CP content ranging from 21 – 25%. Ether extract content was highest in wandering jew, giant milkweed (*Calotropis procera*) and *M. oleifera* in Mangochi and snot apple tree leaves in Kasungu with contents ranging between 12 and 15%. On one hand, Reed grass in Kasungu and Guinea grass and *Nabe nawo* in Mangochi had the highest levels of NDF. On the other hand, *B. balcooa*, *Brachiaria* spp. and reed grass had the highest ADF contents in Mangochi. Snot apple tree leaves from Kasungu had the highest relative nutrient value (RFV) across the feeds surveyed followed by *Calotropis procera* in Mangochi. Wandering jew and *G. sepium* leaves from Mangochi and Kasungu, respectively, had similar RFV.

Table 0.2 Effect of district and species on the nutrient composition of feed samples surveyed in Kasungu and Mangochi districts.

District	Plant species	n	Chemical composition (% DM-basis)								Relative feed value (RFV)*
			DM (as-fed)	Ash	CP	EE	NDF	ADF	Lignin	CF	
Kasungu	<i>Hyparrhenia</i> spp.	10	95.6 ± 2.52	7.5 ± 2.11	15.6 ± 6.94	9.2 ± 1.12	63.9 ± 4.96	44.5 ± 2.87	9.0 ± 1.85	17.4 ± 1.12	79
	Signal grass	18	95.1 ± 1.23	6.8 ± 2.83	15.9 ± 4.42	10.3 ± 1.60	65.0 ± 6.76	43.9 ± 4.36	8.4 ± 1.99	17.4 ± 1.02	78
	Wandering jew (<i>T. fluminensis</i>)	2	94.9 ± 1.63	11.2 ± 2.40	16.8 ± 11.1	10.2 ± 0.90	55.1 ± 1.89	38.1 ± 1.77	5.0 ± 0.27	17.5 ± 0.55	100
	<i>Eragrotis curvula</i>	3	96.1 ± 0.94	8.1 ± 2.28	16.6 ± 7.47	11.0 ± 0.65	60.7 ± 6.66	41.4 ± 2.39	6.8 ± 1.15	17.3 ± 0.88	87
	<i>Bambusa balcooa</i>	2	97.6 ± 0.17	7.5 ± 0.08	22.2 ± 0.32	8.4 ± 0.29	64.5 ± 0.90	41.2 ± 0.79	10.2 ± 0.23	16.3 ± 0.36	82
	Bermuda grass	2	94.7 ± 0.18	2.9 ± 0.08	17.5 ± 0.32	10.9 ± 0.07	65.8 ± 0.07	46.8 ± 3.02	7.9 ± 0.57	17.5 ± 1.31	74
	Brachiaria spp.	2	95.5 ± 0.14	6.5 ± 0.07	18.7 ± 0.32	11.4 ± 0.31	60.0 ± 0.02	42.2 ± 1.06	10.0 ± 0.23	16.8 ± 0.74	87
	<i>Gliricidia sepium</i>	3	94.9 ± 1.55	8.9 ± 2.82	20.7 ± 6.48	10.5 ± 0.76	52.9 ± 3.28	37.5 ± 1.04	4.7 ± 0.29	17.9 ± 1.20	105
	<i>Leucaena leucocephala</i>	2	93.3 ± 0.19	9.9 ± 0.05	35.3 ± 0.33	10.0 ± 0.24	55.1 ± 0.98	37.2 ± 0.10	5.3 ± 0.08	17.0 ± 0.58	101
	Reed grass	2	96.4 ± 0.18	9.6 ± 0.05	11.0 ± 0.32	8.3 ± 0.81	72.6 ± 0.83	45.7 ± 1.27	10.1 ± 0.29	17.1 ± 1.55	68
	Snot apple tree leaves	2	95.6 ± 0.21	11.0 ± 0.33	23.2 ± 0.32	12.0 ± 0.75	51.4 ± 5.12	34.4 ± 0.56	4.7 ± 0.45	18.7 ± 0.14	112
Mangochi	Guinea grass	2	95.0 ± 0.89	7.0 ± 0.10	12.8 ± 0.49	8.1 ± 1.24	72.2 ± 9.11	45.0 ± 0.59	8.7 ± 1.39	17.4 ± 0.47	69
	<i>Hyparrhenia</i> spp.	5	94.8 ± 1.74	5.2 ± 0.45	11.8 ± 6.35	7.9 ± 1.00	69.0 ± 6.14	44.4 ± 1.36	9.2 ± 1.31	17.8 ± 0.72	73
	Signal grass	2	95.2 ± 0.53	6.4 ± 1.17	11.0 ± 0.45	7.7 ± 0.91	65.8 ± 3.65	45.3 ± 2.53	8.4 ± 1.35	16.5 ± 0.55	76
	Wandering jew (<i>T. fluminensis</i>)	2	95.2 ± 0.23	13.2 ± 0.08	21.4 ± 0.32	14.5 ± 0.06	54.2 ± 0.46	35.5 ± 0.75	4.8 ± 0.37	17.3 ± 0.38	105
	Amaranthus	2	96.0 ± 1.19	10.3 ± 2.75	17.7 ± 2.24	9.3 ± 2.12	54.5 ± 3.04	38.0 ± 1.36	5.0 ± 0.30	16.8 ± 1.04	101

Giant milkweed (<i>Calotropis procera</i>)	2	93.7 ± 0.03	15.7 ± 0.11	19.8 ± 0.33	15.0 ± 0.78	51.4 ± 0.88	37.8 ± 1.45	4.8 ± 0.15	17.8 ± 1.68	108
Cassava leaves	3	96.0 ± 0.15	10.8 ± 0.10	21.4 ± 0.32	8.0 ± 0.31	56.4 ± 0.33	40.0 ± 0.41	4.7 ± 0.08	16.7 ± 1.05	95
<i>Khaya nyasica</i> (Khobo)	3	91.8 ± 0.10	16.4 ± 0.09	22.1 ± 0.66	8.2 ± 0.34	53.2 ± 1.04	40.4 ± 0.30	4.8 ± 0.28	17.8 ± 0.83	100
<i>Moringa oleifera</i>	2	93.0 ± 1.42	9.1 ± 1.73	25.2 ± 0.28	14.6 ± 3.22	56.5 ± 2.62	36.6 ± 2.00	4.7 ± 0.32	17.7 ± 0.26	99
Nabe nawo (in Yao)	2	97.2 ± 0.06	7.7 ± 0.11	9.6 ± 0.32	9.4 ± 0.13	76.7 ± 0.14	44.1 ± 0.56	7.7 ± 0.33	16.8 ± 2.14	66
<i>Wild vitis</i> spp.	2	96.1 ± 0.02	9.6 ± 0.08	16.5 ± 0.32	10.0 ± 0.81	54.3 ± 0.34	38.3 ± 1.56	5.4 ± 0.11	16.6 ± 0.29	101

DM – Dry matter; CP – Crude protein, EE – Ether extract (crude fat), NDF – neutral detergent fibre, ADF - acid detergent fibre, CF – Crude fibre.

*RFV = (%DDM × %DMI)/1.29, where %Dry Matter Digestibility (DMD) = 88.9 - (0.779 × %ADF) and Dry Matter Intake (DMI) = 120 ÷ %NDF (Yolcu et al., 2008).

Discussion

Quantitative Data

Key informant interviews

The dominance of the maize-based system as noted from the KI interviews was not unusual. Maize is Malawi's staple and primary food crop cultivated to meet the subsistence needs of farmers, underscoring its importance to both household and national food security (Stevens and Madani, 2016). However, the practice of continuous cropping of maize (monoculture) has been blamed for poor soil fertility (Komarek et al., 2018; Thierfelder et al., 2013). The dependence of communities on a single crop has adverse effects, particularly for Malawi, which has faced repeated climate-related challenges such as droughts and floods. This is why most rural farmers engage in mixed farming systems (MFS), which is the backbone of the rural agricultural system in SSA (Thornton and Herrero, 2015). During the focus group discussions (FGDs), it became evident that in the context of MFS, crops outpace livestock due to lacking capital for buying livestock. Nevertheless, most farmers engage in small-stock animal husbandry. This does not mean that farmers afford seeds for crops whose cost is beyond most of the farmers, a problem they have addressed by utilising recycled maize seeds, thereby minimising their expenditure on maize cultivation, despite the low yields. Crop diversification is the solution. Integration of legumes and cereals in smallholder farming, if properly managed, can contribute to environmentally sustainable intensification, diversification and risk management (Africa RISING, 2014; Danso-Abbeam et al., 2021; Thornton and Herrero, 2015), subsequently improving food and nutrition security.

Despite the notion by KII that the area they service has cattle, discussions with the farmers through the FGDs paint a different picture. Although the figures aren't substantial, most farmers typically maintain a modest small stock. A similar trend was reported by Castellanos-Navarrete et al. (2015) in Kenya where the poorest households lack cattle, whilst those who are moderately wealthier do. Goats and chickens are more prevalent because they have fewer requirements (i.e., spaces and feed) and are easy to dispose of in times of emergencies (i.e., to cover school fees and medical costs; Kaumbata et al., 2020). Apart from lack of finance, the matrilineal system practised across Malawi disincentivises men from investing towards household assets, including cattle because they move to their wife's village "for so long as the marriage lasted" (Simpson, 2000). This was also highlighted by some women in the FGDs conducted in Mangochi where men "after fishing, they sell the fish to restaurants and eat it there and return home to their wives claiming they did not catch any fish". The abundance of farmers rearing pigs in Kasungu compared to Mangochi is attributed to cultural differences, in addition to other factors. The Yao people, dominant in Mangochi indicated that most of them do not farm with pigs because of cultural reasons because the consumption of pork is regarded as a taboo of their faith (Simpson, 2000). Although there are diverse livestock species in both communities, neither the farmers nor KII could identify the breed types. However, it was noted that most of the breeds in these communities are mainly indigenous

breeds (FAO, 2022). Therefore, a comprehensive evaluation is required to determine the breed types in these communities because of the dominance of non-descript breeds in most rural areas in southern Africa (Nyamushamba et al., 2017) because of uncontrolled breeding and introduction of non-local breeds.

The high proportion of KIs who indicated that, in the areas of service, about half of the farmers provided their animals with some form of bought-in feed supplement (i.e., commercial), was unexpected. Overall, most rural livestock farmers rarely purchase bought-in feed supplements because of their exorbitant cost (Chakeredza et al., 2008). Therefore, the high proportion of supplements reported in this study, for instance, the salt lick block, could be related to the supply by donor organisations. Farmers tend to use home-mixed supplements (Chakoma et al., 2016), including crop residues because of their availability (Rusinamhodzi et al., 2015), which concurs with the greater proportion of respondents who reported the usage of energy supplements such as maize stover (INRAE-CIRAD-AFZ and FAO, 2022) than protein supplements. This view is supported by the qualitative data from the FGDs, where most participants expressed concern about the high cost of livestock feed and had to supplement it with local feed resources such as maize residues and groundnut haulms. This is evidenced by the KII data, where maize bran, maize stover, and groundnut haulms were the dominant supplements, soon after harvest and continuing into the dry season. However, due to the scarcity of crop residues, farmers resort to utilising all accessible residues, including those from various cereal (e.g., sorghum stover) and legume (e.g., soybean straw) crops. Apart from these crop residues, farmers also have access to limited improved pastures and tree/ shrub legumes.

The dominance of Napier grass in both districts was expected because it produces significant quantities of biomass and even after being grazed, it has a quick regrowth. It is also tolerant to dry environments and does not undergo seasonal dormancy (Paul et al., 2020). Furthermore, Napier, Rhodes and Lucerne are favoured by dairy farmers (Banda et al., 2012). However, Ndah et al. (2022) observed that the inefficiency of local cattle breeds in utilising improved forage quality due to inadequate water and feed availability, insufficient maintenance leading to feeding low-quality forage which may not yield desired milk production, limited availability of planting materials and extension guidance on forage management and harvesting, and the low milk prices discouraging efficient milk production practices hindered the adoption of improved forages by smallholder farmers in Tanzania. This equally applies and could be more severe in Malawi where land is limited, and farmers would rather prioritise cash crops than improved forages.

There was a considerable number of KII who highlighted that farmers have access to tree legumes such as *L. leucocephala* and *C. sepium*, and improved pastures such as Napier, Rhodes and tropical grasses and Lucerne. Since the 1980s, the World Agroforestry Centre (ICRAF) Southern Africa program, collaborating with local research and development partners (e.g., The Forest Research Institute of Malawi, the Land Resource Conservation Department, the Department of Agricultural

Research Services, and Department of Animal Health and Livestock Development of the Ministry of Agriculture, Department of Forestry and Lilongwe University of Agriculture and Natural Resources, Mzuzu University and National Farmers' Association of Malawi) has been conducting integrated research to tackle issues such as low crop yield, soil fertility, limited cash income, fuelwood scarcity, and inadequate livestock production due to fodder shortages (Chakeredza et al., 2007; Franzel et al., 2014; Sibale et al., 2013). This has led to the growth of some of these tree and shrub legumes, albeit the low adoption rates, especially as fodder. Throughout the FGDs, most of the farmers indicated that they lacked the necessary technical expertise or training to integrate certain tree foliage into livestock diets. A study (Musa et al., 2018) conducted in the Salima district found adopters of tree/ shrub legumes embraced them because of their soil fertility improvement capabilities, provision of shade, a source of food (mainly *C. cajan*), and erosion prevention as primary functions.

Although ICRAF established 36 fodder banks in 1998, , the training given to pioneer farmers was inadequate to ensure optimum tree care, and limited extension support led to low survival rates of the seedlings (Chakeredza et al., 2007). It is, therefore, important for researchers, government and donor organisations to prioritise testing fodder shrubs with farmers, effectively monitor farmers adaptation to their diverse needs, and evaluate optimal scaling approaches for different agroecological zones and farmer contexts. The utilisation of fodder tree/shrub legumes is crucial for the development of the livestock sector among smallholder farmers due to the challenges they encounter concerning poor-quality crop residues and limited pastures (both natural and improved).

Qualitative Data

Focused group discussions

Farmers who participated in the FGD had similar challenges, chief amongst them financial constraints, which have a multiplier effect on farm production. This observation is not peculiar, as over 19 million people in Malawi survive on a per capita gross national income of USD 380 annually (i.e., sixth poorest globally), with 70% of the population depending on farming for a living and living on less than USD 1.08 per day (Bhatti et al., 2021). The repercussions of low incomes are profound, particularly for smallholder farmers who often find themselves trapped in a cycle of subsistence living. Not only do they grapple with the fundamental necessities of farming such as acquiring seeds, fertilisers, and livestock, but their limited resources also mean they struggle to adequately provide for their family's sustenance.

For instance, livestock diseases were highlighted as a major challenge by the farmers. According to Grace et al. (2015) livestock diseases account for nearly USD 9 billion annually, which is about 6% of the value of the livestock sub-sector in Africa. The primary contributors to this issue include climate change, inadequate regulation of livestock transportation, limited implementation of disease prevention measures, and ineffective veterinary services (Nuvey et al., 2022). While the Malawian

government offers veterinary services, farmers have voiced concerns regarding their accessibility and effectiveness. Many farmers report a shortage of veterinarians, and even when available, they often lack essential supplies such as vaccines or medication. Consequently, farmers are burdened with the additional cost of procuring these necessities independently. The impact of diseases has led to a decline in livestock numbers in most communities. Therefore, it would be prudent for government and donor organisations to offer some of these services on behalf of the farmers if the livelihoods of these rural farmers are to be improved. For example, Inter Aide and the Global Alliance for Livestock Veterinary Medicines provided support for increased production of the vaccine and have been training community vaccinators to go door-to-door to carry out vaccination of chickens at a small fee (FAO, 2022).

The issue of cost must be addressed if the livestock sector in Malawi among the smallholder sector is to be improved by reducing disease incidences and prevalence. When addressing the shortage of veterinarians, the government and NGOs must develop a model that trains youth as community-based animal health workers (CBAHWs), akin to the Kenyan model (Mugunieri et al., 2004). This training should encompass not only the identification, diagnosis, and treatment of common diseases but also the proper handling and utilisation of veterinary drugs. Furthermore, it is imperative to enhance research efforts in ethnoveterinary medicine, tapping into the rich knowledge of farmers regarding indigenous plants beneficial for treating animal ailments. For instance, plants like *Mucuna puriens* and *Tephrosia vogelii* are utilised for managing external parasites, while *Vernonia adoensis* and *V. amygdalina* are employed in controlling Newcastle disease among poultry (FAO, 2022).

The farmers also highlighted another critical issue that adversely affected their productivity: exorbitant costs of seeds, fertilisers, and animal feed stemming from financial constraints. Subsidy programs like the Farm Input Subsidy Programme (FISP) and the Affordable Inputs Program (AIP), implemented by the Malawian government, have significantly facilitated access to a variety of seeds (such as maize, sorghum, rice, and legumes) and fertilizers (Matita et al., 2022; Walls et al., 2023). However, the sustainability of farmers' adoption of hybrid seeds remains uncertain in the absence of continued subsidies (Matita et al., 2022; Walls et al., 2023). Despite these efforts to assist farmers, the government will not be able to satisfy all the requirements, given the challenges the country is facing. However, the adoption of SI-MFS would be able to assist in this regard, especially the use of interdependences of the cropping and livestock systems. Crop-livestock mixed farming systems can reduce the cost of feed by utilising crop residues as feed for livestock (Duguma and Janssens, 2016; Rusinamhodzi et al., 2015), thus minimising the need for purchased feeds. Additionally, integrating livestock into the system allows for the recycling of nutrients (Herrero et al., 2009), decreasing the reliance on synthetic fertilisers and costly animal feed supplements.

Other issues such as lack of technical skills and markets often hinge on the poor public system which is failing to serve poor communities. It is paramount to implement training programs specifically tailored to the needs of communal farmers. Most of the farmers and KII indicated that there should training through farmer-field schools, demonstration plots and peer/ group learning. However, training must not only focus on farmers but also on public representatives, especially extension officers. Systems at various spheres of government should be put in place to define the status and regulation of community extension workers, to complement the low professional extension staff (i.e., extension and veterinary officers). According to Warburton et al., (2011), excessive dependence on NGOs for training certain Community Extension Agents (CEAs) and CBAHWs is deemed unsustainable. Therefore, there is a need for increased public sector investment to establish more cost-effective extension systems. Phiri et al. (2019b) advocate for the creation of rural information centres, which champion adult literacy programs to equip rural smallholders with literacy skills for informed decision-making in their agricultural production. Since the extension-to-farmer ratio is very high in Malawi (Antwi-Agyei and Stringer, 2021; Lee et al., 2023; van den Berg et al., 2020), the use of participatory video pilot approach could be used as an alternative to live training methods (Steinfeld et al., 2015). The video-based training can be conducted by unemployed youths in collaboration with extension officers during internships and field attachments.

In terms of markets and access to credit, the establishment of cooperative groups has been touted to expedite the adoption of agricultural technologies among smallholder farmers. Cooperatives give farmers bargaining power. However, in Africa, poor infrastructure, insufficient services, high transaction costs, weak information flows, and imperfect knowledge can hamper the efforts of cooperatives. Good access to markets and market information may help farmers bypass vendors (i.e., middlemen) while selling farm products and thus benefit get more returns than when done via middlemen (Branca et al., 2022). The inefficiency of ADMARC in providing a platform for farmers to market their crops has led to farmers selling maize crops below the floor price to private traders (Maonga and Mgonezulu, 2020). It is therefore important to develop local markets in which the role of privates (e.g., cooperatives) might be relevant to effectively assist smallholder farmers in terms of input access and storage facilities. This will not only increase market opportunities but also reduce transaction costs. Branca et al. (2022) allude that farmers can only benefit from cooperatives if there is a well-functioning infrastructure such as roads and ICTs as they are conduits in facilitating product transport, reducing the cost of the farmer's time, and enabling a more timely market.

Chemical Composition of Livestock Feed Resources Found in Kasungu and Mangochi Districts

In general, the chemical profiles of the feed resources surveyed in the two districts had high nutrient contents because of the time they were collected. These feed resources were harvested at the peak of the rainy season (i.e., January) in Malawi.

This is one limitation of the current study, in that collection of feed resources were only collected during the wet, summer season. Yet, feed gaps from natural rangelands are mainly experienced in the cool, winter season. However, some of the feed resources, mainly the browse species (e.g., *L. leucocephala*, *G. sepium*, *Khaya oleifera*) can maintain the quality of nutrients even during the dry season. Such browse species have been reported (Franzel et al., 2014; Mthi et al., 2021; Ravhuhali et al., 2022) to be potential protein supplement low-quality natural grasses because they go beyond the minimum requirement of protein and have coherent amounts of fibre concentration. The possible differences in the generally higher CP and lower NDF observed between Kasungu and Mangochi could be attributed to the differences in the agro-climatic conditions with the former receiving more rain than the latter. Higher temperatures and less amount of rainfall cause faster maturation of plants resulting in higher structural components of plant (fibre) contents and lower cell contents (Evitayani et al., 2004). Overall, arid zones tend to have pastures with the highest DM yield, with decreased CP and high fibre components (Jayasinghe et al., 2022).

Most of the feed resources had a lower relative feed value (RFV, <110), especially for farmers who want to venture into dairy farming and use some of these resources for silage-making. Relative feed value is expressed as a percentage of Lucerne at 100% bloom, whose RFV is 100 (Yolcu et al., 2008). However, snot apple tree leaves, *Calotropis procera*, wandering jew, *G. sepium*, *L. leucocephala*, Amaranthus, *Khaya nyasica* and wild vitis have the potential to be used in silage making considering that the RFV is comparable to that of Lucerne at 100% bloom.

Conclusion

Insights gathered from FGDs and KII in Kasungu and Mangochi districts shed light on the challenges and opportunities faced by smallholder farmers. Financial constraints emerge as an issue restricting it tough for farmers from accessing essential inputs (i.e., seeds, fertilisers, and animal feed), despite some level of government subsidy programs. Livestock diseases compound these challenges, underscoring the need for accessible and effective veterinary services. However, farmers recognise the benefits of sustainable intensification practices due to the interdependence of the crop-livestock systems. Yet limited technical skills and market access remain significant barriers to the adoption of this system. Overcoming these hurdles requires a strategy involving targeted training initiatives, improved services and innovative market interventions. Supporting community-based animal health workers and exploring ethnoveterinary medicine can enhance disease management practices. In addition, strengthening extension services and rural information centres can enhance farmers' technical knowledge and empower them to make better choices. Establishing group cooperatives and developing market infrastructure are crucial for improving market access reducing transaction costs and ultimately boosting farmers' profits. Analyses of the composition of livestock feed resources collected during the summer season in both districts reveal adequate nutrient quality for animals. Feed resource survey and analyses during the

dry season would have shed a clearer overview of the feed challenge since the livestock feed gaps are more pronounced during this period. However, plant species like *L. leucocephala*, *C. sepium*, *Khaya nyasica* and *Moringa oleifera* can be used as protein supplements all year round as they do not shed leaves during the cold season and there is minimal decline in their nutrient profiles. In addition, snot apple tree leaves, *Calotropis procera* and wandering jew can be used as potential silage-making foliage as they have comparable RFV to that of Lucerne at 100% bloom. Due to the diverse nature of plant species in the two districts, it is important to tailor livestock feed interventions to enhance livestock nutrition and productivity according to the available feed resources. To address the challenges faced by smallholder farmers in Malawi collaborative efforts involving the government, research bodies, NGOs and local communities are essential. By fostering partnerships investing in peoples' skills and promoting sustainable intensification practices, stakeholders can play a role, in enhancing food security, livelihoods and resilience in rural areas.

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