OPTIMIZING PRODUCTIVITY OF CROP-LIVESTOCK SYSTEM IN NORTHERN GHANA: CURRENT STATUS AND CHALLENGES OF LIVESTOCK FEEDING, PRODUCTIVITY AND MANURE UTILIZATION BY SMALLHOLDER FARMERS

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https://dx.doi.org/10.4314/gjansci.v16i1.4

ABSTRACT
A survey was conducted to determine the current status and challenges of livestock feeding, productivity and manure utilization among smallholder farmers in northern Ghana with the aim of introducing strategies for optimizing productivity. With a structured questionnaire, a multi-stage sampling involving purposive and three-tier simple random sampling were used to obtain information from 180 farm households in three regions of Northern Ghana. The data collected were analyzed with STATA software and Microsoft Excel. The result showed that, over 80% of the farmers in northern Ghana owned livestock. Goats were the most common livestock species second to local chicken. The results obtained indicate that over 90% of farmers sell their animals to generate income. In this study, the most livestock species sold were goats and local poultry during the 2022 farming season. The major feeding practices used by farmers were free range in combination with other mixed feeding practices (80%). Stall feeding was least practised by farmers in the study area. Over 30% of the farmers who practised stall feeding fed only small ruminants but not the other livestock species. About 22% of farmers practising stall feeding do not collect the manure at all. The study further revealed that 90% of all livestock farmers collect manure to fertilize their farmland. The uncollected manure form part of resource waste and a source of pollution in the environment. Farmers are encouraged to do more stall-feeding practices to generate more manure which can be used in their farms to increase system productivity.

Keywords: *Crop residues, Feed availability, Livestock farmers, Livestock species, Manure.*

INTRODUCTION
Agriculture is the backbone of Ghana's economy and employs about 50% of the population (MoFA, 2020). It contributes about 20.5% to the gross domestic product (GDP). The bulk of agricultural production is done by smallholder farmers who constitute about 85% of the farming population in Ghana (Chauvin *et al*., 2012; MoFA, 2020).

The Northern part of Ghana consists of the Guinea and Sudan Savannah agroecological zones and is made up of five administrative regions (Savannah, Northern, North East, Upper East, and Upper West regions). These five administrative regions cover 42% of Ghana's land area (MoFA, 2020). The national food insecure households are relatively high among these five northern regions in Ghana; about 48.7, 33, 30.7, 22.8 and 22.6% in the Upper East, North East, Northern Upper West and Savannah regions, respectively (GSS, 2020). The Guinea and Sudan Savannah agroecological zones are usually referred to as the breadbasket of Ghana (MoFA, 2020). Crops cultivated in these agroecological zones include rice, maize, sorghum, yam, cassava, millet, groundnut, sweetpotato, cowpea, soybean, pigeon pea, fonio, tomatoes and pepper. The residue of these crops form fodder for livestock after harvest. This area also accounts for a significant proportion of the national cattle and small ruminants (sheep and goats) population. It is responsible for 25, 30, 35, 40 and 70% of the country's poultry, sheep, goats, pigs and cattle, respectively (MoFA, 2020). This production level is not enough, and the country imports annually 42,838 live cattle, 68,656 sheep and 72,606 live goats to augment what is produced locally (MoFA, 2020). In addition, about USD 124.5 million worth of meat is imported annually to augment local production (MoFA, 2020). There is therefore the need to offset this deficit by developing and disseminating sustainable innovative and climate-smart integrated crop-livestock farming technologies to enhance local productivity.

The different livestock species reared in Ghana contribute significantly to households' food security and as a major protein source. However, the productivity of the major livestock species commonly reared by farmers in Ghana is reported to be lower than their genetic optimal levels mainly due to shortage of quality feed and wide seasonal variations in feed availability (Osei-Amponsah *et al.*, 2019). For instance, the average daily milk production per cow was reported to be less than two litres (CSA, 2021) in Ghana. The smallholder farmers are also unable to purchase commercially formulated animal feed (mixed ration) for their animals due to cost and non-availability.

Most of the smallholder farmers in Ghana produce crops and rear animals simultaneously which assist them in risk diversification. The integration of crop and livestock production enables farmers to effectively harness the benefits inherent in the crop-livestock system and improves nutrient use efficiency that directly reduces production cost and increases profitability (Asrat *et al.,* 2019). This integrated production system needs to be explored more to benefit smallholder farmers.

Livestock manure in the crop-livestock system is a valuable resource and could be used to fertilize croplands and subsequently result in a reasonable increase in productivity (Powell *et al.,* 2004). Studies have showed that introducing forage legumes into crop-livestock production systems improves soil fertility, crop yields, and herbage quality, making the system more sustainable. The high-quality manure produced in this system could be properly managed and used by the same farmer to improve soil fertility in place of chemical fertilizer which is mostly expensive and has availability challenges during the cropping season. The objective of this study therefore was to describe the current status and identify challenges in livestock feeding, productivity and manure usage by smallholder farmers in crop-livestock production systems.

MATERIALS AND METHODOLOGY

Study location

The study was implemented in Northern, North East and Upper East regions of Ghana within Guinea Savannah agro-ecological zones. The major farming system practised in the study locations is integrated farming system where crops and livestock are produced mostly by smallholder farmers (GSS, 2020). The study area experiences unimodal rainfall pattern which begins in April and ends in October with an average rainfall amount of 1100 mm. There is an annual occurrence of harmattan (cold winds) in the area from November to February (GMS, 2016).

Sample Size determination

The sample size for the study was determined using the following Cochran's formula below;

$$n = \frac{Z^2 \times P(1-P)}{M^2}$$

Where;

n	=	Required Sample Size
Z	=	Confidence level at 90% (standard value of 1.645)
P	=	Estimated prevalence of farm attribute in the project area
M	=	Margin of error at the 90% confidence level is 10% (standard value of 0.1)

The value of P is an unknown value that falls between 0 and 1. To solve for *n,* we adopted at a least a minimum prevalence value of 0.4 as farm attributes, P.

$$n = \frac{1.645^2 \times 0.4(1-0.4)}{0.1^2}$$

$$n = \frac{0.64944}{0.01}$$

$$n = 64.944$$

$$n \approx 65$$

We assumed that the sample size obtained, is the sample size for each study reason. Three regions were involved in this study (sampling procedure follows). This therefore brought the total sample size to 195. However, due to the equal randomization of farmers for the study and the limited funds available for the study, the 195 respondents were conveniently reduced to 180 households, thus indication

Sampling procedure

A multi-stage sampling method was used in this study for the selection of sites and respondents for the survey. First, three regions were purposively selected due to its location and level of practice of crop-livestock systems in the study areas. Two districts were randomly selected in each region, followed by another random selection of two communities in each district. Again, simple random selection procedure was used to select fifteen (15) farmers in each community for the study. For each stage of random selection, the randomization was conducted using the lottery method. Thus, during the random selection of districts, all districts under each region were written in small pieces of folded papers of equal sizes and separated according to regions in three different pieces of small open boxes. The pieces of paper were then mixed up rigorously to reduce selection bias. Then, three papers were then randomly selected in each box to determine

Table 1: Survey Sites in Northern Ghana

No.	Region	Districts	Communities	Respondents
1	Northern	Karaga	1. Mankula	15
			2. Nangunkpang	15
		Kumbungu	1. Gumu	15
			2. Wuba	15
2	North-East	West Mamprusi	1. Kparipiri	15
			2. Kpasenkpe	15
		Bunkpurugu /Nankpanduri	1. Kpentaung	15
			2. Nanpontbauk	15
3	Upper East	Kassena Nankana East	1. Pindaa	15
			2. Bui	15
		Talensi	1. Winkongo	15
			2. Yameriga	15
Total	**3**	**6**	**12**	**180**

the districts selected (Table 1). The same procedure was conducted to select the communities and respondents.

Data Collection
The data was collected with a structured questionnaire as a survey tool developed purposely for the study. The survey tool was uploaded into a computerized assisted data collection tool called KOBOCOLLECT and placed in tablets. The questionnaire in this form, was then pretested and revised before the actual data collection exercise. Survey enumerators were recruited and trained before the main survey data collection.

Data analysis
The data collected was analyzed with STATA software version 15 (StataCorp LLC, 2017) and Microsoft Excel. Descriptive statistics were performed and data was presented in the form of percentages, frequencies, graphs and tables. T-Test was performed to determine the effect of ownership of livestock on manure production. Standard deviations of data from means have been given for readers to appreciate the spread of the data. The results are presented in Tables and Figures to improve the clarity of the results for readers.

RESULTS AND DISCUSSION

Demographic Characteristics of the Respondents
The demographic characteristics considered in this study include whether or not the respondents are those responsible for their household agriculture, principal activity of the respondents, age and sex of respondents, farming experience and educational level of respondents.

The results show that majority of the respondents (90%) are responsible for their household agricultural activities (Figure 1). Also, about 99% of the respondents across all regions of study are into agriculture (Figure 2). Of the respondents who were engaged in other activities, the results revealed that they are into masonry, electrical and security work. Of those who are responsible for their household agriculture, about 81% were also heads of their household. This suggested that there are households in which household members are responsible for their household agriculture but are not household heads. This occurs practically in households that have aged persons especially men who are not able to actively participate in agricultural activities (GSS, 2021), but they remain the heads of the household.

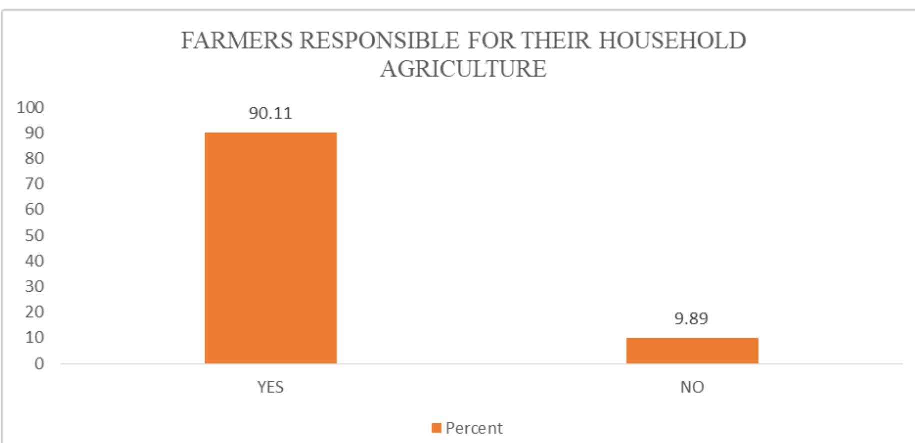

Figure 1: Respondents responsible for household agriculture (Source: Field Survey, 2023)

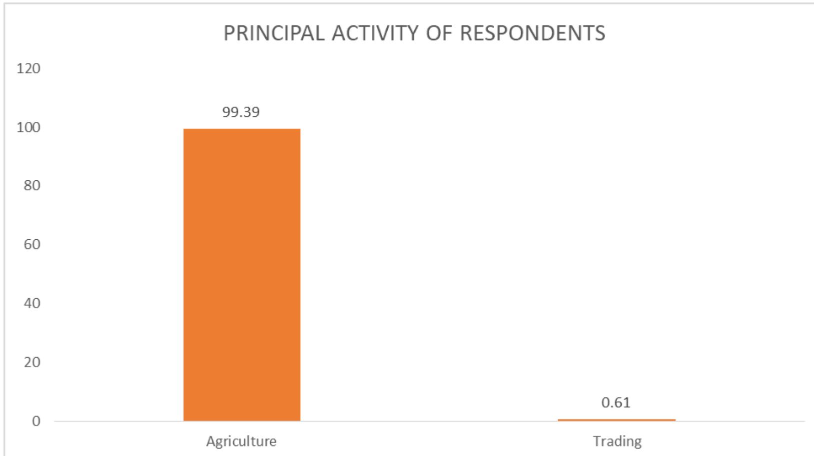

Figure 2: Principal activity of respondents (Source: Field Survey, 2023)

Another important household characteristic is the age of the respondents (Figure 3). The mean age of the respondents was about 45 years, and the average years of farming experience was 24 years. The responding farmers' ages were categorized into three age groups. Majority of the respondents (49%) were aged above 45 years. The mean age (35 years) fell within the active age bracket as stated by the Ghana Statistical Service (GSS, 2020). Across all regions, about 74% of the respondents were males and 26% females. This ratio is therefore consistent with the number of farmers who are principal actors of agriculture in the household since men are usually engaged more in the agricultural labour force than women. Similar results have been reported by other researches on male dominance in agricultural production in the study area (Abdelali Martini & Dey de Pryck, 2015: Azumah *et al.*, 2023).

While the results show that majority of the people are into agriculture, the average farming experience for farmers in the Northern, North-East, and Upper East regions were 20.7, 21.4 and 29.2 years, respectively. Northern Region is lower, possibly because the region is fast developing, and with the powers vested in the chiefs, farmlands are being converted quickly for infrastructural development than it is in the North-East and Upper East regions (Zackaria and Yaro, 2013). In the latter two regions, lands and farmlands are owned by clan or family heads with little or no power vested in the chiefs to sell lands for purposes other than farming (Zackaria and Yaro, 2013).

From the results, majority of the respondents (69%) did not obtain any form of formal education (Figure 4), and therefore, cannot read or write. A significant proportion of the respondents (about 31%) can read and write either through formal education (27.47%) or informal medium (3.3%). The results obtained are expected considering the location of the study sites, where there are few educational infrastructure and resources.

Livestock ownership, sales and losses

In this section, information on ownership, sales and unaccountable losses of livestock in the farmers' flock were sought. Out of a total of 182 respondents interviewed, 84% (152) owned livestock and 16% (30) did not own livestock. This finding confirms the report of the Ghana statistical service in Agricultural census report on livestock ownership in northern Ghana (GSS, 2020).

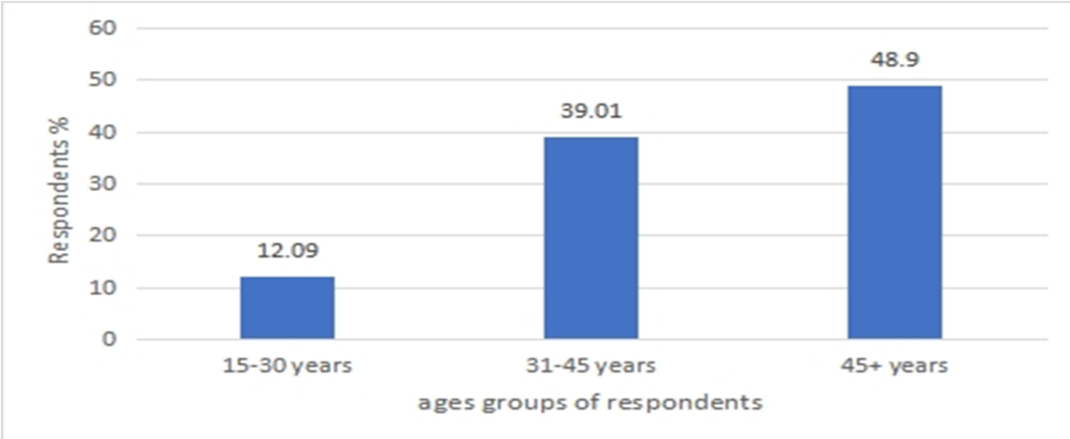

Figure 3: Age Groups of respondents (Source: Field Survey, 2023)

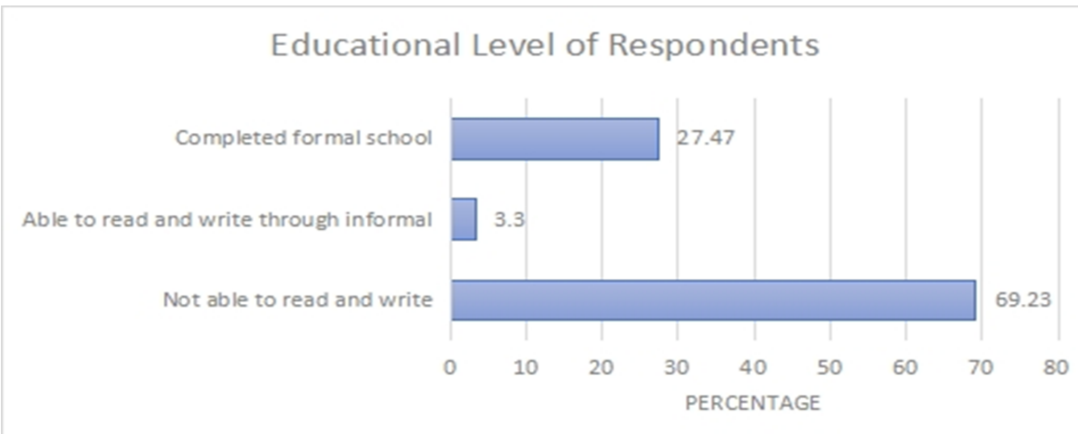

Figure 4: Educational level of respondents (Source: Field Survey, 2023)

The species of livestock owned by the respondents is given in Table 2. The results revealed that goats were the most common livestock specie owned by the respondents (87.5 %) with an average flock size of 8.82 goats per farmer. A similar figure for goat flock size has been reported (GSS, 2020: Tetteh *et al*., 2023). Local poultry breed followed in terms of respondents' (86.18%) ownership of the birds with an average of 35.65 chickens per farmer. Similar results have been found by another study in this area (MoFA, 2018)

Most of the farmers who own livestock sell the animals to generate income for themselves particularly at the onset of the farming season. This confirms the findings of other studies (Konlan *et al*., 2016; Adams et al., 2021). In this current study, the sale of livestock for the 2022 farming season was estimated by the responding farmers to be good. The respondents who owned livestock sold goats (87.50%) more and local poultry (86.18%) during the 2022 farming season as compared to other livestock species. The aver-

Table 2: Respondents' livestock ownership and sales within the 2022 farming season

Livestock species	Livestock ownership % (N)		Number of animals owned			
	Owned	Do not own	Mean	Std. dev.	Min	Max
Crossbred cattle	16.45 (25)	83.55 (127)	06.76	06.65	01.00	27
Local cattle	37.50 (57)	62.50 (95)	07.49	06.72	01.00	35
Sheep	76.32 (116)	23.68 (36)	09.89	08.06	01.00	45
Goats	87.50 (133)	12.50 (19)	08.83	08.20	01.00	56
Pigs	17.76 (27)	82.24 (125)	08.22	08.92	01.00	39
Donkeys	15.79 (24)	84.21 (128)	02.46	01.38	01.00	6
Local poultry breed	86.18 (131)	13.82 (21)	35.65	36.74	02.00	238
Improved poultry breed	04.61 (07)	95.39 (145)	10.57	10.23	02.00	25
Traditional Beehives with honey bees	03.29 (05)	96.71 (147)	05.20	03.42	01.00	10
Modern beehives with honey bees	03.95 (06)	96.05 (146)	03.50	03.33	01.00	10
Rabbits	01.97 (03)	98.03 (149)	03.33	02.31	02.00	6
Other livestock (cats, dogs, both)	07.28 (11)	92.72 (140)	05.54	03.70	02.00	12
Sale of livestock						
Crossbred cattle sold	16.45 (25)	000	00.72	01.43	00.00	5
Local cattle sold	37.50 (57)	000	00.88	01.30	00.00	5
Sheep sold	76.32 (116)	000	01.83	02.49	00.00	11
Goats sold	87.50 (133)	000	01.68	02.42	00.00	10
Pigs sold	17.76 (27)	000	02.70	04.96	00.00	18
Donkeys sold	15.79 (24)	000	00.38	00.82	00.00	3
Local poultry breed sold	86.18 (131)	000	07.04	11.56	00.00	71
Improved poultry breed sold	04.61 (07)	000	03.14	07.47	00.00	20
Rabbits sold	01.97 (03)	000	00.00	00.00	00.00	0
Traditional Beehives with honey bees harvested and sold	03.29 (05)	000	01.60	02.07	00.00	5
Modern beehives with honey bees harvested and sold	03.95 (06)	000	01.00	01.26	00.00	3
Other livestock sold	07.28 (11)	000	02.18	02.14	00.00	6
Livestock losses					00.00	
Crossbred cattle lost	16.45 (25)	000	00.52	01.05	00.00	4
Local cattle lost	37.50 (57)	000	01.33	02.29	00.00	10
Sheep lost	76.32 (116)	000	02.22	02.99	00.00	15
Goats lost	87.5 (133)	000	02.44	03.68	00.00	22
Pigs lost	17.76 (27)	000	01.48	03.21	00.00	12
Donkeys lost	15.79 (24)	000	00.25	00.68	00.00	3
Local poultry breed lost	86.18 (131)	000	08.49	20.49	00.00	207
Improved poultry breed lost	04.61 (07)	000	04.43	08.00	00.00	20
Rabbits lost	01.97 (03)	000	00.67	01.15	00.00	2
Traditional Beehives with honey bees lost	03.29 (05)	000	01.20	01.79	00.00	4
Modern beehives honey bees lost	03.95 (06)	000	00.67	01.63	00.00	4
Other livestock lost	07.28 (11)	000	01.18	01.66	00.00	5
Manure production and usage kg						
Manure production from livestock	100 (152)	000	870.33	3407.65	00.00	40000
Manure usage from livestock	100 (152)	000	767.83	3343.79	00.00	40000

***Source**: Field Survey, 2023*

age number of animals sold by respondents was higher in local chickens (7.04 birds/farmer) followed by pigs (7.70 pigs/farmer). These species have short maturity period compared to others and this might have accounted for their high sale within the year.

The farmers interviewed reported losses of their animals in line with the report of Adams et al. (2021). Among them, those who lost goats were the highest (87.50%) followed by the local chicken (86.18%). These findings follow the pattern of the ownership of various livestock species reported. The average number of the losses of livestock reported during the 2022 farming season was highest among local poultry breed (8.49 chickens per farmer) and followed by improved poultry losses with an average of 4.43 chickens per farmer. The lowest average loss was observed in donkeys which also have the lower number of farmers owning donkeys among the farm animals encountered in this study.

On manure production, all the respondents who owned livestock produced and utilized almost all the manure generated in their pens. This agrees with the report of Avornyo, *et al*. (2015) in studies on manure production of farmers who owned small ruminants in the same area. The average estimated annual manure produced per farmer was 870.33 kg and utilization average were 88% (767.83 kg) per farmer per annum.

As presented in Table 2, we tested if there is any significant difference between ownership of livestock and non- ownership of livestock on manure production among the respondents. We then tested the null (Ho) and the alternative hypothesis (Ha) to determine if ownership or otherwise of livestock contributes to manure production. Thus, the Ho and Ha are presented as;

Ho: There is no mean difference between livestock ownership and non-ownership effect on manure production ($\mu = 0$)

Ha: There is a mean difference between livestock ownership and non-ownership effect on manure production ($\mu \neq 0$)

In effect, we want to test if the mean of the difference between the pairs (ownership of livestock and non-ownership of livestock) is zero for null hypothesis and non-zero for the alternative hypothesis.

Using the two-sample t-test (paired), we show that the p-value is 0.0000 which is less than an alpha value of 0.05. There is therefore a statistical significance effect between ownership and non-ownership of livestock in terms of manure production. Consequently, we rejected the null hypothesis. It is therefore not by chance that we obtained the results in Table 3.

Animal feeding practices

Different feeding practices were found being used by the responding farmers as presented in Figure 5. The feeding practices indicate that there is low intensive livestock production feeding practice among the farmers. The major feeding practice obtained in this study was free range

Table 3: T-Test Results for Ownership of Livestock Effect on Manure Production

Variable	Obs.	Mean	Std Error	Std Dev	95% Conf. Internal	
Own Livestock	180	0.8333	0.0279	0.3737	0.7784	0.8883
Not own Livestock	180	0.1667	0.0279	0.3737	0.1117	0.2216
Diff	180	0.6667	0.5571	0.7474	0.5567	0.7766

Mean (diff) = Mean (Own livestock – Do not own livestock) t=11.9666

H_o: Mean (diff) = 0 Degree of freedom = 179

H_a: Mean (diff), 0 Mean (diff)!=0 Mean (diff).0

Pr (T<t) = 1.0000 Pr(T>t) = 0.0000 Pr (T>t) = 0.0000 grazing which was combined with other mixed feeding practices. In the Savannah ecological zone, this free range or open grazing feeding practice is common and has been widely reported (Konlan *et al*., 2016; GSS, 2020; Adams *et al*., 2021; Ajayi *et al*., 2023) and is associated with low intensification and low cost of feeding animals. About half of the livestock farmers (49%) interviewed practised free range feeding system. The second highest feeding practice indicated by respondents (32%) was combination of free range and stall feeding. This is a unique compelling practice associated with crop-livestock production system by many farmers in the area. The free-range feeding practice alternate in respect of cropping season (GSS, 2020; Seglah *et al.*, 2020; Timpong-Jones *et al.*, 2023). In this alternation, free range is dominant during dry season after all crops have been harvested and stall feeding takes over during the cropping season to prevent animals from grazing on the food crops planted by farmers (Konlan *et al*., 2016). This is in line with low practice of intensive livestock production among the farmers. The results further indicate that pure stall feeding was least practised (3%) by the farmers interviewed.

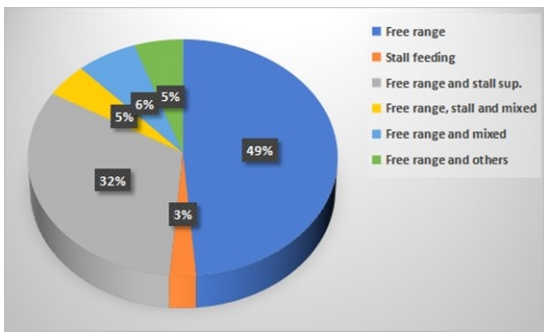

Figure 5: Animal feeding practices of responding livestock farmers

On the stall feeding as an intensive production practice and a major practice promoted by research for increasing productivity due to diminishing availability of grazing land (GSS, 2020; Adams *et al.*, 2021; Ajayi *et al.*, 2023); The study followed to determine the livestock species that are kept on stall feeding. The result showed that over 30% of the farmers who practice stall feeding, keep only small ruminants (sheep and goats) on the stalls (Figure 6). The second combination of animals kept on stall feeding were cattle and small ruminants, which was about 20% of the farmers practicing stall feeding.

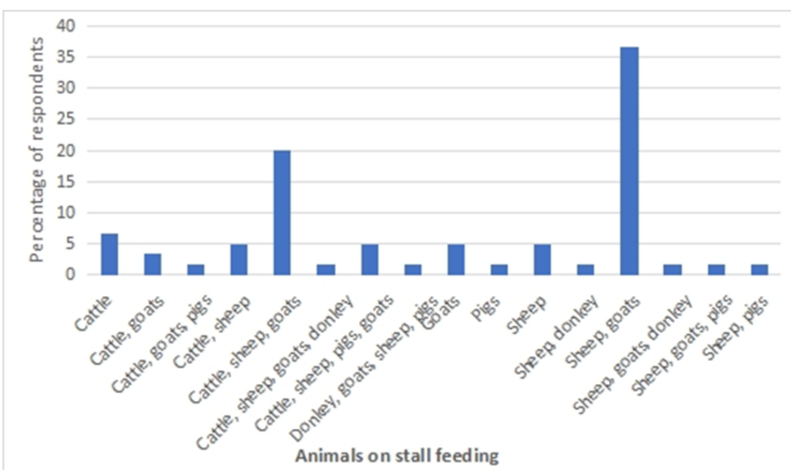

Figure 6: The proportions of farmers keeping various animals under stall feeding

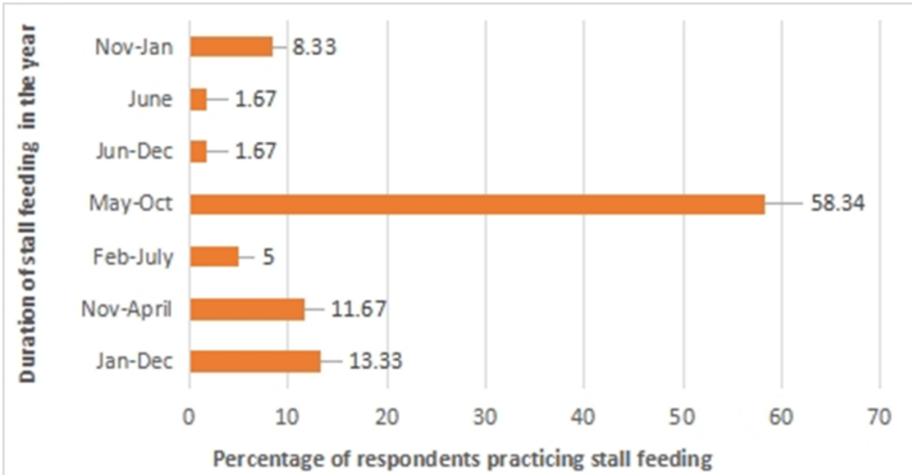

Figure 7: Stall/cut and carry feeding periods within the year.

The farmers in the Savannah agroecological zone of northern Ghana indicated the main cropping season as the period of the year in which they practise stall or cut and carry feeding. A similar finding was also reported by Boakye-Danquah *et al*. (2014) who stated that most farmers practise cut carry during the cropping season. The results showed that 58% of the farmers who practise stall feeding do it from May to October (Figure 7). This period coincides with the main cropping season as alluded to earlier. Similar results were obtained and reported by earlier studies (Konlan *et al*., 2016; GSS, 2020)

On the management of manure produced by animals on stall feeding, close to 40% of the farmers indicated that they collect the manure once per day and 22% do not collect the manure at all (Figure 8). This non-collection of animal manure could lead to sanitation-related problems and waste of a valuable production resource (Rout *et al*., 2023).

Most of the farmers used crop residue for supplementing their animals on free range (Seglah *et al*., 2020; Timpong-Jones *et al*., 2023). The various crop residues used as feed for animals according to the farmers are given in Table 4. The result indicates that cowpea and groundnut residues are the major crop residues used by farmers. This confirms the high crop residue utilization by farmers reported by other researchers in the study area (Konlan *et al*., 2016; GSS, 2020; Adams *et al*., 2021). The estimated mean quantity of crop residues used during the 2022 farming season by farmers were pigeon pea residues, cassava peels and groundnuts haulms with respective mean values of 264, 243 and 229 kg per farmer as the major crop residues utilized (Table 4).

To ascertain the significance of the use of crop residue or otherwise, as feed for animals, we performed a hypothesis test. We want to establish if the mean of the difference between the pairs (purchase of feed and non-purchase of feed) is zero for null hypothesis and non-zero for the alternative hypothesis.

The null and alternate hypothesis are therefore stated as;

Ho: There is no mean difference between crop residue usefulness and non-usefulness as feed for animal production ($\mu=0$)

Ha: There is a mean difference between crop residue usefulness and non-usefulness as feed for animal production ($\mu \neq 0$)

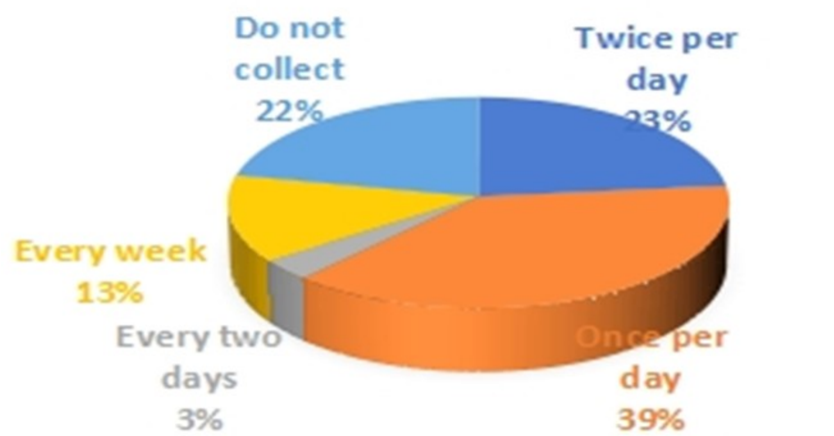

Figure 8: Manure management of animals on stall feeding

Table 4: Respondents' crop residue utilization as feed for animals

Type of crop residue	Percentage respondents		Amount used last year (2022) in kg			
	Used (N)	Not used (N)	Mean	Std. dev.	Min	Max
Pigeon Pea residue	08.55 (13)	91.45 (139)	263.85	529.78	40.00	2000
Groundnut haulms	36.18 (55)	63.82 (97)	228.91	215.28	05.00	850
Sweetpotato vines	07.24 (11)	92.76 (141)	97.818	82.215	25.00	300
Cowpea pods	46.05 (70)	53.95 (82)	198.09	279.80	01.00	2000
Cowpea haulms	32.89 (50)	67.11(102)	192.30	212.64	15.00	1000
Cassava Peels	21.05 (32)	78.95 (120)	242.50	691.15	20.00	4000
Yam peels	11.84 (18)	88.16 (134)	114.17	107.45	10.00	400
Plantain peels	00.00	100 (152)	00.00	00.00	00.00	00.00
Corn mill waste flour	12.5 (19)	87.5 (133)	226.05	259.30	25.00	1000
Cowpea bran	04.61(07)	95.39 (145)	135.71	209.83	30.00	600
Maize bran	13.82 (21)	86.18 (131)	109.29	78.50	10.00	300
Millet bran	04.61 (07)	95.39 (145)	85.03	101.71	05.00	300
Rice bran	17.76 (27)	82.24 (125)	161.11	116.37	15.00	500
Sorghum bran	01.97 (03)	98.03 (149)	77.00	58.03	11.00	120
Soybean bran	05.26 (08)	94.74 (144)	213.75	219.74	40.00	700
Rice straw	17.11(26)	82.89 (126)	280.77	266.51	30.00	1000

Table 5: T-Test Results of Use of Crop Residue as Animal Feed

Variable	Obs.	Mean	Std Error	Std Dev	95% Conf. Internal	
Used Crop residue	180	0.6833	0.0348	0.4665	0.6147	0.7519
Did not use crop residue	180	0.1667	0.0348	0.4665	0.2481	0.3853
Diff	180	0.3667	0.0695	0.9329	0.2294	0.5039
Mean (diff) = Mean (Used Crop residue – Did not use crop residue)						t=5.2729
H_o: Mean (diff) = 0					Degrees of freedom = 179	
H_a: Mean (diff), 0			Mean (diff)!= 0		Mean (diff).0	
Pr (T<t) = 1.0000		Pr(T>t) = 0.0000			Pr (T>t) = 0.0000	

In Table 5, using the two-sample t-test (paired), we show that the p-value is 0.0000 which is less than an alpha value of 0.05. There is therefore a statistical significance effect between purchase and non-purchase of feed for animal production. Therefore, we reject the null hypothesis.

Data on eggs and milk production levels and income generation of farmers from these products are presented in Table 6. The results showed that farmers obtained a limited quantity of milk only from cattle with an annual average of 7.45 L per cow. This low milk production from cattle as the only farm animal milked in Ghana has been reported and indicates further low milk yield during the dry season (Achaglinkame *et al.*, 2023). The mean daily milk production per cow was reported to be 0.8 and 0.4 L for the rainy and dry seasons, respectively (Guri *et al.*, 2018).

The milk is partly consumed by the household (2 L) and a surplus of about 4 L is sold out to generate income. The farmers estimated about GHS 22.32 per annum from sale of milk. This milk consumption value obtained in this study is far lower than the daily consumption rate in Ghana at 9 kg/person/year reported by Achaglinkame *et al.* (2023) and this is attributable to low milk production in the study area.

Egg production from chicken and Guinea fowls was estimated and a mean value of 355 eggs per farmer per year was reported as the annual value. About 62 eggs were reported as the quantity eaten at home per year and the rest sold to generate an estimated average amount of GHS 86.81 per farmer per year.

Feed purchases for livestock feeding

The research team sought to determine the level of feed purchases among farmers in the area. The results indicated that over 60% of the respondent farmers purchased feed for their animals and 40% of the farmers who purchase feed purchase roughage (browses and crop residue) for their animals (Figure 9). Other feedstuff purchased by many farmers were protein-source feed (18.75%) and a combination of energy and protein-source feed (17.71%). The feed purchases indicate a shift towards intensification of the production system as reported by Adams *et al.* (2021). The amount spent on feed purchases during the 2022 farming season, showed that the highest mean amount (GHS 630.83) spent on feed was on the purchase of mixed ration (Table 7). This mixed ration is a commercial feed formulated by feed companies and is well marketed and dominated by poultry feed. A locally formulated feed could be cheaper relative to a commercial feed when emphasis is given to it.

To ascertain the significance of the type of feed purchased for animal consumption or otherwise, we performed a hypothesis test by stating that;

Ho: There is no mean difference between pur-

Table 6: Estimated milk and egg production, consumption and sale by farmers in northern Ghana

Milk and egg production, consumption and sale	Milk production in 2022 in Litres			
	Mean	Std. dev.	Min	Max
Cattle milk production	07.45	61.94	00.00	720
Cattle milk consumption	02.03	17.35	00.00	210
Cattle milk sold	04.69	35.33	00.00	360
Estimated income received from sale of milk (GHS)	22.32	153.59	00.00	1410
Egg production	355.72	1133.49	00.00	10000
Quantity of eggs consumed	62.16	200.30	00.00	2000
Quantity of eggs sold	104.32	660.42	00.00	8000
Amount received from sale of eggs (GHS)	86.81	212.19	00.00	1000

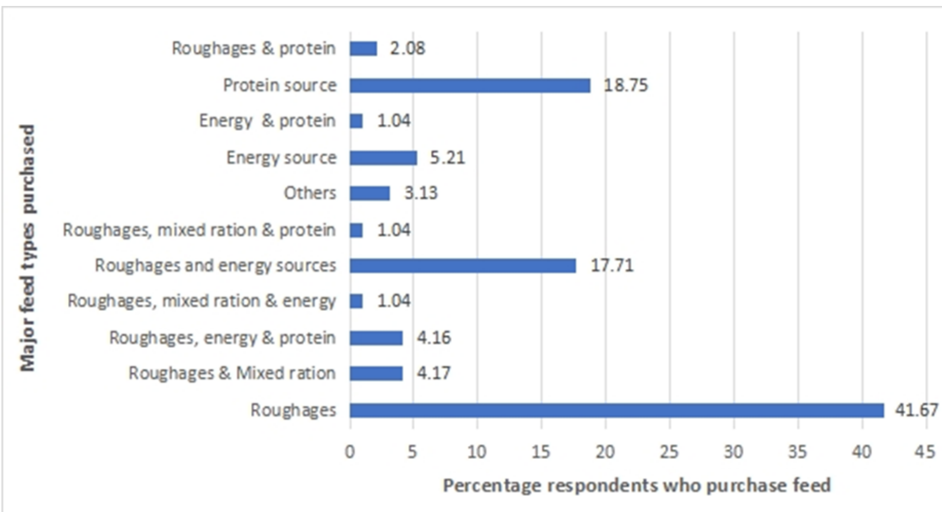

Figure 9: The proportions of farmers purchasing feed for their animals

Table 7: Types of feed purchased and amount spent by farmers during the 2022 farming season

Feed type	Respondents feed purchases (%)		Amount spent on feed purchased in 2022			
	Purchased	Not purchase	Mean	Std. dev.	Min	Max
Roughage	71.88 (69)	28.13 (27)	182.46	233.76	20.00	1200
Mixed ration	06.25 (06)	93.75 (90)	630.83	563.30	25.00	1500
Energy source	29.17 (28)	70.83 (68)	178.21	221.76	20.00	900
Protein source	27.08 (26)	72.92 (70)	190.77	184.28	20.00	820
Others	03.13 (03)	96.88 (93)	13.33	02.89	10.00	15.0

Table 8: T-Test Results for Purchase and Non-Purchase of Feed Resource

Variable	Obs	Mean	Std Error	Std Dev	95% Conf. Internal	
Purchased feed	180	0.5222	0.0373	0.5009	0.4485	0.5959
Did not purchase feed	180	0.4778	0.0373	0.5009	0.4041	0.5514
Diff	180	0.0444	0.0747	1.0018	-0.1029	0.1918

Mean (diff) = Mean (Purchased feed – Did not purchase feed) t= 0.5952

H_o: Mean (diff) = 0 Degrees of freedom = 179

H_a: Mean (diff) , 0 Mean (diff)!=0 Mean (diff)>0

Pr (T<t) = 0.7238 Pr(T>t) = 0.5525 Pr (T>t) = 0.2762

chased feed and non-purchased of feed as a feeding resource for animals (μ = 0)

Ha: There is a mean difference between purchased feed and non-purchased of feed as a feeding resource for animals (μ ≠0)

In Table 8, since the p-value (p=0.5525) is greater than the alpha value of 0.05, we therefore failed to reject the null hypothesis. This indicates that there is no mean difference purchased feed and non-purchase of feed as a feeding resource for animals.

CONCLUSIONS

The result showed that over 80 % of the farmers in the study area owned livestock and goats were found to be the most common livestock specie second to local chicken. Farmers sell their animals to generate income. The most commonly sold livestock species were goats and local poultry during the 2022 farming season. The major feeding practice among farmers was free range/ open grazing in combination with other mixed feeding practices. Stall feeding was the least practised by farmers in the study area. Over 30% of the farmers who practised stall feeding kept small ruminants on the stall feeding. Most farmers collect manure to fertilize their farmland and those who (22%) do not collect. Farmers are encouraged to do so through appropriate technology demonstrations to ensure uncollected manure do not become resource waste and also a source of pollution to the environment. A substantial proportion of farmers (<30%) are unable to purchase feed for their livestock.

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