UNIVERSITY FOR DEVELOPMENT STUDIES

ASSESSING THE FINANCIAL IMPLICATION OF SMALL RUMINANT DISEASES IN THE UPPER EAST REGION

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2025

UNIVERSITY FOR DEVELOPMENT STUDIES

FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES

DEPARTMENT OF ANIMAL SCIENCE

ASSESSING THE FINANCIAL IMPLICATION OF SMALL RUMINANT DISEASES IN THE UPPER EAST REGION

BY

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UDS/MAN/0001/21

THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ANIMAL SCIENCE (ANIMAL PRODUCTION OPTION)

MARCH, 2025

DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere. All cited literature in the text has been well-referenced and any assistance received in writing the thesis is duly acknowledged.

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ABSTRACT

A survey on the economic impact assessment of small ruminant diseases was conducted in the Upper East Region of Ghana. Primary data was collected using simple random sampling technique, a total of four hundred (400) questionnaires designed with open and closed questions were administered randomly to selected small ruminant farmers from Kassena Nankana Municipal, Bolgatanga Municipal, and Bongo District in the Upper East Region of Ghana during the period of 2nd July, 2022 to 30th July, 2022. The results of the survey indicate that demographic factors, production factors, animal housing factors, feeding characteristics, management practices, and herd structure are significant determinant of small ruminant production. The results also indicate that more small ruminant diseases were recorded in the rainy season (75.8%) than the dry season (14.2 %) with worms' infestation (43.5%) being the highest. Major small ruminant diseases recorded in this study includes; PPR, Anthrax, Bloat, Mastitis, and Mange. The effect of diseases outbreak per annum on small ruminant production includes loss of investment (32%), high cost of treatment (29.1%), and mortality (24.0%). Total cost of disease prevention was GH¢412 while that of disease control measures was GH¢784.80p per each farmer. The number of sheep and goats that died in a year as a result of diseases were 1,237 and 1,192 respectively. In monetary terms, GH¢435,509 and GH¢346,552 were lost for sheep and goats, respectively while each farmer losses GH¢1,408.30p and GH¢1,162.90p for sheep and goats, respectively due to mortality in a year. The study on the economic impact of diseases on small ruminants in the Upper East Region reveals that major small ruminant diseases have both direct and indirect consequences on small ruminant production as well as Ghana's economy. Its therefore recommended that, farmers should implement proper management practices, to optimize the health and productivity of their herd, improve overall efficiency, and enhance profitability.

ACKNOWLEDGEMENT

First of all, I want to thank God Almighty for everything He has done for me. Secondly, I want to thank my able supervisor Dr. Alhassan Mohammed for his generous supervision support and guidance, may God bless him abundantly. I also want to thank my family and friends for their prayers and support throughout my studies. I want to thank my son (co-student) Divine Awenibuno for his understanding during our studies, may God bless him always. I will not forget to thank my colleagues for their wonderful support throughout the period of our studies may God bless you all. Lastly, I thank all the staff of the Department of Animal Science for their support.

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LIST OF ABBREVIATIONS

FAOSTAT	Food and Agriculture Organization statistics
GEPA	Ghana Environmental Protection Agency
FAO	Food and Agriculture Organization
WAD	West African Dwarf
ADF	African Development Fund
IFAD	International Fund for Agriculture Development
GDP	Gross Domestic Product
UN DESA	United Nations, Department of Economic and Social Affairs, Population Division
FAO-OIE	Food and Agriculture Organization-Office international des Epizooties
OIE	Office international des Epizooties
FMDV	Foot-and-Mouth Disease Virus
PPR	Peste des Petits Ruminants
GHS	Ghana cedis
GSS	Ghana Statistical Service
CCPP	Contagious Caprine Pleuropneumonia

CHAPTER ONE

1.1 INTRODUCTION

FAOSTAT (2021) reported that the global population of small ruminants in 2019 was approximately 2.33 billion consisting of 1.24 billion sheep and 1.09 billion goats. Asia accounts for nearly half (47%) of the total small ruminant population, while Africa holds a 37% share. Within Africa, the Sahel in West Africa (35%) and the East African Highlands (31%) are regions where small ruminants are prevalent. The increasing population of small ruminants can be attributed to their crucial role in the livelihoods, food security, and sustenance of millions of small farmers, for whom they are often the most significant asset (Wodajo *et al.*, 2020; de Haan *et al.*, 2015). Small ruminants commonly raised by small-scale farmers including women with limited resources and access to basic health services perform various livelihood functions serving as income-generating activities and raw materials for local and regional industries (Wodajo *et al*, 2020). This livestock ownership is cited as one of the most important wealth accumulation activities among smallholder households in Sub-Saharan Africa (de Haan *et al.*, 2015).

Small ruminants play a vital role in the livelihoods and food security of rural households in developing countries. Animal proteins are identified as a crucial and accessible means of improving nutrition for impoverished populations. There has been a continued increase in the global demand for livestock-derived foods (Clonan *et al.*, 2016). Due to their smaller size, low cost per capita, and rapid reproduction rates, small ruminants are essential for enhancing livelihoods among the less privileged. Small ruminants are adapted to a wide variety of environments, often foraging in landscapes

and sustenance that would otherwise be of limited value for food production (Jeffrey *et al.,* 2016). Sheep and goats also have advantages over other livestock in converting forage such as straw and grasses, as well as other by-products such as kitchen waste and other waste products into high-quality, value-added food for domestic consumption (Bettencourt *et al.,* 2015).

1.2 Problem Statement and Justification

Identifying the most cost-effective diseases and quantifying their direct and indirect impacts on livestock can enhance productivity and uplift the livelihoods of impoverished farmers. Limited information exists regarding the economic consequences of small ruminant diseases in the Upper East Region. This study seeks to assess the financial ramifications of prevalent diseases in this area. Livestock rearing in the arid zones of sub-Saharan Africa reflects traditional systems (Adams *et al.,* 2021) where animals fend for themselves in terms of food, water, and shelter often lacking adequate veterinary care (Covarrubias *et al*., 2012).

Despite the significance of livestock farming for underprivileged households, they face challenges such as climate change, population growth, disease outbreaks, and evolving development patterns. The economic impact of animal diseases is substantial manifesting through fatalities, miscarriages, weight loss, diminished quality, and the resources expended to manage and combat these illnesses. Consequently, these diseases result in both direct and indirect losses for breeders and producers, diminishing the quality and quantity of animal products available for local consumption (Amani, 2012; Adams and Kwasi, 2015). Adams and Kwasi (2015)

highlighted key constraints hindering small ruminant production in tropical Africa, including disease and pest infestations, inadequate nutrition, limited water resources, substandard breeding stock, poor marketing strategies, insufficient capital, lack of credit access, natural disasters, political instability, and inadequate veterinary and advisory services.

1.3 General objective

To assess the economic impact of small ruminant diseases in the Upper East Region.

1.4 Specific objectives

1. To determine the head structure of small ruminants in the Upper East Region
2. To determine the major diseases of small ruminants in the Upper East Region.
3. Investigate the season that which diseases are prevalent in the Upper East Region.
4. To determine small ruminant disease preventive and control measures put in place by farmers in the Upper East Region.
5. To estimate both the direct (death, morbidity, and reduction in productivity) and indirect (prevention and control measures) economic impact of small ruminant diseases in the Upper East Region.

CHAPTER TWO

2. 0 LITERATURE REVIEW

2.1 Small Ruminant Production

FAOSTAT (2021) reported that in 2019 the global population of small ruminants stood at approximately 2.33 billion, with sheep accounting for 1.24 billion and goats at 1.09 billion. Asia holds the majority share of small ruminants at 47%, while Africa retains 37% of the total population. Regions like the Sahel in West Africa (35%) and the East African Highlands (31%) are home to significant populations of small ruminants. Small ruminants play a crucial role in the livelihoods and food security of small farmers worldwide serving as vital assets for millions of individuals, particularly those with limited resources and access to basic services (Wodajo *et al*, 2020; de Haan *et al*, 2015). In Ghana, data indicates that approximately 6.02 million people in rural areas, accounting for about 40.5% of the population engage in livestock farming as a means of livelihood (Ghana Statistics Service, 2012). However, the production of ruminants faces significant challenges such as high mortality rates, pest infestations, and recurring diseases, resulting in economic losses estimated at around 50 million United States dollars (MoFA, 2007; Mahama, 2012). Despite the significant economic contribution of ruminant farming to the country, the government's allocation of funds for this sector is notably inadequate (MoFA, 2010; Oppong-Anane, 2011). In the northern regions of Ghana, small ruminants play a crucial role in the agricultural systems of small-scale farmers due to their distinctive biological traits, including high fertility rates, efficient conversion of rough fodder into feed, short gestation periods, fast growth rates, and resilience to diseases (Lebbie, 2004; Peacock, 2005).

However, in Northern Ghana, the full potential of small ruminant production remains untapped due to challenges such as high mortality rates and low productivity levels (Baah *et al.*, 2012).

These animals not only provide income and raw materials for industries but also fulfill various socio-cultural roles such as in ceremonies and inheritance. Ownership of small ruminants offers a source of emergency funds for herders, enabling them to meet various financial obligations. These animals serve as adaptable trading assets, providing quick access to cash for a range of needs, from health and education expenses to investments and social activities (Kosgey *et al.,* 2008; de Haan *et al.*, 2015).

In some communities, owning small ruminants signifies social status and helps in accessing financial services. Livestock systems in developing countries are evolving rapidly due to factors like population growth, urbanization, and increasing demand for animal products (Jejaw *et al.*, 2014). Livestock farming in arid regions reflects traditional systems where animals play multiple roles beyond mere monetary gain, providing socio-economic benefits like skin, fertilizer, savings, insurance against crop failures, and cultural services (Weyori *et al.*, 2018). Sheep and goats are efficient in converting various forages and by-products into high-quality food, making them valuable assets for domestic consumption and economic sustainability (Bettencourt *et al.*, 2015).

2.2 Agro-ecological Zones and Smallholder Small Ruminant Production in Northern Ghana

2.2.1 Agro-Ecological Zones in Northern Ghana

The agroecological zones in Ghana reflect the natural vegetation found in different regions, influenced by soil and climate characteristics (Ghana Export Promotion Authority, 2002; FAO, 2005). Ghana comprises six distinct agroecological zones (Amekudzi et al., 2015). To the south of the Sudan savannah lies the Guinea savannah zone, covering an area of 147,900 km^2. This zone encompasses most of the Southern portion and the Northern Region of the Upper West Region (Tsibey *et al.*, 2003; Karbo and Agyare, 1997; Canagarajah and Portner, 2003). Additionally, the Sudan savannah zone includes the entirety of the Upper East region and a significant portion of the Upper West region, totaling approximately 1,900 km^2 (Codjoe, 2010).

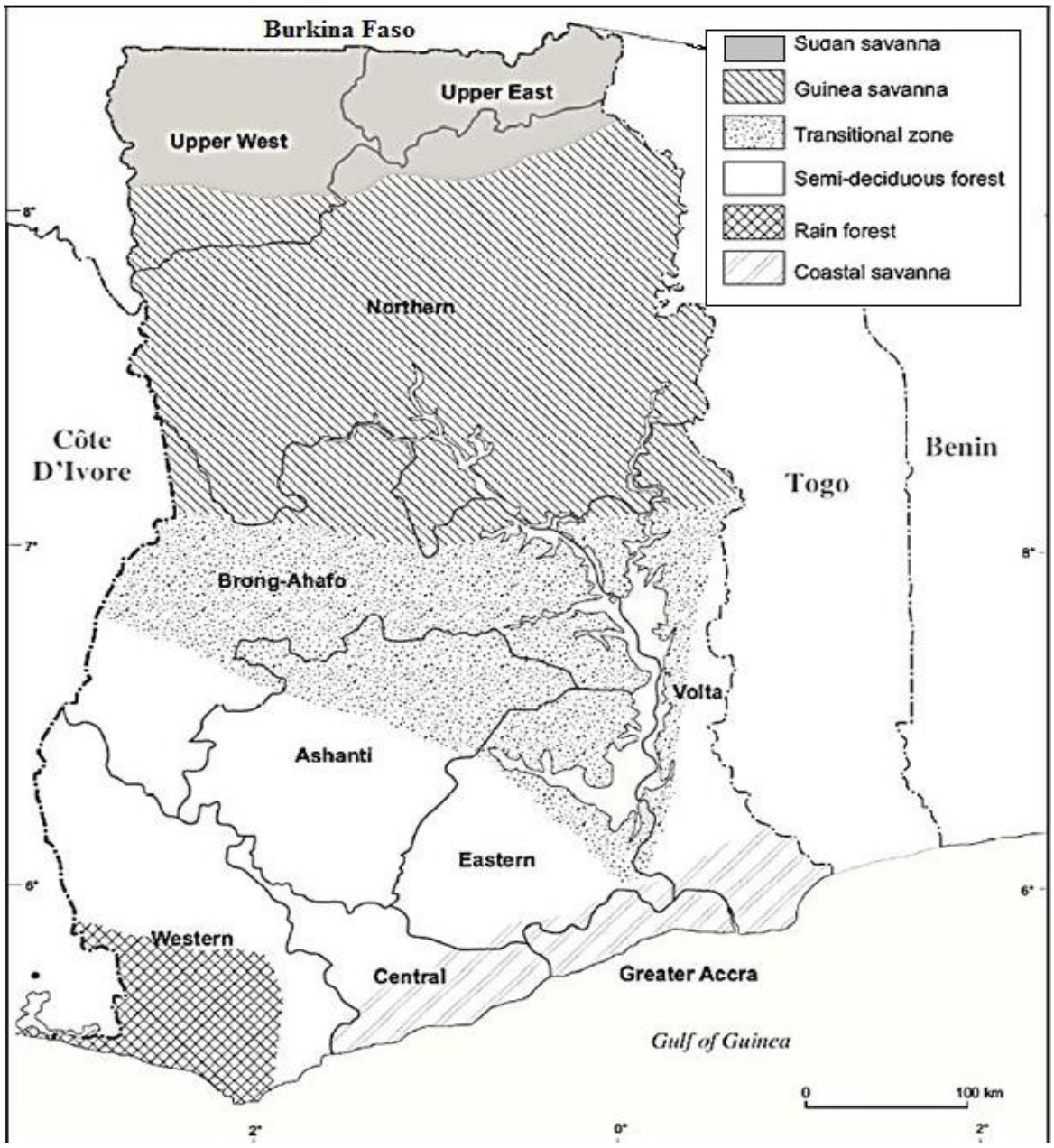

Figure 2.1: Map Illustrating Agro-Ecological Zones of Ghana. Source: Quansah et al. (2001)

The characteristics of Ghana's Guinea Savannah and Sudan Savannah Agroecological Zones exhibit variations in precipitation levels, temperature, vegetation cover, and their impact on agricultural activities in these regions (Codjoe, 2010). These

differences influence agricultural production systems, risk management strategies, production challenges, and the diverse motivations and objectives of small-scale farmers. The Sudan savanna zone is characterized by sparse grass cover, scattered drought-resistant deciduous trees, open savanna grasslands, and prevalent surface soil erosion (Ghana Export Promotion Authority, 2002). Variations in annual rainfall and vegetation features, such as grass availability and type contribute to differences in livestock farming practices and herd sizes within these zones (Wilson, 1991). The dry savannah regions including the Guinea and Sudan savannahs are responsible for approximately 75% of small ruminants and 70% of the country's cattle (Oppong-Anane, 2011). Furthermore, the disparities in socio-cultural and agroecological zones influence impact the significance of livestock rearing for smallholder farmers in the area (Mapiye *et al.*, 2009).

2.3 Breed Types and Production Systems of Small Ruminants in Ghana

2.3.1 Breeds of Sheep and Goat in Ghana

When choosing the appropriate animal breed for a specific agroecological zone, key factors to consider are its adaptability to local environmental conditions, management expenses, and potential for commercial viability (Adams and Kwasi, 2015). The long-legged, larger, Sahel breeds are less resistant to trypanosomiasis compared to the West African dwarf breeds (Opasina and David-West, 1987), while the WAD breeds are widespread throughout the country (Mahama *et al*, 2003). A notable breed category that has gained importance over time is the crossbreeds between WAD and Sahelian types developed through various breeding initiatives like the Smallholder Rehabilitation Development Program, the National Livestock Services Projects, Open

Nucleus Breeding Schemes, and the Land Conservation and Smallholder Rehabilitation Program (Oppong-Anane, 2011). The West African dwarf sheep known as djallonke is a prominent breed in the country widely utilized in breeding programs due to its hardiness, trypano-tolerance, high fertility, and year-round breeding capabilities. Adult djallonke sheep typically weigh between 25 kg to 30 kg for males and 20 kg to 25 kg for females with black and white coloration (Opong-Anane, 2006). They have an average reproductive output of 1.28 lambs per ewe annually with a low lamb mortality rate of 0.3 from birth to weaning (Mourad *et al.*, 2001).

In contrast, Sahel breeds are characterized by their tall stature, with mature females weighing around 45 kg and males between 45 kg to 55 kg. They have distinct physical traits such as long legs, ears, and a dangling tail. The West African dwarf (WAD) and Sahel goat breeds exhibit similar adaptive qualities as the djallonké sheep but differ in characteristics. The West African dwarf goat shows achondroplastic dwarfism, with mature weights averaging between 20 kg to 25 kg for male adults and 18 kg to 22 kg for female adults (Adams and Kwasi, 2015). Reproductive performance indicators for the West African dwarf goat include an average of 2.2 kids per doe annually, an all-cause mortality rate of 23.7%, and a reduction rate of 38% (Opong-Anane, 2006; Adams and Kwasi, 2015).

2.4 Production Systems

Small ruminant production systems in sub-Saharan Africa can be broadly categorized into modern and traditional systems (Adams, 2015). The traditional production systems can be further classified into semi-intensive (agropastoral), intensive

(agricultural or village), and extensive (pastoral) systems. The Pastoral or Extensive System is typically found in semi-arid and arid regions with low rainfall below 700m (Adams, 2015). The relationship between animal husbandry systems and their environment is crucial in understanding the evolution of specific local characteristics and is fundamental to any efforts to enhance animal production (Adams, 2015). Livestock systems in the tropics can be broadly divided into traditional and modern production systems, with various subdivisions based on factors such as climate, environment, operational methods, regulations, urbanization levels, adaptation, and rangeland capacity (Hughes *et al.*, 2019). A key aspect of livestock farming systems is the integration of livestock rearing with crop production, facilitating the use of animal manure to enhance soil fertility. Additionally, crop residues are utilized to feed animals promoting environmental sustainability (Oppong-Anane, 2011; African Development Forum, 2001). The main types of small ruminant management systems in northern Ghana include:

- Extensive system
- Traditional or landless system
- Intensive system
- Semi-intensive system

The progression from traditional to more intensive systems of goat and sheep farming in the region is marked by a continuum where grazing land decreases while null grazing intensity increases (Oppong-Anane, 2011). These four production systems are intertwined with the primary economic activities of arable or tree cultivation. In traditional, semi-intensive, and extensive systems small ruminants graze on farmland

post-harvest, consume crop by-products, and are tethered during harvest seasons. The animals' dung fertilizes the land during grazing or tethering activities (Adam, 2015).

2.4.1 Traditional or landless production systems

In the traditional system of production, animals are predominantly reared in free-range conditions presenting challenges for conducting systematic studies of the production system. Livestock numbers per person or household are typically small, ranging from 1 to 10 head, with goats outnumbering sheep (ADF, 2001; FAO, 2012; Adams and Kwasi, 2015). Farmers rearing small free-range ruminants often face resource constraints leading to limited use of veterinary care, supplements, proper quality breeds, and housing systems (ADF, 2001). These animals typically forage for food and water near villages without designated ranchers, freely moving within the village and intermingling extensively.

In traditional sheep and goat production systems in northern Ghana, inbreeding is common, contributing to issues like dystocia due to the early mating of young females (Adam, 2015). High mortality rates are attributed to inadequate housing, overcrowding, poor ventilation, and disease outbreaks like diarrhea and pneumonia particularly during the rainy seasons (Turkson *et al.*, 2004). Despite many rural households in agroecological savannah areas owning sheep or goats, productivity remains low due to disease-related mortality and nutritional deficiencies. Both sheep and goats are dwarf breeds, with goats being more prolific (Adams and Kwasi, 2015). Livestock are typically acquired through inheritance, purchase, or gift to replenish farm stocks (Suleman, 2006). The dominant systems in northern Ghana are the

traditional landless and extensive systems, characterized by low production costs and yields, utilizing natural grazing lands and crop residues for feeding (Turkson and Naandam, 2006). Labor costs are minimal as scavenger animals receive little care, although mortality due to road accidents is notable (Alenyorege *et al.*, 2010). The traditional system of small ruminant production has been in place for many centuries across the three Northern regions of Ghana, however, the rise of urbanization, soil fertility loss, and technological advancements has led to the emergence of alternative production systems like intensive/backyard, semi-intensive, and extensive systems (Oppong-Anane, 2011).

2.4.2 Extensive system

The extensive system, similar to the traditional outdoor system, involves providing more care and attention to animals and supplementing their feed at specific times of the year (Adams and Kwasi, 2015). The average number of animals per farm in this system typically ranges from two to ten per household similar to the free-range system (Suleman, 2006). Studies by Naandam and Turkson (2006) have highlighted that the extensive and traditional production systems are commonly practiced for small ruminant production in northern Ghana known for their low output and production costs relying on crop residues and naturally grown pastures. However, these systems often face limitations in veterinary services, feed supplements, and proper housing due to resource constraints among farmers (African Development Fund, 2001). On the other hand, in the intensive production system, small ruminants are continually housed in constructed enclosures and fed throughout without access to communal grazing lands (Oppong-Anane, 2011). This system is based on utilizing household-generated

waste and crop residues following a zero-grazing approach (Oppon-Anane, 2006). According to Food and Agriculture Organisation (2012) data goat, and sheep production contributed approximately 41% of domestically produced meat in Ghana in 2010.

2.4.3 Semi-intensive system

In contrast to the extensive system of small ruminant production, grazing is restricted in the semi-intensive system with barn feeding relying on family labor, timing, and the availability of forage (Adams, 2015). Typically, grazing occurs during late morning or evening hours. The construction of simple kraals in this system involves using locally sourced materials like wood, bamboo, branches, and mud, often roofed with leaves, sheet metal, or split bamboo (Opong-Anane, 2011). Common feed sources include cut-and-carry forage, crop by-products, household food waste, and crop residues (Duku *et al.*, 2010). As a result of limited grazing opportunities on natural pastures in the semi-intensive system of production goats and sheep may lack essential minerals. Reports indicate that mineral supplements like bone meal, dicalcium phosphate, and salt lick are not commonly used in semi-intensive systems, as small-scale farmers may find them unaffordable or may live in rural areas where such supplements are not readily available (Karbo *et al.*, 1999).

2.4.4 Intensive system

In the system of small ruminant production, animals housed in kraals are restricted from grazing on communal land, with all their food provided within the kraals (Oppong-Anane, 2011). The intensive system of small ruminant production also

adopts a zero-grazing approach, household waste, and utilizing crop residues. Sheep and goats are typically fattened in this system to supply meat for city markets during celebratory and religious events. The intensive system of production is commonly observed in peri-urban and urban areas. While access to veterinary services is on the rise some farmers still resort to self-medication using herbal remedies (Oppong-Anane, 2006). In the intensive system of production, animals are typically fed crop by-products or grasses, with occasional return of manure to the farmland. In a symbiotic relationship within the integrated livestock-crop system, small-scale farmers often invest proceeds from the harvest in small ruminants at the end of the growing season. These animals are then kept until the new harvest season begins, at which point they are sold to acquire inputs for arable farming (Opong-Anane, 2011).

2.5 Economic importance of small ruminant production

2.5.1 Provision of livelihood

Devendra and Chantalakhana, (2002) reported that the economic significance of small ruminants for the welfare of landless and impoverished households is often greater than commonly acknowledged. Sheep and goats play a crucial role in the livelihoods of economically vulnerable households by strengthening social bonds, ensuring food security, creating employment opportunities, and poverty alleviation. The economic contribution of small ruminants is particularly vital in fostering sustainable livelihoods in arid regions of sub-Saharan Africa (Otte *et al.*, 2010; International Fund for Agricultural Development, 2004; ADF, 2001), where they are seen as valuable natural and financial assets in vulnerable households (Heffernan *et al.*, 2003).

2.5.2 As a source of capital

According to Adams and Kwasi (2015), many farming households in the Northern region of Ghana, goats and sheep serve as essential forms of investment, savings, and security against income fluctuations providing a safety net for unforeseen expenses like medical bills and school fees. Small ruminants outshine other agricultural products, including larger livestock like cattle, as a means for capital accumulation due to the relatively low initial investment required for starting a sheep and goat enterprise. Additionally, goats and sheep are easier and quicker to sell than large cattle herds providing a potential source of immediate cash in times of financial need (Adams and Kwasi, 2015). Their biological adaptability enables them to withstand droughts better than cattle, and their short gestation periods allow for quicker recovery from environmental challenges like drought or disease outbreaks, providing a steady income for farmers even during difficult times.

2.5.3 Natural wealth

In Ghana small ruminant production is prevalent among arable farmers, enhancing the sustainability of farming systems by integrating sheep and goats into crop production (International Fund for Agricultural Development, 2004). The manure from these animals improves soil fertility, especially for farmers unable to afford chemical fertilizers. The utilization of goat and sheep products in rural households, often unreported in official statistics, contributes significantly to local nutrition and agricultural sustainability. Additionally, these animals play a role in combating soil erosion and bushfires by grazing on marginal lands, reducing fire risks and erosion potential (International Fund for Agricultural Development, 2004). Sheep and goats

are valuable sources of protein in local diets, particularly benefiting vulnerable groups like children and pregnant women in improving their nutrition (International Fund for Agricultural Development, 2004). Women raising sheep and goats often experience improved economic prospects in situations such as divorce or when husbands go on seasonal migration (International Fund for Agricultural Development, 2004). The income generated from selling sheep and goats can be used to purchase food or support children's education, leading to enhanced decision-making roles for women in households where these livestock contribute to overall wealth (International Fund for Agricultural Development, 2004).

2.8 Determinants of smallholder small ruminant production

Overall, the production and livelihood decisions of agricultural households are greatly influenced by a combination of socioeconomic and demographic variables (LeMay, 2006) as well as institutional, technological, and political factors (Barrett *et al.*, 2001). Studies conducted on small ruminant production systems in various countries indicate that these factors can generally be categorized as follows: economic status factors (such as demographic variables like gender, age, education, household size, and cultural and sociological factors (including beliefs, religious practices, and ethnic characteristics) (Verbeek *et al.*, 2007; Dossa *et al.*, 2008; Omandi *et al.*, 2008; Fakoya and Oloruntoba, 2009; Duku *et al.*, 2011). Furthermore, important policy and institutional factors impacting small ruminant husbandry and management include access to credit from savings in formal financial entities, formal financial institutions, and availability of advisory services (Oluwatayo and Oluwatayo, 2012; Dossa *et al.*,

2008). The subsequent section will delve into the implications of these factors on small ruminant husbandry and management.

2.8.1 Demographic factors

A wealth of literature focusing on diverse regions of rural areas across Africa has established that women are more inclined to own and raise small ruminants compared to men (Devendra and Duku *et al.*, 2012; Duku *et al.*, 2011; Chantalakhana, 2002; Lebbie, 2004). In contrast to adult males, females typically do not hold the role of ancestral land guardians (Kasanga and Kotey, 2001; Apusigah, 2009; Adolwine and Dudima, 2010) resulting in constraints on their land use rights (Awumbila, 2007). Women also face limited non-agricultural job opportunities relative to men (Awumbila, 2007; Simth *et al.*, 2001) further exacerbated by restrictions on using family land as collateral in formal financial markets (Lebbie, 2004; Dossa *et al.*, 2008).

These challenges drive rural African women towards less male-dominated survival options such as diversifying into small ruminants like sheep, poultry, and goats (Oladele and Monkhei, 2008). Women often excel in raising these animals as they are commonly kept near homes and can be sustained on kitchen waste and other household by-products. Studies suggest that younger and more educated individuals tend to transition from farming to non-agricultural jobs, while older rural household heads, particularly those with limited off-farm opportunities, tend to remain in agriculture (Dossa *et al.*, 2008).

Elderly individuals in rural communities of sub-Saharan Africa typically manage large numbers of small ruminants compared to younger household heads, often supported

by larger household sizes (Kunene and Fossey, 2007). They are more likely to engage in the day-to-day tasks related to small ruminant rearing, as they are less inclined to seek non-agricultural employment in distant locations (Asafu-Adjei and Dantankwa, 2001). Studies in various African countries, including Ghana, Botswana, and Benin, highlighted that older household heads show more willingness to acquire and raise small ruminants (Adam *et al.*, 2010). Technical advancements in livestock farming in Africa necessitate the adoption of new information and practices. Households with technical training tend to embrace innovative approaches (Alene and Manyong, 2007; Adam *et al.*, 2010; Legesse *et al.*, 2013), indicating that higher education levels influence decisions to raise and own sheep and goats (Asfaw and Adamassie, 2004).

In the realm of agricultural household modeling education is often regarded as a proxy for human capital (Pender and Gebremedhin, 2006). Research conducted in sub-Saharan Africa demonstrates a positive correlation between farmer education and livestock ownership (Oluwatayo and Oluwatayo, 2012; Fakoya and Oloruntoba, 2009; Alene and Manyong, 2007). Pender and Gebremedhin (2006) suggested that higher levels of formal education coupled with increased income, play a role in influencing livestock management. Similarly, Ampire and Rothschild (2010) reported that technical training and enhanced literacy in livestock husbandry enable farm households to recognize the profit potential in livestock rearing, leading to a greater likelihood of engaging in livestock farming as a business venture.

In regions of sub-Saharan Africa where mechanized agricultural systems are limited households often rely heavily on the labor provided by numerous individuals for both

domestic and farm activities (Duku *et al.*, 2011). Several studies highlight a significant positive link between household size and the keeping of small ruminants (Oluwatayo and Oluwatayo, 2012; Duku *et al.*, 2011; Fakoya and Oloruntoba, 2009). For instance, Duku *et al.* (2011) reveals that a higher number of children and active adults within households in Ghana's agroecological transition zone increases the likelihood of farm households raising sheep, goats, or both. Similarly, Verbeek *et al.* (2007) find that households with a higher dependency ratio are more inclined to keep livestock.

2.8.2 Institutional factors

In rural African communities, the availability of formal credit and agricultural insurance is often limited. As a result, individuals and rural households are compelled to seek available financing avenues beyond traditional financial markets to mitigate the impact of income fluctuations on consumption. In such scenarios, income diversification among rural households and individuals underscores the importance of accumulating liquid assets through animal husbandry. Sheep and goats play a crucial role in providing financial security and acting as a form of private insurance, given their strong market demand and the ability to stabilize liquidity fluctuations (Adams and Kwasi, 2015). Small ruminants also function as a medium-term reserve of liquidity in rural areas (Adams and Kwasi, 2015).

Consequently, rural and agrarian households particularly those with restricted access to formal credit invest in small ruminants as they can be readily sold to expand agricultural holdings or purchase agricultural inputs (Duku *et al.*, 2012; Dossa *et al.*, 2008). In regions with established formal savings institutions, small-scale farmers

often opt for livestock farming as a means of saving and financing due to high transaction costs and low returns associated with traditional banking savings and investments (Dossa *et al.*, 2008). In economies like Ghana, the provision of livestock health and veterinary management services is a key aspect of advisory services (Adams and Kwasi, 2015).

Research conducted in developing countries indicates a positive relationship between household heads' access to advisory services and livestock ownership as well as the adoption of livestock-related innovations (Kalinda *et al.*, 2012; Adam *et al.*, 2010). Therefore, the availability and utilization of advisory services can catalyze enhancing animal production. Access to advisory programs can also contribute to improving farmers' knowledge regarding feed utilization and animal disease management. According to Kalinda *et al.* (2012), there is a positive connection between farmers' access to advisory information and services and their ownership of livestock.

2.8.3 Economic factors

In the realm of economic factors, non-agricultural income encompasses earnings from activities outside of agriculture, such as non-agricultural wage labor, self-employment in non-agricultural sectors, and other sources of non-agricultural income. Agricultural households engaged in non-agricultural pursuits generate cash flow that can be utilized to fund investments in livestock and crops. Research by Barret *et al.* (2001) demonstrates that engaging in non-agricultural economic endeavors in rural sub-Saharan Africa is linked to increase household income and the accumulation of livestock wealth (Adams and Kwasi, 2015). Various studies focusing on rural areas in

sub-Saharan Africa indicate a positive correlation between non-farm income and the decision of individual members or households to engage in livestock rearing (Barrett *et al.*, 2001; Duku *et al.*, 2011; Thys *et al.*, 2005).

2.5.4 Utilization of Sheep and Goats for Financial and Insurance Purposes in Rural African Communities

In many sub-Saharan African regions, the majority of the population resides in rural areas where smallholder agriculture encompassing both crop cultivation and livestock farming serves as the primary economic activity. As a result, promoting rural development has become a key focus for national governments, with a particular emphasis on countries like Ghana. A critical aspect of such efforts involves the establishment of robust financial markets that can facilitate savings mobilization, investment opportunities, and the provision of credit to small-scale farmers (Slingerland, 2000). In the absence of efficient financial markets livestock including goats and sheep have emerged as alternative mechanisms for wealth creation (as savings or collateral) and risk mitigation strategies akin to insurance policies. Livestock serves as both long and short-term savings avenues to prepare for future needs and plays a very important financing role in environments where formal banks are sparse or inadequately developed (Moll, 2003). Additionally, livestock is utilized as a form of insurance providing a financial buffer against unforeseen circumstances within rural households.

The financial role of livestock is multifaceted. The proceeds from livestock sales enhance the stability of smallholder agricultural activities by enabling farmers to

acquire necessary inputs for crop production (Dankwantah and Asafu-Adjei, 2001). Furthermore, the capital invested in the production of livestock serves as a safety net offering security against unexpected financial burdens and income shortfalls. Household livestock holdings can be utilized as collateral to cover financial gaps and unforeseen expenses that may arise in the future (Ouma *et al.*, 2003).

In rural agricultural contexts, livestock play a vital role in providing liquidity, acting as a readily convertible asset to generate immediate cash income when needed, without significantly disrupting farm operations (Moll, 2003). Compared to other assets like land or equipment livestock are more easily and quickly monetized due to their high market demand (Moll, 2003). Additionally, farm animals have the potential to appreciate over time, as they possess the capacity to grow and reproduce, unlike annual crop production which lacks this wealth accumulation trait (Slingerland, 2000; Ouma *et al.*, 2003; Moll, 2003). The accessibility and controllability of small ruminants such as sheep and goats make them particularly appealing to farm households for financing and insurance purposes. Unlike assets such as land that may be communal or leased, livestock ownership provides individuals with greater autonomy and decision-making authority over their productive resources (Devendra and Chantalakhana, 2002). Moreover, the relatively low capital requirements for owning sheep and goats make them accessible to smallholder farmers, further enhancing their appeal as financial assets (Devendra and Chantalakhana, 2002).

2.6 Advantages of Small Ruminant Production

Livestock farming serves as a crucial risk mitigation plan for vulnerable communities and individuals living in poverty particularly those situated on the fringes of African urban centers (Thornton, 2010). Research conducted by Wilson (2018) and Weyori *et al.* (2019) highlighted the significant contributions of animal husbandry in peri-urban and urban areas towards alleviating poverty and enhancing household food security. Wilson (2018) underscores that the production of livestock enables households to diversify their sources of income and livelihood. Moreover, research by Mendes *et al* (2021) and Adams *et al.* (2021) demonstrates that maintaining livestock including pests offers an accessible means of generating immediate income to meet the expenditure of households particularly for children's education, while also serving as a financial security and medium-term savings avenue against income shortfalls.

For agricultural households, the presence of livestock acts as a protective shield against the repercussions of crop failures, facilitates diversification of investments, and enables fulfillment of social and cultural obligations during festive occasions like naming ceremonies, funerals, and weddings (Weyori *et al.*, 2019; Mendes *et al.*, 2021). At a macroeconomic level, livestock production contributes substantially to the agricultural sector's GDP share in African economies ranging between 30% and 80% (African Union Commission, 2015). Global projections indicate a significant rise in the cattle population from 1.5 billion to 2.6 billion and in the goats and sheep population from 1.7 billion to 2.7 billion between 2000 and 2050 as reported by Robinson *et al.* (2011).

As the demand for meat and animal products escalates worldwide, driven by factors like population growth, and increasing incomes, especially in the Global South, urbanization, animal production, particularly small ruminants emerge as a vital means of meeting the burgeoning urban populace's animal protein requirements (Robinson and Pozzi, 2011; Thornton, 2010). Therefore, bolstering the symbiotic relationship between local marginal farmers and urban food sources, especially for animal protein, is imperative, particularly in secondary cities experiencing rapid population expansion (Carey and James, 2018; Roberts, 2014).

2.7 Small ruminant production challenges

Livestock farming plays a critical role in supporting impoverished families; however, it faces various challenges such as climate change, population growth, disease outbreaks, and evolving development trends. Animal diseases are particularly significant due to their economic impact, resulting in losses for breeders and producers through deaths, weight loss, quality deterioration, and the resources needed for disease management (Amani, 2012). The escalating urbanization in Africa and Asia poses challenges for livestock farming in suburban areas as the world's urban population continues to rise, with a projected increase to 8.6 billion by 2030, primarily concentrated in sub-Saharan Africa and Asia (UN DESA, 2019).

Urban expansion and land use changes for residential and commercial purposes are converting agricultural lands on the outskirts into permanent urban spaces, impacting peri-urban areas with implications for water and food availability for animals and humans (UN-Habitat, 2020). Livestock farming in arid regions of sub-Saharan Africa

typically follows traditional systems with animals having limited access to veterinary services and relying on natural resources for sustenance (Covarrubias *et al.*, 2012). Key constraints affecting small ruminant management in tropical Africa include disease outbreaks, inadequate nutrition, pest infestations, water supply, breeding stock, capital, marketing, natural disasters, credit access, insufficient veterinary and political instability, and advisory services (Adams and Kwasi, 2015). Research in Ghana highlights disease, management knowledge, feeding, housing, lack of drugs, mortality rates, and destructive behaviors as primary constraints in sheep and goat production (Turkson and Amakye-Ansah, 2005; Turkson and Naandam, 2006; Oppong-Anane, 2006).

According to Duku *et al.* (2010) parasitic disease infections and forage shortages are frequently identified as the primary impediments to small ruminant production in other sub-Saharan African countries and Ghana surpassing all other challenges. The prevalence of diseases and parasites affecting sheep and goats, along with limitations in feed availability, often leads to elevated mortality and illness rates, undermining the animals' overall economic viability. Despite the widespread recognition and discussion of the threats posed by parasitic diseases and forage scarcity in existing literature (Turkson and Amakye-Ansah, 2005; Dossa *et al.*, 2007; Turkson and Naandam, 2006; Oladeji and Oyesola, 2008) there is a notable dearth of research examining how farmers' socioeconomic, production-related, and institutional characteristics influence the vulnerability of smallholders to these constraints in the Northern region of Ghana.

The institutional and socioeconomic conditions in which farmers operate are essential for enabling the adoption of innovations or technical interventions at the farm level (Verbeek *et al.*, 2007; Dossa *et al.*, 2008). However, the crucial characteristics including institutional and socioeconomic factors necessary for a comprehensive understanding of small farmers' production realities in Ghana are frequently overlooked (Duku *et al.*, 2010). This oversight often results in small farmers being inadequately served by interventions and programs aimed at enhancing meat production and increasing farmers' income levels (Mapiye *et al.*, 2009). Hamadeh *et al.* (2001) identified increasing population pressure on farmland and uncontrolled bushfires as the primary factors impacting forage shortages among smallholders. Additionally, Duku *et al.* (2010) highlights the importance of the knowledge, skills, and perceptions of small livestock farmers in managing feed restrictions for small ruminant production.

Smith (2008) emphasizes that management systems and climatic conditions are key determinants influencing disease incidence and parasitic challenges in smallholder ruminants in sub-Saharan Africa. Turkson (2003) attributes the prevalence of disease and parasitic infections to inefficient veterinary care for smallholder livestock farmers. Poor animal husbandry practices, as identified by Dei *et al.* (2007) contribute to the promotion of disease and parasitic infections, while the extensive scavenging system exposes animals to hazardous conditions, including disease parasites and theft (Oladeji and Oyesola, 2008).

2.9 Factors influencing small ruminant productivity of producers

Research indicates that the productivity of male and female agricultural producers is significantly impacted by various demographic and socioeconomic factors (Marinda *et al.*, 2006; Epeju, 2010) as well as institutional and political influences (Luquman *et al.*, 2006; Hulela, 2010). Numerous researches have highlighted the gender disparities in crop production enterprise productivity (Tiruneh *et al.*, 2001; Marinda *et al.*, 2006; Epeju, 2010). However, the factors that affect the productivity of female and male producers in livestock, particularly sheep and goats remain poorly understood (Hulela, 2010; Duku *et al.*, 2011). Consequently, there is limited household data including gender concerning the management of small ruminants (Paudel *et al.*, 2009). This knowledge gap is particularly crucial for sub-Saharan Africa in semi-arid and arid regions like the Northern region of Ghana where women play an equally important role in managing goats and sheep within the family. Although research on the gender productivity gap in livestock production is scarce, significant factors such as economic characteristics and personal characteristics of farmers are influential along with political and institutional factors that strongly affect these production differences (Tiruneh *et al.*, 2001; Chengole *et al.*, 2003; Duku *et al.*, 2011; Hulela, 2010). The personal and economic characteristics of farmers determine their access to and control over production resources, while political and institutional frameworks often offer technical support to farmers (Food and Agriculture Organisation, 2011).

For this reason, selected factors affecting the productivity of small ruminants in both female and male farmers are discussed as follows.

2.9.1 Household characteristics

Farmers who are older and reared small ruminants (both males and females) are more inclined to enhance the productivity of these animals compared to younger farmers, assuming all other factors are equal. Research backing this theory demonstrates a positive correlation between small ruminant productivity and farmer age (Oluwatayo and Oluwatayo, 2012; Fakoya and Oloruntoba, 2009). Research indicates that farmer age serves as a representation of farming experience and is anticipated to have a positive impact on the productivity of small ruminants (Marinda *et al.*, 2006; Elizabeth, 2006; Epeju, 2010). Oluwatayo and Oluwatayo (2012) highlighted that farmers' social standing and wisdom enhance with age enabling them to oversee the resources necessary for enhancing production and productivity of small ruminants. Similarly, Marinda *et al.* (2006) also argued that older farmers have amassed more experience and expertise in livestock management, which may contribute to increased productivity of small ruminants. According to Dossa *et al.* (2008), older women in rural areas tend to enhance small ruminant productivity more than their younger counterparts due to their control over productive resources. Al-Rimavi (2002) also noted that older women exhibit greater ownership and productivity increases in livestock compared to younger females. Meanwhile, Legesse *et al.* (2013) found that younger farmers, regardless of gender, show more inclination towards innovation and adoption of new technologies to enhance productivity, in contrast to older farmers. Faizal and Kwasi (2015) further support this by reporting that younger farmers are more open to utilizing livestock technologies to boost productivity, displaying a higher level of adventurousness in this regard. The influence of marital status on small

ruminant productivity is varied among male and female farm managers. For married individuals, male managers typically exhibit higher productivity levels, while female managers tend to have lower productivity (Epeju, 2010). The marital status of a farmer is often taken as an indicator of additional labor availability, primarily through spouses and children (Epeju, 2010).

In the transition zone of Ghana, Duku *et al.* (2011) discovered a correlation between large household sizes and the increased production of small ruminants. Small ruminants are typically kept near the homestead in northern Ghana and other regions of West Africa (International Fund for Agricultural Development, 2007), enabling households with more family members to expand their small ruminant populations and enhance productivity by leveraging the additional labor available for tasks such as feeding, herding, and constructing enclosures (Verbeek *et al.*, 2007). Examining a study conducted in Nigeria, Fakoya and Oloruntoba (2009) identified a positive association between household size and small ruminant productivity, utilizing semi-log and log-log production functions.

Managers with higher levels of education within small ruminant enterprises are more inclined to improve productivity compared to their less educated counterparts. The impact of training on small ruminant productivity varies for both male and female farmers. Fakoya and Oloruntoba, (2009) suggest that farmers with advanced education levels are more likely to adopt new technologies essential for enhancing small ruminant productivity. Conversely, farmers with lower levels of education encounter challenges in acquiring and applying the scientific knowledge and skills necessary for

incorporating technologies aimed at increasing agricultural productivity (Epeju, 2010).

A study conducted in Nigeria by Fakoya and Oloruntoba (2009) and Oluwatayo and Oluwatayo (2012) revealed a positive connection between formal training for farmers and an uptick in small ruminant productivity. It is posited that farmers with a solid formal education possess the requisite understanding and knowledge to assess risks in livestock production, thereby boosting productivity (Marinda *et al.*, 2006). Furthermore, education empowers farmers to adopt improved livestock management practices, consequently striving for enhanced productivity (Oluwatayo and Oluwatayo, 2012).

Conversely, Faizal and Kwasi (2015) observed that male farmers with lower levels of education, coupled with access to technical training, play a crucial role in enhancing agricultural productivity. They also noted an increase in agricultural productivity among female farmers with at least an elementary education level compared to those with higher or no formal education. Supporting this stance, Sulo *et al.* (2012) identified a positive association between female farmers with a minimum of primary education and the adoption of advanced agricultural technologies to bolster productivity. On the contrary, Dossa *et al.* (2008) discovered minimal to no correlation between education level and small ruminant husbandry, as well as the probability of escalating productivity in southern Benin.

2.9.2 Institutional factors

Farmers who have better access to extension services are more likely to enhance the productivity of their small ruminants compared to those with limited or no access. Regular interaction with extension services is anticipated to boost production and productivity in small ruminants (Adam *et al.*, 2010). Training sessions not only improve farmers' awareness of new agricultural technologies (Elizabeth, 2006; Marinda *et al.*, 2006) but also equip them with information on input and output markets, thereby enhancing productivity. Consequently, extension training is expected to have a positive impact on the productivity of small ruminants. Supporting this notion, Oluwatayo and Oluwatayo (2012) highlight a positive correlation between farmers' (specifically women's) utilization of extension services and the productivity of small ruminants in Nigeria. Studies have shown that continued engagement with extension services promotes the adoption of technology in small ruminants, resulting in increased productivity in sheep and goats.

In contrast, Quisumbing (1995) presents a different perspective, revealing a negative relationship between women farmers' advisory contact and agricultural productivity. This suggests that women engaged in small ruminant farming face challenges in accessing counseling services, and even when available, they may not derive significant benefits due to discomfort with male counselors. Small ruminant managers (both male and female) who have easier access to formal credit facilities tend to experience higher small ruminant productivity. Research indicates that access to credit is closely linked to increased livestock productivity, particularly among female farmers, as it enables them to purchase necessary inputs for boosting productivity.

Correspondingly, Adam *et al.* (2010) reported a positive correlation between farmers accessing formal credit and adopting small ruminant technologies that can enhance productivity. Epeju (2010) also supports this observation, highlighting the role of credit access in elevating agricultural productivity, including livestock farming. Additionally, Slingerland (2000) suggests that farmers' access to credit indirectly contributes to enhancing livestock productivity. In traditional production systems, sheep and goat production are interconnected with crop production, where cash obtained from credit is used to finance crop activities. Any surplus income from crop production is then allocated towards investments in animal production (Siegmund-Schultze *et al.*, 2011).

In the literature, Ayalew *et al.* (2003) observed that in smallholder agriculture, the use of credit solely for animal production purposes is limited, as animals are usually reared to meet the needs of smallholders rather than for commercial demand. Small ruminant farm managers (both men and women) who are part of cooperative associations are more likely to enhance productivity compared to farmers who do not have such collaborative platforms for sharing knowledge and insights on animal production (Ayoade *et al.*, 2009). Membership in these associations not only links farmers to markets and essential service providers that can boost productivity but also fosters awareness of modern agricultural technologies and acts as a gateway to further education aimed at increasing productivity (Legesse *et al.*, 2013). Through these cooperative associations, farmers can access informal loans to invest in their small ruminant enterprises, as highlighted by Oluwatayo and Oluwatayo (2012) in their

study on the positive link between farmers' cooperative membership and small ruminant productivity in Nigeria, particularly among women farmers.

2.9.3 Economic factors

Small ruminant productivity tends to be higher for male and female small ruminant managers who have opportunities for non-farm employment. According to Reardon *et al.* (1994) non-farm income can serve as an alternate source of funding for investment in and expansion of animal production activities in sub-Saharan Africa. Supporting this idea, Al Rimavi (2002) noted that the additional income generated from non-agricultural activities is often utilized to purchase more livestock breeds, essential inputs, and veterinary services, all of which contribute to enhancing small ruminant productivity. Similarly, Diiro (2013) established a significant positive relationship between the adoption of agricultural technologies and increased procurement of farm inputs necessary for enhanced productivity among farmers with non-farm income streams.

2.10 Major Diseases Affecting Small Ruminant Production

2.10.1 Peste des Petits Ruminants

Peste des petits ruminants (PPR) are a highly contagious disease affecting sheep and goats, caused by the PPR virus belonging to the Morbillivirus genus, which also includes viruses responsible for rinderpest (RP) in cattle, measles in humans, and distemper in dogs (Jeffrey *et al.*, 2016). RP was the first animal disease to be globally eradicated in 2011 and is only the second disease, after smallpox, to have been eradicated (Jeffrey *et al.*, 2016). PPR poses a significant challenge to small ruminant

production in Africa, Asia, and the Middle East, with many pastoral communities ranking it among the top animal diseases impacting meat and milk production (Jeffrey *et al.*, 2016). The disease is prevalent in regions such as Africa, the Middle East, Turkey, Central Asia, South Asia, and East Asia, and has expanded to new areas over the past decade, including North Africa, Southern Africa, China, and Kazakhstan (Banyard *et al.*, 2010; Wu *et al.*, 2015; Kock *et al.*, 2015). The overall livelihood impacts of PPR on affected communities, though challenging to quantify, are among the most significant reported, with an estimated annual mortality rate of 1.44 billion small ruminants in infected countries at the end of 2014 (Jeffrey *et al.*, 2016).

2.10.2 Coccidiosis

Coccidiosis is a disease of significant economic importance worldwide, leading to reduced productivity due to the associated morbidity, mortality, clinical and subclinical illness, as well as the costs of prevention, control measures, and treatment (Temizel *et al.*, 2011). This condition is caused by microscopic, single-celled protozoal parasites that have a direct and intricate life cycle, resulting in damage to gut cells (Coffey, 2014). Known as "bucket disease," coccidiosis is an infection caused by parasites of the Eimeria genus, which proliferate in the small and large intestines of various animal species, particularly impacting young animals (Chartier and Paraud, 2012). While several Eimeria species affect different ruminants (such as cattle, goats, and sheep), the strict host specificity prevents cross-infection, which can pose a significant challenge for young and stressed animals (Etsay *et al.*, 2020). Small ruminants harbor numerous species of coccidia, with some being potentially highly pathogenic while others exhibit low pathogenicity under normal conditions.

Eimeria infection can affect small ruminants of different ages and breeds (Rehman *et al.*, 2011). Coccidiosis is most commonly observed in young animals aged 4–6 months, with lambs showing a higher prevalence, particularly in intensive farming environments (Etsay *et al.*, 2020). The disease presents clinically when non-immune young animals face a significant challenge from sporulated oocysts (Etsay *et al.*, 2020). Some studies conducted have documented the prevalence of coccidiosis in small ruminants (Khan *et al.*, 2011; Nourollahi *et al.*, 2014). This condition leads to gradual weight loss, anemia, hindered growth and development, reduced weight gain, decreased feed conversion efficiency, fatigue, and in severe cases, even death in sheep (Mohammed *et al.*, 2016; Seyoum *et al.*, 2018; Zajac *et al.*, 2020). Coccidiosis affects the quality of skin, coat, meat, and milk production, while also increasing breeding costs and reducing economic returns (Yan *et al.*, 2021). The global cost of parasite treatment is estimated to be in the tens of billions of dollars annually (Roeber *et al.*, 2013). Despite the recent use of anthelmintics for chemical control, an increasing number of nematodes have developed resistance to these treatments (Yan *et al.*, 2021).

2.10.3 Brucellosis

Brucellosis in small ruminants, affecting goats and sheep, is characterized by mass abortion in ewes, as well as epididymitis and orchitis in rams during the initial stages of the disease. However, it transitions to a chronic and latent phase following the initial onset (Wogayehu *et al.*, 2020). In sheep and goats (excluding *Brucella ovis* infection), the disease is primarily caused by one of the three biovars of *B. melitensis* and *B. abortus*, with *B. melitensis* being the most common infecting sheep and goats. This organism is known to be the most virulent among the Brucella species and is

responsible for the majority of brucellosis cases in humans. While breed susceptibility varies among sheep, goat breeds are highly vulnerable. Rams are primarily affected by *B. ovis. Brucella melitensis* is notably prevalent in the Mediterranean region, as well as in the Middle East, Central Asia, the Persian Gulf (Arabian Gulf), and certain countries in Central America. Although this organism has been documented in Africa and India, it does not appear to be endemic to Northern Europe, North America (excluding Mexico), Southeast Asia, Australia, or New Zealand (Wogayehu *et al.*, 2020). Brucellosis is a globally significant endemic zoonotic disease caused by gram-negative coccobacillus bacteria of the genus Brucella. Various animal hosts, including humans, can be infected by Brucella spp. (Bagheri *et al.*, 2020).

The Brucella genus currently consists of 12 species, with the possibility of additional species being recognized in the future (Hull and Schumaker, 2018). Notable among these species are *B. melitensis* and *B. abortus,* which have significant zoonotic implications worldwide, primarily affecting small ruminants and cattle, respectively. The diseases caused by these species are characterized by symptoms such as abortion in late pregnancy, fetal death, infertility, and decreased productivity in livestock (Poester *et al.*, 2013). Brucellosis in cattle carries negative socioeconomic consequences, particularly in vulnerable, low-income communities, notably in regions like the Middle East. The economic losses resulting from this disease in livestock production within resource-poor endemic areas go beyond direct impacts, influencing socioeconomic development and exacerbating poverty levels (Hotez *et al.*, 2012; Musallam *et al.*, 2016; Franc *et al.*, 2018). The primary economic impacts of brucellosis in small ruminants include infertility, high mortality rates in lambs and

kids, disease outbreaks, costs related to vaccination and research, movement restrictions, culling, market losses due to the risk of infected meat and milk, mortality, morbidity, reduced production, export setbacks, depletion of animal genetic resources, and the financial burden associated with disease prevention and mastitis. The reproductive losses linked to brucellosis pose a significant challenge to optimizing the small ruminant sector. These reproductive issues stem from abortion, the birth of weak offspring, and infertility (Bagheri *et al.*, 2020).

2.10.4 Foot and Mouth Disease (FMD)

Foot and mouth disease (FMD) is a significant livestock ailment with a global impact (FAO-OIE, 2012). The annual economic toll including production losses and vaccination costs in endemic areas, is estimated to be between US$6.5 billion and US$21 billion (FAO-OIE, 2012). Moreover, outbreaks in FMD-free regions lead to losses surpassing US$1.5 billion annually (Knight and Rushton, 2013). As per OIE (2015) FMD is a highly contagious disease affecting cloven-hoofed animals, caused by the foot-and-mouth disease virus (FMDV) found in the Aphthovirus genus within the Picornaviridae family. FMDV consists of seven antigenically distinct serotypes (O, A, C, Asia 1, SAT 1, SAT 2, and SAT 3) that do not provide cross-protection. The disease typically starts with a high fever within two to three days, leading to the development of blisters and erosions in the mouth, resulting in excessive salivation. Additionally, blisters can emerge on the nose, teats, and feet, potentially rupturing and causing lameness.

It also leads to gradual weight loss in adult animals over several months and a notable temporary or permanent decrease in milk production (Chepkwony *et al.*, 2021). The disease can persist for up to nine months in sheep and up to six months in goats (Stenfeldt *et al.*, 2014). While foot-and-mouth disease in adult sheep and goats often presents as asymptomatic, it can result in high mortality rates among young animals. Clinical manifestations in young lambs and kids include nonvesicular death due to cardiac failure following myocarditis (Chepkwony *et al.*, 2021). Lameness is typically characterized by a reluctance to stand up and move (Mahmoud *et al.*, 2019).

2.10.5Mycoplasmosis

Mycoplasmosis is an infectious disease caused by mycoplasma, the smallest wall-less prokaryotes (Kumar *et al.*, 2011). This ailment has emerged as a significant threat and a transboundary epidemiological concern, affecting the global regulation of small ruminant production and imposing substantial economic burdens on small ruminant farmers and rearing nations (Kumar *et al.*, 2011; Chakraborty *et al.*, 2014; Prats-van der Ham *et al.*, 2015). The agents responsible for these diseases demonstrate autonomous replication and behave as extracellular parasites on the mucous membranes of animals (Yatoo *et al.*, 2018). Although primarily commensal, they can cause severe morbidity and mortality under specific conditions (Tigga *et al.*, 2014). Typical mycoplasmal diseases, including arthritis, encompass contagious goat pleuropneumonia, contagious agalactia, pneumonia, mastitis, inflammation of the seminal vesicles, ampullitis, epididymitis, orchitis, urethritis, conjunctivitis, and meningitis, either individually or forming part of classic syndromes (Kumar *et al.*, 2014). These diseases manifest a variety of clinical symptoms such as respiratory

problems, genito-urogenital symptoms, mastitis, arthritis, conjunctivitis, and neurological symptoms, making clinical diagnosis complex (Ravishankar *et al.*, 2011; Awati and Chavhan, 2013; Chakraborty *et al.*, 2014). While some mycoplasma infections exhibit distinct signs, the convergent clinical outcomes of two or more organisms can impede further clinical diagnosis (Chakraborty *et al.*, 2014).

2.10.6 Salmonellosis

Salmonellosis is a rare disease in sheep, but severe outbreaks can lead to significant animal losses (Demirbilek *et al.*, 2018). Sheep can contract various Salmonella species from the Enterobacteriaceae family. Ovine salmonellosis may serve as a crucial zoonotic reservoir for human infections (Demirbilek *et al.*, 2018). Severe diarrhea is a common symptom, and pregnant ewes may experience abortions. Salmonella abortus-ovis, a bacterial pathogen, can induce abortions, stillbirths in pregnant ewes, and neonatal mortality (Andrs and Juan, 2021). Salmonella species can be isolated from the liver, spleen, or gastrointestinal tract of aborted fetuses, as well as from fetal membranes and vaginal secretions of affected ewes (Schlafer and Foster, 2016). Polymerase Chain Reaction (PCR) testing enables the detection of *S. abortusovis* DNA up to 3 months post-infection in culture-negative samples (Andrs and Juan, 2021).

2.10.7 Mastitis

Mastitis, an inflammation of mammary gland tissue, is a common condition affecting highly productive buffalo, cattle, sheep, and goats worldwide. This condition is characterized by physical, chemical, pathological, and bacteriological changes in milk and mammary tissue. Various causative organisms and predisposing factors, both

genetic and non-genetic, contribute to caprine mastitis, with staphylococci being a significant etiologic agent. Non-genetic factors like poor hygiene practices, inadequate management, teat injuries, and improper milking techniques are known to facilitate the entry of bacterial pathogens into the glands, leading to disease occurrence (Muhammad *et al.*, 2017). Mastitis is defined as inflammation of the mammary gland, often resulting from intramammary infections with different pathogens, although physical, chemical, or mechanical injuries can also trigger mastitis (Accorsi *et al.*, 2002). Mastitis in small ruminants holds significant importance from various perspectives. Primarily, the economic impact is substantial as mammary gland diseases cause a decrease in both quantitative and qualitative milk production, necessitating costly therapeutic interventions. Severely affected animals are typically culled as well. Additionally, the hygiene and safety standards of milk and dairy products are crucial to prevent consumers from falling ill due to potential contamination risks (Olechnowicz and Jakowski, 2014).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The study area

The Upper East Region, one of the five northern administrative regions of Ghana is situated within the savannah vegetation belt characterized by modest rainfall that supports the cultivation of cereal crops and legumes. Agriculture and agro-based industries form the backbone of the local economy with animal husbandry playing a significant role in agricultural production. Livestock farming in the region primarily involves cattle, sheep, goats, and various types of poultry such as chickens, ducks, guinea fowl, pigeons, turkeys, and doves. Geographically, the Upper East Region lies in the Northeast corner of Ghana, bordered by Burkina Faso to the North, the Republic of Togo to the East, the Sissala District in Upper West to the West, and the West Mamprusi District in the Northern Region to the south.

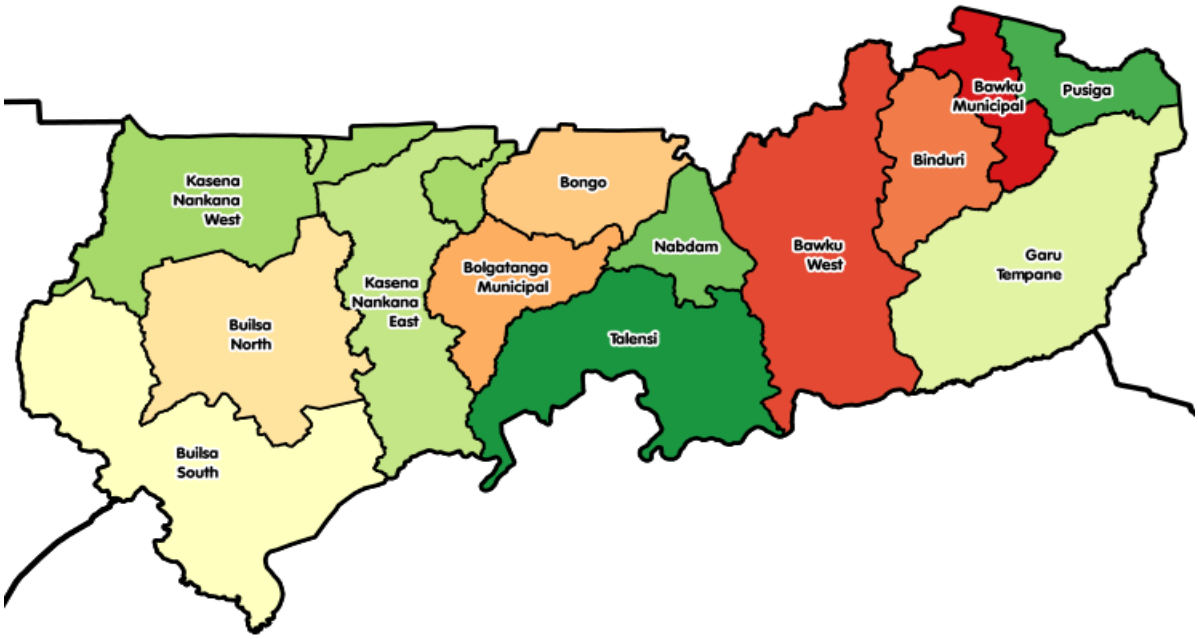

Figure 3.1 Administrative map of Upper East Region

3.2 Data collection

A cross-Sectional survey was conducted and primary data was collected from one districts and two municipalities (Kassena Nankana Municipal, Bolgatanga Municipal, and Bongo District) in the region based convenient sampling. Four hundred questionnaires were designed with open and closed questions and administered to small ruminant farmers who were randomly selected across the three districts from the region with follow-up questions. Farmers consent was sought by way of explaining to them the purpose and objective of the survey and the questionnaires administered to

those who agreed to participate. Data collection covered 4 weeks starting from 2nd July 2022 to 30th July 2022.

The questionnaire was developed to cover the following areas;

1. Demographic characteristics of respondents
2. Herd structure of small ruminants in the study area
3. Major small ruminant diseases in the study area
4. Seasonal prevalence of small ruminant diseases in the area
5. Small ruminant diseases' preventive and control strategies by respondents
6. Direct economic impact of small ruminant diseases on productivity
7. Indirect economic impact of small ruminant diseases on productivity

3.4 Sample size

The formula below for determining sample size was used to calculate the number of respondents

$$n = \frac{N}{1 + (\alpha^2)}$$

Where,

n = sample size

N = number of units in a population (total number of small ruminant farmers)

α = level of confidence (α at 95% confidence level is 100-95 = 5% = 0.05)

(Source: Yamane formulae for sample size determination, (2017). https://www.quora.com/what-is-Yamane-sample-calculation)

According to Ghana Statistical Service's 2020 population and housing census (Population and Housing Census, 2020), Kassena Nankana municipal has an agricultural household of 19,790, Bolgatanga municipal, 14,145 and Bongo district has 15,188. Therefore, the total agricultural household in the three districts gives 49,123.

$$n = \frac{N}{1+ (\alpha^2)}$$

$$n = \frac{49,123}{1+ 49,123\ (0.05^2)}$$

$$n = \frac{49,123}{122.81} = 399.99 \approx 400$$

3.4 Data analysis

Data collected were summarized in Statistical Package for Social Scientist (SPSS) Version 16.0 software using descriptive statistics, and Chi-square was used to compare observed results and expected results and the purpose was to determine if a difference between both is due to chance or a relationship between the variables under study, and the results were presented in the form of tables, pie and bar charts, frequencies, and percentages.

CHAPTER FOUR

4.0 Results

The results of the demographic characteristics of the respondents are presented in Table 4.1. The results in Table 4.1, indicate that most of the respondents/farmers were males (71.4%) while 28.6% are females. In terms of age, the highest age ranges recorded were within 40-49 years (33.7%), followed by 30-39 years (33%), 20-29 years (19.3%), 50-59 years (9.8%) with above 60 years being the least (4.2%) among the respondents. Moreover, Christianity was the most dominant religion recorded by the respondents representing 50.9% while 25.7% belong to the Islamic religion, with 23% being traditionalists and lastly, 0.5% being others. The respondents' educational status reveals that most have received no formal education (43.7%). In contrast, 18.8, 16.9, 11.5, and 9.0% have received tertiary, basic, senior high, and junior high education respectively.

Additionally, the respondents' occupational status shows that most were farmers (58.7%), 16.4% were traders, and 9.5% were civil servants. Artisans and pensioners recorded 1.7% each, while other occupations (1%) were the least. The marital status of the respondents indicates that 73.6% are married, 20.3% are single, and only 6.1% are divorcee.

Table 4.1: Demographic characteristics of small ruminant farmers

Variable	Category	Percentage	Chi
Gender	Male	71.4	X^2=74.88***
	Female	28.6	
Age	20-29	19.3	X^2=146.00***
	30-39	33.0	
	40-49	33.7	
	50-60	9.8	
	Above 60	4.2	
Religion	Islam	25.7	
	Christianity	50.9	
	Traditionalist	23.0	
	Others	0.5	
Level of education	No formal education	43.7	X^2=173.00***
	Basic education	16.9	
	Junior high education	9.0	
	Senior high education	11.5	
	Tertiary education	18.8	
Occupation	Farmer	58.7	X^2=716.29***
	Civil servant	9.5	
	Artisan	1.7	
	Trader	16.4	
	Pensioner	1.7	
	Others	1.0	
Marital status	Married	73.6	
	Single	20.3	
	Divorced	6.1	

***=p<0.001

The results for the types of animals reared by the respondents are presented in figure 4.2. From the figure, a higher percentage (53%) of farmers reared both small ruminants and poultry, 25% reared small ruminants only, 12% also reared both small ruminants and pigs while only 10% reared both large and small ruminants.

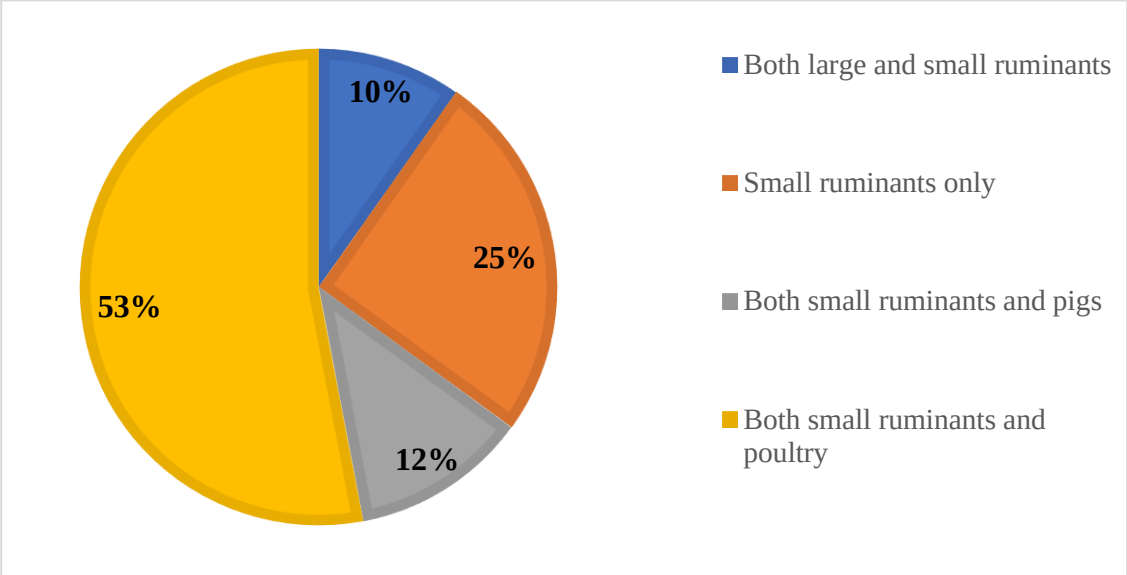

Figure 4.2: Types of animals reared

The rearing experience results of the respondents are presented in figure 4.3. There was a significant association in the rearing experience of farmers (x^2= 131.33, p<0.001, df 4). The results in figure 4.3 indicate that farmers with higher rearing experience were within 3-5 years, while the least rearing experience was within 0-11 months. Moreover, 28.6% of the farmers had 6-10 years of rearing experience, whereas 17.8% had more than 10 years of rearing experience.

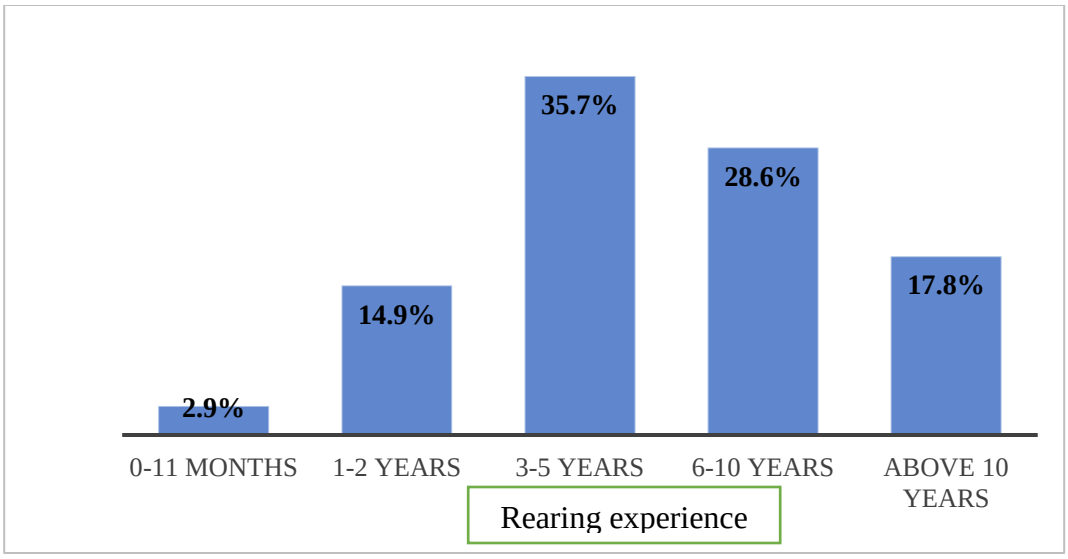

Figure 4.3:Types of animals reared

The results for the system of housing and quality of housing are presented in figure 4.4 and Figure (4.4) respectively below. From figure 4.4, it can be observed that the majority of the farmers (78%) practiced a semi-intensive system of housing while the least (7%) was an intensive system of housing. In terms of the quality of the housing system, the majority of the farmers (72%) had a good housing condition. Farmers with very good (15%), and poor (14%) housing conditions were almost the same as shown in figure 5.

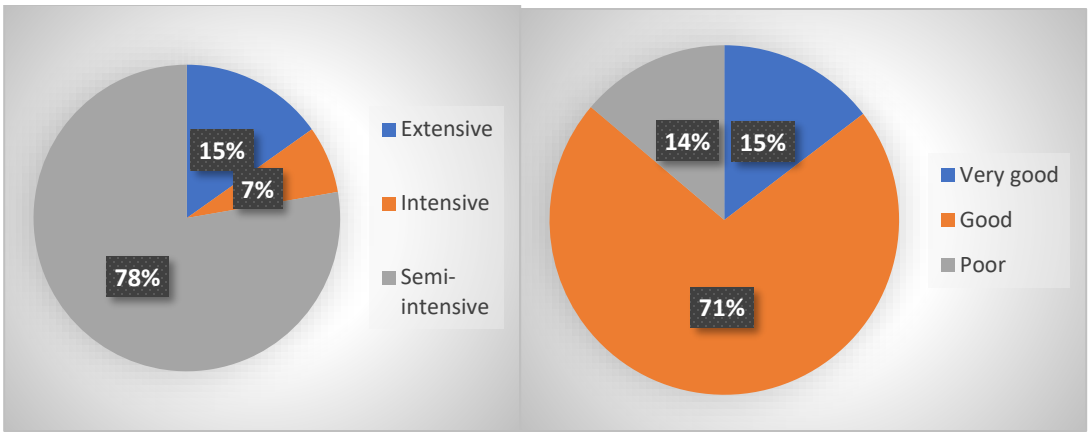

Figure 4.4: System of housing and quality of housing

Table 4.2 shows the results of housing sanitation and frequency of cleaning. From table 4.2, 93.4% of the farmers being the majority, cleaned their small ruminant pens while only 6.6% did not clean them. Again, the majority of the farmers (40.6%) cleaned their small ruminant pens daily, and 21.8% cleaned weekly. The number of farmers who clean their animal housing monthly was 12.6%, those that clean at any other times was 12.6%, while 12.4% cleaned biweekly.

Table 4.2: Housing sanitation and frequency of cleaning

Variable	Category	Percentage	Chi
Do you clean the pen of your animals?	Yes	93.4	
	No	6.6	X^2= 295.88***
What is the frequency of cleaning?	Daily	40.6	
	Weekly	21.8	
	Biweekly	12.4	X^2= 120.47***
	Monthly	12.6	
	Any other times	12.6	

***=p<0.001

Table 4.3 shows the results of the sources of supplementary feed and quantities mobilized per year by farmers. The result from Table 4.3 shows that 75.3% of the farmers practice supplementary feeding while 24.7% do not practice supplementary feeding. Additionally, 47.3% of the farmers indicated they had available supplementary feed all year round, whereas the majority of the farmers (52.7%) reported not having available supplementary feed all year round. About 35.3% of respondence mobilized 5-9 bags of supplementary feed, 17.2% of them had 10-15 bags, 13.5% of them mobilized 16-20 bags and those who were able to mobilize over 20 bags of supplementary feed were 34% of the respondence

Moreover, the majority of the farmers (46.3%) relied on any other available feed as a means of feed supplementation. Among the types of supplementary feed used,

groundnut haulms (34.1%) were the highest agricultural crop residues supplemented, followed by cowpea (12.8%) and maize husk (6.8%). In terms of the sources of supplementary feed mobilized, 52.2% of the farmers mobilized their supplementary feed from their farms after harvesting. 43.7% relied on buying. Additionally, 3.7% of the farmers obtained their supplementary feed through other means whereas, only 0.3% through their friends. The results also indicated that 86.7% of the farmers being the majority, resort to free-range feeding as a backup when there is no available supplementary feed, 12.7% of the farmers search and buy, and only 0.60% receive assistance from friends.

Table 4. 3: Sources of supplementary feed and quantities mobilized per year

Variable	Category	Percentage	Chi
Do you practice supplementary feeding?	Yes	75.3	X^2= 101.01***
	No	24.7	
Is supplementary feed available all year round?	Yes	47.3	X^2= 0.87ns
	No	52.7	
What quantities (bags) of supplementary feed do you mobilize in a year?	5-9	35.3	
	10-15	17.2	X^2= 32.72***
	16-20	13.5	
	Above 20	34.0	
What kind of supplementary feed do you use?	Groundnut haulms	34.1	
	Maize husk	6.8	
	Cowpea residues	12.8	X^2= 120.41***
	Any other available feed	46.3	
What are the sources of supplementary feed?	Own farm	52.2	
	Buying	43.7	X^2= 128.71***
	From friends	0.3	
	Other sources	3.7	

How do you cope without supplementary feed?	Allow animals on free-range	86.7	
	Search and buy	12.7	X^2= 148.69***
	Assistance from friends	0.6	

***=p<0.001, ns=non-significant

The results of small ruminant diseases and the associated cost of treatment are shown in table 4.4 below. From table 4.4, the majority of the farmers (75.8%) recorded more small ruminant diseases in the rainy season while only 14.2% were recorded during the dry season. Worm infection (43.5%) was the highest disease recorded by farmers during the rainy season, 21.5 % of the farmers recorded PPR, 21.2% pneumonia, and 13.8% also recorded mange within their flock. The results also indicated that the majority of the farmers (91.7%) consulted veterinary services on animal health-related issues while 8.3% did not consult. Again, 62.9% of the farmers practiced self-treatment of their sick animals without consulting veterinary service whereas, 37.1% sold their sick animals. Additionally, 48.2% of the farmers spent above GH¢300 as a cost of treating their sick animals, 22.5% spent GH¢50- GH¢100, 16.3% spent GH¢201-GH¢300, and 13% spent within GH¢101- GH¢200.

Table 4.4: Small ruminant diseases and associated cost of treatments

Variable	Category	Percentage	Chi
Which season do you record more small ruminant diseases?	Dry season	14.2	X^2=332.90***
	Rainy season	75.8	
What are the common diseases in the rainy season?	PPR	21.5	X^2=219.03***
	Pneumonia	21.2	
	Worm infestations	43.5	
	Mange	13.8	
Do you consult veterinary services on animal health?	Yes	91.7	X^2=283.33***
	No	8.3	
Reasons some farmers do not consult a vet. services	Self-treatment of animals	62.9	X^2=2.31ns
	Sell sick animals	37.1	
How much money (GHS) do you spend on treating animals?	50-100	22.5	X^2=108.34***
	101-200	13.0	
	201-300	16.3	
	Above 300	48.2	

***=p<0.001, ns=non-significant

The results for the marketing challenges and cost of deaths associated with small ruminant diseases are shown in Table 4.5. From Table 4.5, 53.3% of the farmers recorded (1-4) mortalities within their flock annually, followed by 31.6% (5-10), and 15.2% (above 10) being the least range. Moreover, 69.3 % of the farmers indicated that low pricing of sick small ruminants was the main effect of diseases in the marketing of small ruminants while buying on credit was the least (0.6%). 28.8% of farmers also indicated that unwillingness to buy was an effect of diseases on the marketing of small ruminants whereas, only 1.2% of the farmers lost their sick animals before reaching the market. In terms of the amount of money that farmers would have realized if dead animals were to be alive, the majority of the farmers fall below GH¢1,000, while 34.6% fall above GH¢2,000. 16.5% of the farmers fall within the range GH¢1,000- GH¢1,500, and only 8.3% fall within GH¢1,501- GH¢2,000.

Table 4.5:Marketing challenges and cost of deaths associated with small ruminant diseases

Variable	Category	Percentage	Chi
How many deaths do you encounter in a year?	1-4	53.3	X^2=70.71***
	5-10	31.6	
	Above 10	15.2	
How much money (GHS) would you have realized if dead animals were to be alive?	Below 1000.00	40.7	X^2=90.16***
	1000.00-1500.00	16.5	
	1501.00-2000.00	8.3	
	Above 2000.00	34.6	
What is the effect of diseases on the marketing of small ruminants?	Low pricing	69.3	X^2=409.36***
	Unwillingness to buy	28.8	
	Buying on credit	0.6	
	Animals die before reaching the market	1.2	

***=p<0.001

The reasons for rearing small ruminants stated by the respondents are represented in Figure 4.5. The majority of the respondents indicated that financial needs and others (38%) are the main reasons for keeping small ruminants, those who keep small ruminants for religious and social needs as well as other needs were 24%, 19% of small ruminant farmers kept them for meat and other purposes. Some farmers kept

small ruminants for only one reason, which include keeping small ruminants for financial needs (6%) and meat (2%).

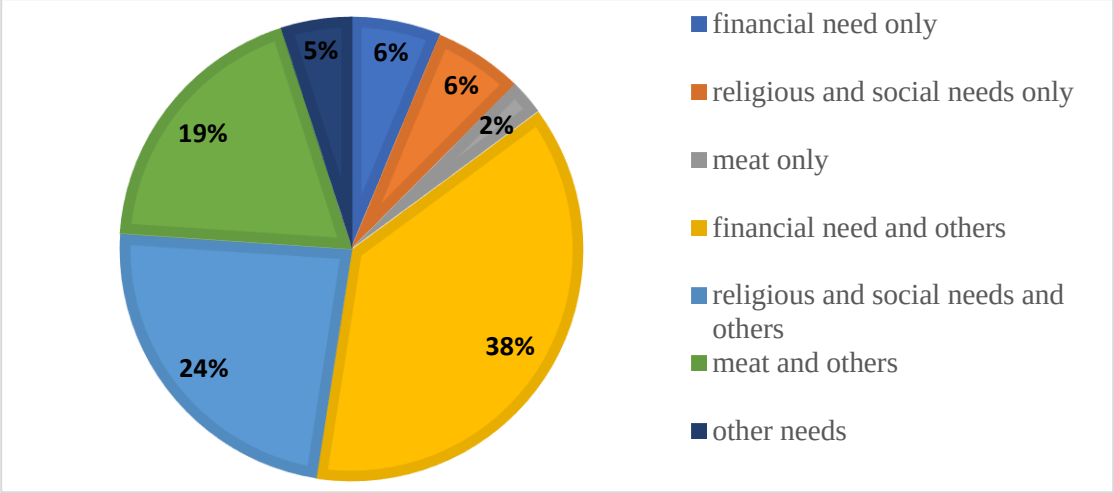

Figure 4.5: Some reasons for rearing small ruminants

The management practices of small ruminant farmers are represented in figure 4.6. The results show that 17% of the farmers are engaged in regular deworming of their flocks, 15% of them have a housing system to keep their small ruminants, and 14% also practice regular vaccination and good farm sanitation. Additionally, 13% of the farmers practice feed supplementation, 12% practice castration while 8% and 7% practice de-ticking and ear tagging, respectively.

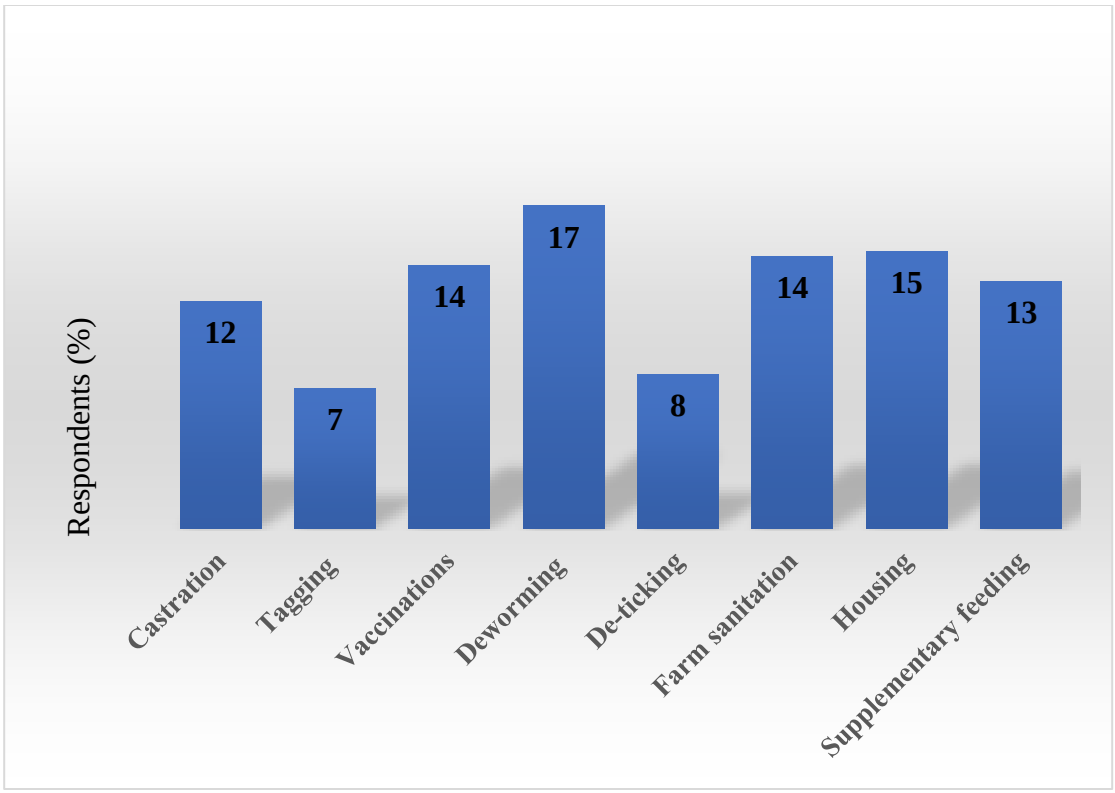

Figure 4.6: Some management practices of small ruminant farmers

The effects of disease outbreaks on small ruminant production are shown in table 4.6. The results of the survey indicated that 128.4 (32%) of the farmers lost their investment as a result of disease outbreaks, and 116.7 (29%) of the farmers could not treat their affected animals due to the high cost of treatment. Additionally, 95.9 (24%) of the farmers whose animals were affected by disease outbreaks led to mortality, while 59 (14.8%) of the farmers recorded reduced productivity in their flock due to disease outbreaks.

Table 4.6: Effect of disease outbreak on small ruminant production

Variable	Number of respondents	%
Loss of investment	128.4	32.1
Mortality	95.9	24.0
High cost of treatment	116.7	29.1
Reduced productivity	59.0	14.8

The results of the disease prevention strategies practiced by the respondents are represented in figure 4.7. From the figure, it can be observed that good husbandry practices (47%) are the major disease prevention strategies recorded by the farmers, followed by vaccination (40%) while prophylactic treatment is the least.

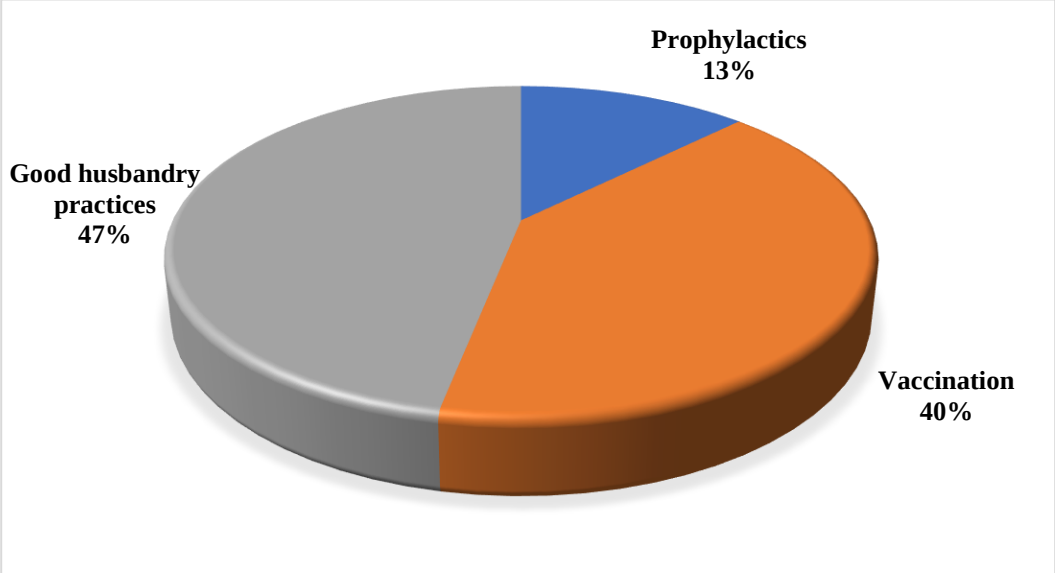

Figure 4.7: Disease prevention strategies by respondents

The results of the disease control strategies practiced by the respondents are shown in figure 4.8. 41.8% of the farmers practice treatment before vaccination, while 25.3% also engage in isolation of infected animals as a disease control strategy. Moreover, 24.1% employed improved biosecurity measures as a disease control strategy whereas, only 8.8% were engaged in burning and burying dead carcasses as a disease control strategy.

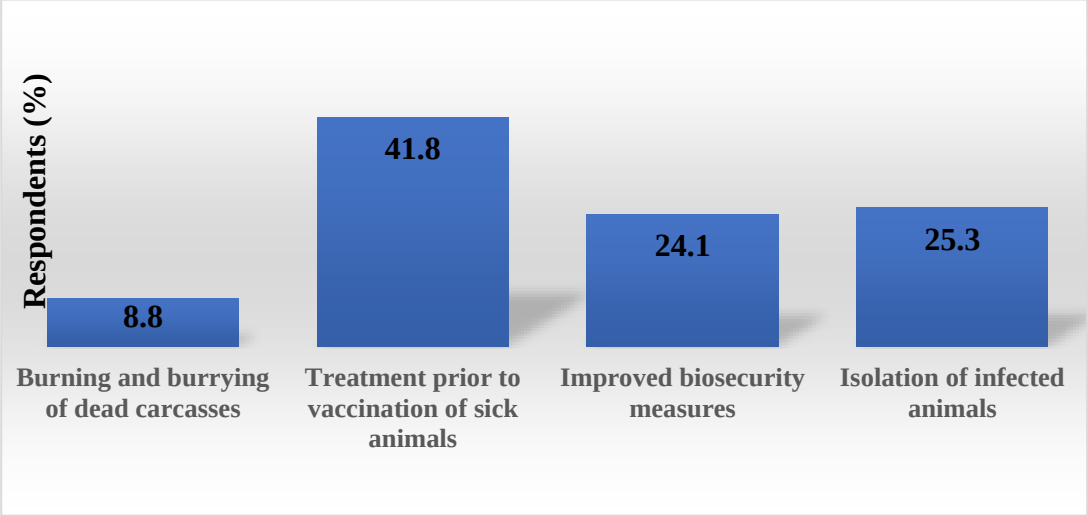

Figure 4.8: Disease control strategies

The results of the number of small ruminants reared by the farmers are shown in table 4.7.

In Table (4.7), 78(20.3%) and 70 (18.3%) of the farmers kept sheep and goats, respectively which are less than five (<5) in number. The highest number of farmers 118 (30.7%) reared sheep, while 114 (29.8%) reared goats which are within the range of 6-10. Moreover, 84 (24.9%) of the farmers reared sheep, whereas 107 (28%) reared

goats within the range of 11-15, and lastly, 104 (27.1%) and 91 (23.8%) of the farmers also reared sheep and goats, respectively whose number is greater than 15.

Table 4.7: Number of animals reared

Category	Sheep		Goats	
	Respondents	(%)	Respondents	(%)
<5	78	20.3	70	18.3
6-10	118	30.7	114	29.8
11-15	84	21.9	107	28.0
>15	104	27.1	91	23.8

The results of the age distribution of small ruminants reared by farmers are shown in table 4.8. The results indicate that the majority of the farmers 136 (32.9%) and 118 (30.1%) had sheep and goats which are 2 years old respectively, whereas the lowest age distribution of small ruminants kept by farmers is less than 1 year old. Moreover, 120 (29.1%) of the farmers kept sheep which are up to 3 years old, while 101 (26.1%) had goats. 29.3% (121) of the farmers had sheep within their flock which was older than 3 years, whereas 29.7% (115) had goats.

Table 4.8:Age distribution of small ruminants

Age	Sheep		Goats	
	Respondents	(%)	Respondents	(%)
1	36	8.7	53	13.7
2	136	32.9	118	30.5
3	120	29.1	101	26.1
>3	121	29.3	115	29.7

The factors affecting small ruminant pricing are presented in table 4.9. Among the factors that affect the pricing of small ruminants recorded by the respondents, 31.2% indicated that the festive season was the major factor determining the price of small ruminants. In comparison, 22.6% of the respondents also indicated that the breed of the animals also influenced the price determination. Additionally, 13.8% of the respondents stated that the time of the year also affected the pricing of small ruminants, while feeding accounted for 12.2% of the respondents. Moreover, 11.2% of the respondents indicated that body condition also impacted the determination of the price of small ruminants. Lastly, those who perceived medication as a factor accounted for 5% of the respondents, whereas 1.2% had no idea of the factors that affected the pricing of small ruminants.

Table 4.9: Factors Affecting Small Ruminant Pricing

Factors	Respondents (%)
Body condition	11.2
Breed	22.6
Time of the year	13.8
Feeding	12.2
Medication	5
Cost of living of buyers	2.8
Festive seasons	31.2
No response	1.2

The period of marketing of small ruminant results are shown in table 4.10. In terms of the period of marketing of small ruminants, the majority of the farmers sold their sheep and goats in the Christmas festive season as compared to the Eid festive season. The number of farmers who sold their sheep and goats in the Christmas festive season was 231 (57.8%) and 229 (57.3%), whereas 132 (33%) and 102 (25.5%) sold theirs in the Eid festive season respectively. The number of farmers who sold their sheep or goats when they need cash were 241 (60.3). Additionally, 244 farmers sold more matured sheep than the number of farmers (205) who sold matured goats. Similarly, 39 farmers sold more mature goats when they were sick as compared to 30 farmers who sold their sick sheep. The number of farmers who sold their sheep for other reasons was 39 (9.8%), whereas 34 (8.5%) of the farmers also sold their goats for other reasons as well.

Table 4.10: Periods of marketing small ruminant

Period of marketing of small ruminants		Sheep		Goats	
		Respondents	(%)	Respondents	(%)
Religious festive seasons	Christmas	231	57.8	229	57.3
	Eid	132	33.0	102	25.5
when in need of cash		241	60.3	241	60.3
when animals are matured		244	61.0	205	51.3
when animals are sick		30	7.5	39	9.8
other		39	9.8	34	8.5

The results of major small ruminant diseases are presented in table 4.11. The major prevalent small ruminant diseases recorded by farmers within the study area include; PPR, Anthrax, Bloat, Mastitis, and Mange. Among these diseases, PPR is the most prevalent disease recorded by farmers (181). 144 (36%) of the farmers recorded mange as the second most prevalent small ruminant disease. Additionally, 35 (8.8%) of the farmers also recorded bloat within their flock, while 28 (6.9%) recorded anthrax, and lastly, only 12 (3%) of the farmers recorded mastitis.

In terms of the season of disease occurrence, the majority of the farmers recorded PPR (116), Mange (100), and Anthrax (22) during the dry season as the most prevalent small ruminant diseases, whereas 25 and 9 of the farmers also recorded the highest

incidence of bloat and mastitis during the rainy season respectively. Moreover, among the major small ruminant diseases recorded by the farmers, mastitis had the highest survival rate (73.18%), followed by mange (67.96%), bloat (60.84%), PPR (56.04%), and lastly, anthrax (10.86%).

Table 4.11: Major small ruminant diseases

			Season		
Disease condition	number of respondents	(%)	Rainy season	Dry season	survival rate
PPR	181	45.3	65	116	56.04
Anthrax	28	6.9	6	22	10.86
Bloat	35	8.8	25	10	60.84
Mastitis	12	3.0	9	3	73.18
Mange	144	36.0	44	100	67.96
Total	400	100.0			

The results of the indirect impact of small ruminant diseases on farmers are shown in table 4.12. The data from table 13, indicates that GH¢412 was the total cost incurred by each farmer for disease prevention within their flock. Out of the total cost of GH¢412 incurred on disease prevention strategies, biosecurity accounted for the highest expenditure (GH¢191), followed by vaccination (GH¢113), whereas prophylactic treatment accounted for GH¢108. Moreover, GH¢784.80p was recorded as the total expenditure on disease control measures per farmer. The highest expenditure was recorded on antibiotic administration (GH¢234.80p), GH¢187 was

spent on tick treatment, GH¢182.20p on multi-vitamin administration, and lastly, GH¢180.80p on deworming.

Table 4.12:Indirect impact of small ruminant diseases on farmers

The associated cost of disease prevention strategies by farmers	
Preventive measures	Cost of disease prevention /farmer (GHS)
Prophylactic treatment	108.00
Vaccinations	113.00
Biosecurity	191.00
Total cost of disease prevention (GHS)	412.00

The associated cost of disease control strategies by farmers	
Control measures	Cost of disease control /farmer (GHS)
Deworming	180.80
Tick management	187.00
Multi-vitamin administration	182.20
Antibiotic administration	234.80
The total cost of disease control (GHS)	784.80

The direct impact of small ruminant diseases on farmers is presented in table 4.12. From able 4.12, the result indicates that out of the two species (sheep and goats) of small ruminants reared by farmers, sheep were the most highly affected by diseases as

compared to goats. Two thousand, six hundred and fifty three (2,653) affected sheep were recorded by 365 farmers while 2,598 affected goats were recorded by 368 farmers. The difference (55) indicates that sheep are more susceptible to diseases than goats. Moreover, on the average, 7 (sheep or goats) were recorded by individual farmers being affected by diseases within their flock. In terms of the cost of treatment, GH¢72,007.00p was recorded as the total cost of treatment for the affected 2,653 sheep reported by the farmers in a year, whereas GH¢64,402 was also incurred for treating the 2,598 affected goats in a year.

Again, on average GH¢199.50p and GH¢178.40p were spent by each farmer on treating their affected sheep and goats, respectively. The cost of treatment for sheep was more expensive than that of goats.

Additionally, 1,237 sheep mortality was recorded by 302 farmers while 1,192 goats mortality were recorded by 319 farmers. The mortality rate for sheep was higher than that of goats.

On average, each farmer recorded 4 mortalities in their flock within a year. In monetary terms, GH¢435,509 were lost from sheep mortality due to disease incidence compared to GH¢346,552 for goats in a year. Again, on average each farmer losses about GH¢1,408.30p and GH¢1,162.90p for sheep and goats respectively due to mortality. Generally, the number of animals affected by diseases, cost of treatment, mortality, and money lost due to mortality are higher in sheep than in goats.

Table 4.13:Direct impact of small ruminant diseases on farmers

	Species	Number of respondents	Total number of animals	Av. Number of animals /farmers
Number of sick animals	Sheep	365	2653	7
	Goats	368	2598	7
			Total cost of treatment (GHS)	Av. cost (GHS) of treatment/farmer
Cost of treatment	Sheep	361	72,007.00	199.50
	Goats	361	64,402.00	178.40
			Total dead animals	Av. number of dead animals /farmers
Number of sick animals dead	Sheep	302	1237	4
	Goats	319	1192	4
			Total amount (GHS)	Av. amount /farmer
Amount to be realized from dead animals	Sheep	302	435,509.00	1,408.30
	Goats	319	346,552.00	1,162.90

CHAPTER FIVE

5.0 Discussion

Demographic characteristics are essential in survey research for understanding the target population, segmenting and analyzing survey data, conducting comparative analysis, assessing sample representativeness, tailoring survey design and communication, and gaining insights into behavior and preferences across different demographic groups. The percentage of male respondents recorded in this study is higher than the 67% reported by Baah *et al.* (2012), but lower than the 74% reported by Adam (2015). The finding of this study indicates that more males are into livestock rearing than females and this agrees with Nwachukwu and Berekwu (2020) but contradicts the finding of Fakoya and Oloruntoba (2009) who reported a high percentage of females in small ruminant production in Nigeria Osun-state. The higher percentage of males in livestock rearing as compared to females could be attributed to cultural norms and gender roles in society which dictate that men are responsible for livestock rearing while women are to focus on household chores. Additionally, a lack of training and technical knowledge in livestock rearing could hinder many women's ability to effectivity manage livestock and improve productivity. Turkson and Naandam (2006) reported that a higher proportion of male farmers are essential for transferring and adopting technology as men are mostly engaged in the decision-making process in most African societies.

The results indicate that most of the respondents are within the active age range, which shows strong lower middle-age demographics for livestock farmers.

The above finding implies that respondents within the active age range are more open to adopting and using new technologies in livestock rearing as older individuals may be more resistant to change and may prefer traditional methods of livestock management. Moreover, respondents within the active age range have more physical strength and energy to handle the physical demands of livestock rearing. Ajala *et al.* (2008) reported that active age range was a positive factor for better decision-making and sustainability of animal husbandry.

The finding in this study shows that the majority of the respondents have not received formal education. The percentage recorded is lower than the rate (63.9%) reported by Adam and Yankyera (2014). The higher illiteracy level recorded indicates that respondents may struggle to adopt and use new technologies, and innovation in livestock production and this can result in lower efficiency, higher costs, and reduced competitiveness in the sector. Additionally, high illiteracy levels among respondents may lead to limited knowledge and skills in livestock production practices such as animal health, nutrition, breeding, and management. Lwoga *et al.* (2011) and Young *et al.* (2015) state that a high literacy level facilitates the acquisition of knowledge and skills, accepts change, and adapts to new technologies and innovation for enhanced productivity.

The majority of the respondents are Christians as revealed in this study, the percentage recorded is lower than the 50.9% reported by Adam and Yankyera (2014) in the region when assessing the socio-economic characteristics of subsistent small ruminant farmers in the three Northern regions, but it is higher than 44.5% reported by GSS

(2010). The current finding also contradicts the GSS (2020) report which indicated that approximately (57%) of the population are Muslims and this difference could be attributed to population growth and emigration.

Additionally, the result of the survey reveals that the majority of the small ruminant holders are farmers and this is in line with the Ghana Statistical Service (2020) report which states that approximately 70% of the population in the Upper East region are engaged in farming or agriculture. The percentage recorded in this study is higher than the 20% reported by Baah *et al.* (2012) when assessing small ruminant production characteristics in urban households in Kumasi and Effiduasi. This observation indicates that small ruminant production in the Upper East region is a primary household activity.

Moreover, the percentage of respondents who are married in this study is higher than the 69% reported by Adam (2015) and comparable to 72.5% reported by Fakoya and Olorumtoba (2009) in Nigeria Osun-state. The higher proportion of respondents being married in the study indicates that there could be a division of labor which could lead to more efficient and effective livestock management as well as aid in succession planning. Adam and Yankyera (2014) reported that when more married couples are engaged in livestock rearing, they would be a better division of labor to contribute to household livestock management practices.

The higher proportion of respondents keeping small ruminants over large ruminants could be attributed to the fact that generally, small ruminants require less initial capital investment as compared to large ruminants making them more accessible to small-

scale farmers and this agrees with Onyango *et al.* (2015) who reported that the set-up capital for small ruminants are relatively low and the loss risk are also low. Additionally, small ruminants are generally more adaptable to diverse climatic conditions, have faster reproduction rates, are easier to manage, and are well suited for grazing on marginal lands or areas with limited forage availability as compared to large ruminants. Estefanos *et al.* (2015) reported that small ruminants have greater environmental adaptability, faster growth rate, shorter production cycle, low feed requirements, and ease of management as compared to large ruminants.

Zindove and Chimonyo (2015) stated that large ruminants have high surface-to-body ratio and maintenance requirements hence are more vulnerable to water scarcity, heat stress, and feed shortage and this could be a reason why most of the respondents preferred to keep small ruminants over large ruminants.

Rearing experience is an important parameter in determining output. The result obtained in this research indicates that the majority of the farmers have more years of experience in rearing and this implies farmers would have a deep understanding of animal behavior, health management, nutrition, and reproduction and enhance the efficiency of the production system, optimize resources utilization and maximize productivity leading to higher profitability for the farm.

Kosgey *et al.* (2006) stated that experience and educational levels can enhance methods of production, record keeping, management ability, and access to market opportunities. Nwachukwu and Berekwu (2020) reported that the more years of

experience farmers get involved in animal production, the more knowledge and skills they acquire which can enhance their efficiency of production.

Moreover, the finding in this research indicates that the majority of the farmers practiced a semi-intensive system of production and this contradicts that of Turkson and Naandam (2006) who observed that extensive and traditional production systems are the common system of small ruminant production in northern Ghana. Nwachukwu and Berekwu (2020) also reported that extensive system of production is the common type of goat production system in Nigeria's Imo state. This trend of production could be attributed to the numerous advantages associated with semi-intensive production such as improved productivity, flexibility, adaptability, and reduced environmental impact on the animals making this system a viable and effective approach for small ruminant production as compared to other systems of production.

Housing sanitation is essential in small ruminant production for preventing disease spread, promoting animal health and welfare, reducing parasite burden, improving feed and water quality, preventing respiratory issues, and ensuring compliance with regulations and standards. The finding shows that the majority of the respondents have a good housing system for their small ruminants. This finding for development implies that good housing is essential for small ruminant production as it contributes to the health, welfare, productivity, and overall success of the operation. Additionally, a good housing structure helps to minimize the risks of disease transmission among small ruminants by providing a clean and hygienic environment, and protection from predators, theft, and other security risks and this agrees with Ayantunde *et al.* (2021)

who stated that good housing is important to facilitate the collection of manure and prevent the transmission of diseases that may occur from poor housing with inadequate ventilation and overcrowding. Good housing also protects against the theft and accidents associated with free roaming.

The finding for housing sanitation indicates that a greater proportion of the respondents practice good sanitation. This observation is very crucial for small ruminant production as good sanitation promotes animal health, welfare, productivity, and biosecurity. Roque *et al.* (2016) reported that bacteria found in livestock housing units increase the chances of spreading diseases among livestock and pose health implications for farm workers and nearby residents. The implication of the above finding for development is that good housing sanitation can also influence the quality and safety of feed and water provided for small ruminants as the majority of the respondents practice the semi-intensive system of production thereby reducing the introduction or spread of pathogenic microorganisms which can compromise the health and performance of the livestock.

Feed supplementation is essential in small ruminant production for meeting nutritional requirements, enhancing growth and development, supporting reproduction and lactation, boosting immunity and disease resistance, improving feed efficiency and productivity, and addressing seasonal or environmental challenges. The outcome of the study also shows that a high percentage of the farmers in the Upper East region engage in feed supplementation as part of small ruminant management practices. The most commonly used feed supplements are legume crop residues (groundnut and

cowpea) and this finding agrees with Adam and Yankyera (2014) who reported that leguminous crop residues are mostly commonly used crop residues in the three (3) Northern regions of Ghana as supplementary feed for livestock production. The feeding of legumes feed supplementation to small ruminants might be due to the higher nutritional value of leguminous crops as compared to other crop residues. Singh and Diwaker (1993) and Amole and Ayantunde (2019) reported that groundnut haulms contain 8-15% crude protein, 9-17% minerals, 1-3% lipids, and 38-45% carbohydrates in higher quantities than cereal fodder as well as 53% nutrient digestibility. Cowpea hay can provide adequate energy and protein to sustain ruminant production at times of scarcity of feed, particularly during the dry season (Amole and Ayantunde, 2019). The high percentage of legume haulms compared to other cereal crop residues as small ruminant feed supplements also indicates that the majority of the farmers might be engaged in leguminous crop farming.

From the outcome of the study, it can be deduced that a higher percentage of small ruminant producers in the Upper East region obtained their feed supplement through buying and this suggests that there is an available market for ruminant feed in the region and this confirms the report of Ayantunde *et al.* (2014) who stated that there are available feed markets that have sprung up in some towns and cities of West African Sahel in response to growing livestock populations in per-urban areas.

Grings *et al.* (2010) also reported that ruminant feed marketing exists at many levels with informal selling of crop residues directly off the farm to nearby livestock producers selling bundled crop residues in or around livestock markets. Moreover, the

lack of supplementary feed all year round as reported by the majority of the farmers could be attributed to a lack of facilities or poor storage methods which hinders all year-round availability. Grings *et al.* (2010) suggested that improved storage methods will aid in reducing leaf loss after harvest and this could enhance the market potential of cowpea and groundnut haulms over a longer period of the year. Additionally, seasonal variation in rainfall patterns may also affect crop residue yield and its nutritional quality. Konlan *et al.* (2018) reported that seasonal variations had an impact on the quality of feed resources sampled from some locations in the Northern region.

Small ruminants, such as sheep and goats, are susceptible to various diseases that can impact their health, productivity, and overall well-being. The cost of treating these diseases can vary depending on factors such as the type and severity of the illness, the number of affected animals, the treatment approach, and the veterinary services required. The results of the study show that disease prevalence was high during the rainy season as compared to the dry season. The high prevalence of disease recorded in the research area during the rainy season can be attributed to several factors such as increased humidity which can create a favorable environment for the growth and spread of disease-causing organisms such as bacteria, viruses, and parasites, also rainy season makes more challenging for livestock farmers to maintain good hygiene practices in livestock management leading to increased risk of disease transmission among livestock. Moreover, agricultural activities during the rainy season reduce access to grazing lands or areas limiting the availability of nutritious forage which can lead to malnutrition and can weaken the immune system of the animal thereby increasing their disease susceptibility.

Takunda *et al.* (2018) reported that low pasture quality and quantity leads to malnutrition and compromise of the immune system of malnourished animals thus causing a high incidence of diseases. Nguluma *et al.* (2020) stated that during the rainy season, most of the lands are used for farming activities leaving no or little land available for heading and free grazing by livestock. Changes in weather patterns and environmental conditions during the rainy season can also be a contributive factor that can cause stress in small ruminants weakening their immune systems and making them more susceptible to diseases.

Prevalence of worm infestation, PPR, and pneumonia which were the most common diseases mentioned by the farmers could be attributed to the management practices of the farmers. Nguluma *et al.* (2020) reported that helminthics and CCPP were the common ruminant diseases recorded by livestock farmers in Tanzania. The high incidence of worm infestation recorded by the majority of the farmers could be a result of misuse or overuse of deworming medication which can lead to the development of resistance in the parasite population, as well as the grazing habits which can also lead to injection of parasites larvae increasing the risks of worm infestation. The practices of self-treatment of livestock without consulting veterinary services on livestock health, despite the availability of veterinary services by the majority of the farmers reflected by worm infestation, PPR, and pneumonia prevalence within the research area. A similar trend of self-treatment by livestock farmers has been reported in Tanzania by Nguluma *et al.* (2020). Self-treatment practiced by livestock farmers is positively correlated to the high amount of money spent on treating small ruminant diseases and this might be a result of overuse or misuse of medication leading to future

treatments being less effective. Chengula *et al.* (2013) reported that high losses of livestock through diseases and resistance of some pathogenic diseases causing microorganisms to certain drugs are caused by farmers practicing self-treatment of livestock without consulting animal health professionals.

Small ruminant diseases can pose significant challenges for marketing small ruminants. These challenges can impact the reputation, marketability, and profitability of small ruminant operations. The findings in this study indicate that the majority of the farmers lose about 1-4 sheep and goats yearly. A similar trend has been reported by Baah *et al.* (2012) where the majority of the farmers lost about 4-10 sheep and goats in Kumasi and Effiduasi. Additionally, it can be observed that huge sums of money are lost by small ruminant farmers as a result of marketing challenges and the cost of deaths associated with small ruminant diseases. A high proportion of the farmers lamented that buyers offered prices lower than their expectations and, in some instances, buyers were unwilling to buy their sick animals. The combined effects of marketing challenges and costs of deaths associated with small ruminant diseases can have significant economic, social, and emotional impacts on farmers and their livelihoods. Zanou *et al.* (2023) reported that unattractive pricing mechanisms, poor road networks, high losses due to animal death, inadequate market information, lack of standard measurement for purchase, and price fluctuation hamper small ruminant marketing performance.

The outcome of the research indicates that small ruminant farmers in the Upper East region rear sheep and goats purposely for financial needs and other means and this

agrees with Adam and Yankyera (2014) who reported that small ruminant farmers in the Northern region reared small ruminants mainly for financial means. Baah *et al.* (2012) also reported that financial motivation was the main objective in rearing small ruminants among urban households in Kumasi and Effiduasi.

However, some sections of the farmers also indicated that religious and social purposes were their main motivations for rearing small ruminants and this also agrees with the previous finding in the region by Adam and Yankyera (2014). Apori *et al.* (2010) reported that small ruminant subsistent households in the savannah zone in the Northern reared sheep and goats for socio-cultural functions.

Management practices in small ruminant production are crucial for the overall success and profitability of the operation. These practices can have a significant impact on the health, productivity, and welfare of the animals, as well as the efficiency of the operation as a whole. Effective management practices are essential for the success and sustainability of small ruminant production. Management practices such as castration, tagging, vaccinations, deworming, de-ticking, farm sanitation, housing, and supplementation are the common management practices among small ruminant farmers in the Upper East region. A similar small ruminant management practice has been stated by Hamza *et al.* (2010) who identified supplementary feeding, record keeping, improved housing system, prophylactic treatment, castration, improved breeding, general management and care, forage conservation, and utilization as husbandry practices for small ruminant production among smallholders in the Tolon-Kumbungu district in the Northern region of Ghana. Husbandry management

practices such as concentrate supplementation, good housing systems, health monitoring, improved breeding programs, and selection of animals with good reproductive traits are being practiced by farmers in semi-intensive and intensive systems of small ruminant production (Dehouegnon *et al.,* 2017). Yemane *et al.* (2020) reported that husbandry practices such as housing serve as a means of protecting small ruminants from extreme temperatures, rainfall, predators, wind, and theft by minimizing stress and facilitating easy management by smallholder farmers.

The finding indicates that deworming is the major management practice by small ruminant farmers and this is a true reflection of the high prevalence of worm infestation during the rainy season. Deworming is an essential practice in small ruminant production to prevent parasitic infections, improve health and welfare, enhance production performance, prevent pasture contamination, and delay the development of drug resistance this explains why the majority of the farmers in the Upper East region practice deworming regularly.

Some small ruminant farmers stated that they practice castration as a management practice in the flock as a means of livestock population control, behavior modification, meat quality improvement, and disease prevention and a similar finding has been reported by Zamiri *et al.* (2012) and Gkarane *et al.* (2017) who stated that farmers practice castration as a management practice in small ruminant production to remove the smell from the meat of goats and increase eating quality (Zamiri *et al.,* 2012; Gkarane *et al.,* 2017). Kebede *et al.* (2008) indicated that castration renders livestock docile and friendly, improves the body condition, and appearance of livestock, and

increases market preference. The practices of feed supplementation by small ruminant farmers play a critical role in small ruminant production by meeting nutritional requirements, improving production performance, enhancing health and immunity, managing seasonal variations, supporting weight gain and body condition, and enhancing reproductive performance.

Disease outbreaks can have devastating effects on small ruminant production, leading to reduced productivity, increased costs, loss of market opportunities, negative impacts on animal welfare, disruption of breeding programs, and potential risks to human health. The effects of disease outbreaks on small ruminant production in the Upper East region as stated by the farmers are as follows; loss of investment, mortality, high cost of treatment, and reduced productivity. Our finding indicates that disease outbreaks negatively impacted small ruminant production in the region. Solomon *et al.* (2010) reported that small ruminant health challenges result in a higher death and cause a reduction in reproduction and growth performance leading to a decrease in their output. Reduced productivity as an effect of disease outbreaks stated by the farmers can lead to decreased growth rates, reduced reproductive performance, and increased mortality rates in small ruminants and this can result in lower overall productivity and profitability for producers. Moreover, the high cost of treatment associated with disease outbreaks stated by the farmers can be costly, especially if large numbers of animals are affected during an outbreak.

Disease prevention strategies play a critical role in small ruminant production by protecting animal health and welfare, minimizing economic losses, preserving genetic

resources, ensuring food safety, preventing disease spread, and supporting sustainable production practices. Small ruminant farmers in the research area employed good husbandry practices, prophylactic treatment, and vaccination as disease prevention strategies. The findings of this study indicate that the majority of the farmers practiced good husbandry practices and vaccinations to minimize the devastating effects of disease outbreaks within their flocks. Good husbandry practices as a disease prevention strategy focus on creating a healthy and clean environment for animals, promoting proper nutrition and management, implementing biosecurity measures, and monitoring animal health to prevent the introduction and spread of diseases. Sargison (2020) reported that small ruminant health program is good nutrition, effective biosecurity, protection from infectious pathogens and endemic disease management, and effective implementation of vaccination programmes to offer protection of small ruminants against prevalent endemic disease in individual flocks and exotic disease threats.

Disease control strategies play a critical role in small ruminant production by protecting animal health and welfare, minimizing economic losses, preserving genetic resources, ensuring food safety, preventing disease spread, and supporting sustainable production practices.

Common disease control strategies practiced by the farmers within the research area include; burning and burying dead carcasses, treatment before vaccination of sick animals, improved biosecurity measures, and isolation of infected animals. The finding indicates that the majority of the farmers medicate their sick animals before

vaccination as a disease control strategy. Chengula *et al.* (2013) reported that deworming, vaccination, and spray/dipping as the main disease control strategies practiced by ruminant farmers in some areas of Tanzania. Disease outbreaks can have devastating consequences for small ruminant operations, leading to high mortality rates, reduced productivity, and financial losses. Implementing disease control strategies such as vaccination, biosecurity measures, and regular health monitoring can help prevent the introduction and spread of diseases within the herd or flock.

The flock/herd size and age distribution recorded in this study is similar to the flock/herd size and age distribution reported by Baah *et al.* (2012) in Kumasi and Effiduasi. The results indicate that respondents within the research area manage sheep or goats within their households. The flock/herd size is influenced by some factors by the respondents for instance, financial resources, personal preferences and experience, and labor availability. In determining the flock/herd size costs associated with purchasing animals, feed, health care, and infrastructure are considered. The availability of household labor to care for the animals influences the flock/herd size as more animals require more time and effort to feed, water, and manage. Duku *et al.* (2011) reported that the flock/herd size of sheep or goats or both to manage is positively influenced by the economic available to that household. Moreover, the age distribution structure recorded by the respondents in this study indicates that the majority of sheep and goats owned by the respondents are less than 3 years old and therefore can be described as a young flock/herd structure.

Young flock/herd structures have higher reproductive potentials, improved genetic diversity, high growth rate, and increased adaptability as compared to older flock/herd structures which sometimes are highly susceptible to diseases, decreased reproductive potential, reduced adaptability, and limited genetic diversity.

The outcome of this study indicates that several factors affect small ruminant pricing in the Upper East region. Factors such as; body condition, breed type, season, and festive seasons were the most prominent factors affecting small ruminant pricing. Several researchers have established similar findings. Zanou *et al.* (2023) stated that several factors such as the animal body condition, age, sex, purchase period, coat color, and breed type influence small ruminant prices in Benin. Tarekegen (2021) reported that body condition, color, sex, and season were the factors that determined the market price of Bonga sheep in southwestern Ethiopia. Additionally, Jabo and Adamu (2018) also indicated that body condition, sex, breed type, and age were important factors that determined sheep price in Kaduna state, Nigeria. The above observation is an indication that small ruminant pricing is influenced by a complex interplay of factors. However, these factors can vary depending on the local market conditions, demand-supply dynamics, and other external factors. Body condition plays a significant role in determining the pricing of small ruminants, as it reflects the overall health, productivity, and quality of the animal.

Periods of marketing small ruminants can have a significant impact on the overall success and profitability of a small ruminant operation. The findings indicate that there is no decisive period for marketing small ruminants in the research area. The period of

marketing small ruminants depends on the farmer's financial needs and other related reasons. For instance, religious festive seasons which are a major factor that influences the marketing of small ruminants in Ghana often coincide with increased consumer spending and higher demand for livestock products.

The finding indicates that small ruminant demand for meat purposes and other sacrifices is often high during religious festive seasons like Christmas and Eid. Religious festive seasons in Ghana are often accompanied by cultural traditions and customs that involve the consumption of meat and this influences the marketing demand for small ruminants. Budisatria *et al.* (2008) reported that Eid al-Adha as a religious festive season has a major influence on livestock marketing. Ibrahim *et al.* (2019) stated that the demand due to religious and cultural activities results in seasonal demand of livestock from year to year. Farmers indicated that the need for cash is a critical factor that can influence the marketing decisions of small ruminant producers, shaping their sales timing, pricing strategies, marketing efforts, financial management practices, and risk management considerations to meet their immediate financial needs while optimizing their business performance,

Major small ruminant diseases can have a significant impact on the health and productivity of sheep and goats. These diseases can lead to decreased growth rates, and reproductive issues, ultimately affecting the overall profitability of small ruminant farming operations. In addition, some diseases can also have zoonotic potential, posing a risk to human health. The results indicate major small ruminant diseases of economic importance such as PPR, mange, bloat, anthrax, and mastitis. The outcome of this

research indicates that PPR incidence in the Upper East region is more prevalent in small ruminants as compared to other major small ruminant diseases of economic importance and this agrees with the outcome of several other researchers (Balamurugan *et al.,* 2012; Saravanan *et al.,* 2012) who reported that PPR is highly prevalent in sheep and goat production. The high incidence of PPR within the research area could be attributed to a lack of vaccination coverage, poor biosecurity practices, and a lack of surveillance and early detection by farmers.

Transboundary movement of small ruminants could have also been attributed to the high incidence of PPR as the region shares a boundary with Burkina Faso and Togo. Ahaduzzaman (2020) reported that PPR is considered the most important economic threat to the growth of sustainable small ruminant production across Africa and Asia. Parida *et al.* (2016) stated that morbidity and mortality associated with PPR are often high and this can create epidemics that can result in up to 100% mortality in susceptible small ruminant populations.

Additionally, the incidence of mange was recorded as the second most major small ruminant disease of economic importance and this contradicts Abdulai *et al.* (2020). The incidence of mange reported by farmers could be a result of poor management practices, lack of parasite control, introduction of infected animals, stress and poor nutrition, lack of veterinary care, and environmental factors that could have influenced the prevalence of mange in small ruminants. Several researchers have stated that the prevalence of parasitic diseases such as mange is a major challenge in small ruminant production (Abebe *et al.,* 2010; Gizaw et al., 2010; Umeta *et al.,* 2011; Tadesse *et al.,*

2014; Beyene and Anja, 2018). The high incidence of mange in the dry season recorded in this study agrees with Omoike *et al.* (2014) and Abdulai *et al.* (2020), but contradicts Sheferaw *et al.* (2010).

The high prevalence of bloat recorded by the farmers in the rainy season in this study could be attributed to environmental conditions such as weather changes, and pasture quality which could have promoted the growth of bloat-inducing forages. Dietary changes or management practices could have also upset the balance of rumen microorganisms and predispose small ruminants thereby increasing the incidence of bloat. Additionally, the high incidence of bloat in the rainy season could be attributed to the rapid intake of succulent pasture, dietary composition, and inadequate fiber intake.

Wang *et al.* (2023) indicated that the intake of a high-concentrate diet by ruminants results in enlargement and swelling of the foam in the rumen which prevents the release of gases produced by rumen fermentation thus resulting in rumen bloat. Tan *et al.* (2024) reported that rumen bloat can have a direct effect on animal health which can cause economic losses.

Moreover, anthrax another small ruminant disease of economic importance recorded by the farmers was more prevalent in the dry season. The incidence of Anthrax in the region could be attributed to spore persistence in the environment as grazing animals can ingest the spore as a result of feeding contaminated pastures or drinking from contaminated water sources. Alam *et al.* (2022) reported that anthrax outbreaks may occur through spore ingestion, skin abrasions, or skin lesions. Lack of vaccination,

movement of infected animals, poor carcass disposal practices, and lack of surveillance and early detection could have also contributed to the incidence of Anthrax in the region. Pittiglio *et al.* (2022) and Opare *et al.* (2000) reported that lack of surveillance, consumption of diseased animals, and improper dumping of dead carcasses in open areas are some of the compounding factors of the persistence of anthrax incidence. Generally, major small ruminant diseases cause economic losses, reduced marketability, welfare concerns, and environmental impacts such as increased use of antibiotics and other medications, leading to potential antimicrobial resistance and environmental contamination.

The result indicates that farmers spend more money on disease prevention strategies as compared to disease control strategies and this could be attributed to the high prevalence of major small ruminant diseases reported by farmers. Moreover, disease prevention is a critical component of animal health management, economic viability, public health, and sustainability of the production system.

Farmers indicated that they invest a high amount of money in disease prevention as it leads to improved health, productivity, and profitability of the production system thereby reducing the risk of disease outbreak and minimizing economic losses. Abdullah *et al.* (2015) reported that vaccination is the best disease control method and it is an alternative non-antibiotic prophylaxis strategy. Afata (2018) reported that prevention and control of pneumonia pasteurellosis can be achieved through antimicrobial treatment, vaccination for infected animals, and implementation of biosecurity measures.

The outcome of the research indicates that a large number of sheep and goats fall sick as reported by the farmers. This finding could be attributed to a lack of vaccination and preventive care leaves small ruminants unprotected against common infectious diseases. Moreover, poor management practices such as inadequate housing, sanitation, and biosecurity measures could have also created a conducive environmental condition for the spread of diseases thereby increasing the risk of sickness and reducing overall herd health. Afata (2018) stated that management practices that reduce stress as well as antibiotic treatment and early diagnosis are important strategies for controlling diseases. However, more sheep were recorded sick as compared to goats and this indicates that sheep are more susceptible to diseases as compared to goats. Poor nutrition can weaken the immune system of small ruminants thereby making them more susceptible to diseases and infections.

The study shows that a high sum of money is spent on treating small ruminant diseases in the Upper East region as reported by the farmers and this could be due to the high cost incurred by farmers in implementing disease prevention, and disease control strategies as well as veterinary services.

Moreover, the results indicate that Ghana loses about 2,429 small ruminants to diseases in the Upper East region. Innocent *et al.* (2022) reported in their research that out of 16,587 small ruminants recorded by 303 herds in Ethiopia, 5,611 (34%) died while between 2009 and 2017, the total number of sheep and goat deaths was 22,059 and 23,674, respectively as a result of diseases. The high incidence of mortality recorded in this study could be attributed to the prevalence of infectious diseases and

parasitic infections recorded as well as nutritional deficiencies which could have predisposed the animals to health disorders thereby increasing the rate of mortality as observed. Gizaw *et al.* (2010) stated that the prevalence of diseases and the occurrence of high mortality and morbidity are the major constraints in ruminant production in Ethiopia. Otte and Chilonda (2002) reported that high mortality associated with ruminants is considered a significant challenge in traditional livestock systems in Sub-Saharan Africa. Central Statistical Agency (2017) stated that between 2005 and 2015 average annual mortality in small ruminants and cattle was estimated to be 7% and 20% respectively in Ethiopia.

Additionally, huge sums of money (GH¢72,007.00 and GH¢64,402.00) are lost due to small ruminant diseases for sheep and goats respectively in the Upper East region and this indicates that small ruminant diseases have a negative consequence on Ghana's animal production sector and this explains why more small ruminants are imported from Burkina Faso. Innocent *et al.* (2022) and Berhanu (2002) reported that US$150 million are estimated to be losses annually due to small ruminant diseases in Ethiopia .

A similar financial loss has been reported in fetal wastage at Kumasi abattoir of slaughtered pregnant ewe and doe which amounted to GH¢2,755,140.80 and GH¢3,534,791.80 respectively for 1 year by Mohammed and Anane (2022).

CHAPTER SIX

6.0 Conclusion and Recommendation

6.1 Conclusion

The study on the economic impact of diseases on small ruminant production in the Upper East Region reveals;

1. Majority of farmers reared both small ruminants and poultry with higher proportion of them practicing semi-intensive housing system
2. PPR was the most prevalent small ruminant disease recorded in the study followed by mange
3. Majority of farmers recorded more small ruminant diseases in the rainy than in the dry season
4. Good husbandry practice and vaccination were the major disease prevention measures whiles disease control measures were improved biosecurity and isolation of sick animals
5. The direct financial implication (cost of disease control) of small ruminant diseases on farmers in the region stood at GH¢72,007.00 and GH¢64,402.00 for sheep and goats respectively. Whiles indirect financial implication (cost of disease prevention) of small ruminant diseases on farmers in the region stood at GH¢199.50p and GH¢178.40p for sheep and goats respectively.

6.2 Recommendation

It is recommended that;

1. Farmers should implement good management practices, such as vaccination, biosecurity measures, regular deworming and proper nutrition, which can help prevent diseases and reduce the need for costly treatments.
2. Veterinary support programs should intensified among farmers to optimize the health and productivity of their herd, improve overall efficiency, and enhance profitability.

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