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Abiodun Elijah Obayelu

Livestock Feed Development Pathway in Nigeria: Drivers, Challenges, and Opportunities

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Abiodun Elijah Obayelu

AKADEMIYA2063 - Kicukiro/Niboye KK 341 St 22 I P.O. Box 1855 Kigali-Rwanda
Email: kigali-contact@akademiya2063.org

*AKADEMIYA2063 | Lot N*3 Almadies | BP 24 933 Ouakam Dakar-Senegal*
Email: dakar-contact@akademiya2063.org

www.akademiya2063.org

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Authors

Abiodun Elijah Obayelu is a Professor in the Department of Agricultural Economics and Farm Management at the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria: obayelu@yahoo.com

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Contents

Abstract

Feed is the most essential input in all livestock production systems. Therefore, it deserves greater attention by any nation seeking to assure the food and nutritional security of its citizens. This study provides an assessment of livestock feed development pathways in Nigeria by examining the drivers of that development and the challenges and opportunities confronting Nigeria's livestock feed subsector. Data on livestock-raising households were obtained from the 2018/19 wave of the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) panel survey for Nigeria. These data were analyzed using descriptive statistics, Ordinary Least Square regression, multinomial and ordered logit models, and gross margins analysis. The major findings are

• The main sources of livestock feed for cattle, sheep, and goats—are crop residues, forages, and fodder shrubs. Only a few households feed their livestock using zero-grazing. The main feeding regime of cattle is only grazing. Cattle production systems are largely pastoral and most of them are maintained in transhumance and agropastoral systems.

• Farmer practices are consistent with the gross margins of the feeding regimes examined. Grazing with some feeding was the feeding regime with the highest gross margin (GM) per head, followed by only grazing. The worst feeding regime financially was zero-grazing which was estimated to provide a loss.

• The average milk productivity for farmers who only graze their dairy animals is higher than the productivity realized under other feeding regimes. Egg productivity was highest for layer poultry farmers operating under the feeding regimes that mainly use grazing with some feeding.

Nigeria does not have an effective livestock feeding policy to encourage private investment in the sub-sector. Transformation of the livestock sector in Nigeria supported by an effective livestock feed sub-sector will require the promotion of efficient crop-livestock systems that are integrated with large-scale modern feed mills to reduce feed production costs, livestock feed value chain development, and the institution of feed safety standards, among others. Policies that reduce the cost of feeding will increase gross margins for livestock-raising households. Lower feed costs likely will enable greater adoption of zero-grazing, which will enhance milk productivity. These policies will require an expansion of fodder production in Nigeria and the facilitation of trade in feed concentrates. The results from this study can be used by decision-makers both in Nigeria and elsewhere to focus greater investment in the livestock sector to improve feed systems for greater production and profitability.

Livestock Feed Development Pathway in Nigeria: Drivers, Challenges, and Opportunities

Abiodun Elijah Obayelu

1. INTRODUCTION

Livestock feed is essential in the livestock production chain. Livestock production is central to the livelihoods of poor communities in Nigeria and elsewhere in sub-Saharan Africa, both in rural and urban settings (Randolph et al. 2007). It plays a crucial role in providing nutrient-rich foods for humans (Moorby and Fraser 2021). The livestock sector is made up of large (cattle) and small (sheep and goats) ruminants, as well as non-ruminants (pigs and poultry). Livestock feed plays an important part in the food chain and the composition and quality of the livestock products, including meat, milk, and eggs, that people consume (Malomo and Ihegwuagu 2017). Livestock production primarily depends on feed obtained from natural pasture and crop residues—residues can both be harvested by the farmers or purchased. Livestock in Nigeria are kept on grazing pasture for most periods of the year, except during the wet season when they are constrained so that they do not damage planted fields before the crops are harvested.[1]

Livestock feeds can be classified as fodder, forage, or mixed feeds. Fodders can be further classified as roughages, which include fresh cut forage, hay or dry forage, straw, root crops, stover, and silage; or as concentrates, such as grains, legumes, and by-products of agricultural processing. While some feeds, such as pasture grasses, hay and silage crops, and certain cereal grains, are grown specifically for livestock, other feeds, such as sugar beet pulp, brewers' grains, and pineapple bran, are by-products that remain after a food crop has been processed for human use. Through livestock production, plant parts that are indigestible by humans can be converted to proteins by livestock so that they are transformed into edible food for humans.

A key challenge to the livestock sector in Nigeria is the unavailability of feed resources for ruminant animals, in particular, especially during the dry season, and reduced access to grazing areas with increased conversion of pastures to cropland (Bayala et al. 2014; Diogo 2010; Rischkowsky 2006). In the wet season when fodder is more available, arable crop cultivation constrains free-range grazing of livestock, making tethering or stall feeding of animals a necessity to protect crops from livestock damage. Livestock farmers are increasingly relying on purchased feeds, but these usually can only be obtained at high prices and in some seasons have limited supply. Adeyonu et al. (2021) found that the low productivity of livestock in Nigeria can be attributed to a lack of high-yielding local livestock breeds, the high cost of feed, poor infrastructural facilities, inadequate market integration, and poorly developed livestock value chains.

The decline in access to natural pasture due to the expansion of cropland and urban areas is putting pressure on livestock farmers to explore other feed sources for their animals. Feed markets have sprung up with sellers harvesting leaves from naturally occurring grasses and browse species, crop residues, and agricultural and agro-industrial by-products, like cereal bran and cottonseed cake, for sale to farmers engaged in stall feeding (Husseini et al. 2011). Feed concentrates are also produced by small-scale factories for sale in these markets. These feed markets contribute to alleviating feed shortages, particularly in urban and peri-urban areas (Konlan et al. 2015). Animal feed accounts for about 80 percent of the total cost of meat production. Thus, improving animal feeding systems is necessary to optimize livestock production (den Hartog and Sijtsma 2013).

Ayantunde et al. (2014) observed that to enhance resource use efficiency and optimize livestock feeding strategies in both suburban and urban livestock production systems, it is necessary to obtain information on the quality and price of feeds within these markets. Policy discussions on the challenges and opportunities for livestock feed development are underway in Nigeria. The animal feed sector directly or indirectly employs over 5 million people in Nigeria as suppliers,

1 A glossary of key terms related to livestock production and livestock feed can be found in Annex Table 2.

distributors, and tool or machinery fabricators for feed production, among others (Contact Consulting Nigeria 2022). The sector has the potential to employ over 20 million Nigerians, as the industry has yet to reach even a quarter of its estimated potential market size (Mohammad 2023)

The livestock subsector has always been an important component of the Nigerian economy. But Nigeria's animal feed sector supporting the sector is faced with recurrent feed shortages. The sustained availability of desired types and quantities of animal feed serves as a foundation for sustainable livestock production systems (Makkar 2016a). Feed is financially the single most important element of animal production, irrespective of species and production system.

Inadequacy of feed, both in quantity and quality, is a basic cause of poor nutritional management of livestock in developing countries (Idio and Okoro 2017). Animal feeds are not readily available. If available, they are not easily affordable for an average farmer (Bamaiyi 2013). The shortage of feed in terms of quality and quantity during the dry season is one of the most serious problems faced by farmers in northern Nigeria. Crop residues from farms are the main feed for livestock in this area. Shortages push the Fulani ethnic group to drive their cattle during the dry season to wetter regions in the center of Nigeria.

Since farmers go into animal production for profit, they need to obtain feed at a price at which they can make a reasonable profit. Ruminant production likely does not feel the impact of high feed prices as much as the intensive poultry production industry, which requires a constant supply of feeds for maximum productivity. In contrast, ruminants can be fed on pastures and forage or allowed to freely graze to find food when feed prices are high. Due to the high cost of feed, various alternatives have been researched as other means of providing animal feed at a lower cost. This includes the use of activated sludge from wastewater treatment (Vriens et al. 1989). Many livestock and poultry farmers compound feed for their farm animals themselves, but they face the challenges of very expensive or unavailable raw materials for compounding the feed.

The range of feeding regimes gives a fair idea about the level of intensification in feed resource use patterns. The Nigeria livestock sector is confronted with the twin challenges of low productivity and low resilience (World Bank 2017). The low productivity of livestock can be attributed to several underlying constraints:

- low quality of animal species and stock;
- sub-optimal animal husbandry practices;
- poor animal health due to deficient pest and disease management;
- low quality of livestock feed;
- limited market and value chain integration;
- sub-optimal supportive infrastructure, such as livestock markets, abattoirs, and processing facilities; and
- limited availability of public services for livestock production, with weak institutions and a poor enabling environment.

In addition, the livestock sector is exposed to a large number of risk factors, including droughts, floods, and other adverse effects of climate change, pests and diseases, and conflict and insecurity. There are limited social safety nets for livestock-producing households to use to manage these risks. Moreover, livelihood diversification options are scarce, so households have limited capacity to absorb shocks. All these factors contribute to low resilience in livestock production in Nigeria.

The major objective of this study is to evaluate potential livestock feed development pathways in Nigeria. The specific objectives are to:

- Document past and current policies for improving access to livestock feed in Nigeria;
- Assess the characteristics that determine the livestock feeding regimes employed in Nigeria;
- Examine the opportunities and threats to the main livestock feeding regimes; and
- Identify feasible pathways for the development of the livestock feed sub-sector in Nigeria.

Through the identification of the bottlenecks and the drivers of the choice of feeding systems used by farmers, it becomes relatively easier to identify and describe possible investment options that will stimulate local production and increase the sector's contribution to the growth of Nigeria's economy.

The rest of this paper is organized as follows: Section 2 describes livestock feed policies. Section 3 discusses the research that has been done on livestock feeds in Nigeria. Section 4 presents the sources of data and empirical methods for the analysis of the data. Section 5 discusses the results of the analysis. Section 6 concludes and draws recommendations from the analytical results.

2. LIVESTOCK FEED POLICIES IN NIGERIA

Nigeria's feed industry produces an average of 5.5 million metric tons of animal feed per year. Poultry feed makes up 85 percent of this, with commercial ruminant and swine feed making up the rest (Consumer Halla 2021). In the absence of well-defined feed legislation, the government has harnessed other policy instruments to support the animal feed industry. Under the Nigerian Enterprises Promotion Act, both integrated poultry production and the manufacture of animal feeds have been categorized as Schedule III activities. This enables foreign investors to participate in the industries, either individually or in joint ventures with Nigerians (The Regulation for the Feed Milling Industry in Nigeria 2017).

The Federal Government in 2019 inaugurated a 10-year National Livestock Transformation Plan to devise and implement alternatives to open grazing of cattle. This was aimed at addressing and mitigating the frequent deadly conflicts between herders and farmers. Anti-open grazing laws have also been instituted in some states in Southern Nigeria to reduce such conflicts.

2.1 FEED QUALITY REGULATIONS AND ENFORCEMENT

The Federal Government of Nigeria mandated in 2007 the Nigerian Institute of Animal Science (NIAS) under the Federal Ministry of Agriculture and Rural Development to be the regulatory agency for matters pertaining to animal husbandry in Nigeria.

The regulations under which NIAS operates seek to ensure:

- the distribution of quality animal feed and feed ingredients from feed mills to farms;
- that animal products in Nigeria conform to international benchmarks on animal feed safety;
- that no person shall market in Nigeria any animal feed that is not manufactured or formulated in an establishment acceptable and approved by the institute;
- that no person shall operate a business of manufacturing, importation, exportation, advertisement, sale, or distribution of feed in Nigeria unless the feed business entity and premises have been registered by the institute in accordance with the provision of this regulation;
- that no feed business entity shall use any feed ingredients not listed in the current listing of approved feed ingredients for feed in Nigeria released by the institute;
- that all incoming raw materials shall be tested for quality by the quality assurance departments and records maintained;
- that raw materials and finished products shall be properly packaged and labeled for traceability and other label regulatory requirements;
- that every feed business entity in Nigeria shall have in its employment, either permanent or part-time, at least one registered animal scientist as a technical officer supervising the operation of the feed mill.

Revised standards for poultry feeds were set in 2018 by the Nigerian Standards Council. These new standards pay more attention to nutrient balances in the feed, quality assurance, the right methods of testing, and ingredient selection. Commercial feed manufacturers are required to state expiry dates on the labels accompanying feed bags. The new standards include a list of which testing methods should be used, following International Organization for Standardization guidelines. Further guidelines for nutrient requirements for both layers and broilers are given in different life stages. These guidelines are to help feed manufacturers produce better quality feeds with better digestibility. It has also implemented strict regulations on the storage and recordkeeping of raw materials. A Standard Operating Procedure manual for feed millers was developed by NIAS as a first step towards ensuring that a common standard is established for feed producers in the market, especially for complete feed. In addition, NIAS restricts the marketing of poultry feed products to manufacturing companies whose premises have been inspected and approved for the making of the feeds and those that are using the recommended feed formulations in feed production. NIAS has also made it mandatory for feed makers to keep a record of the origin, date of receipt, and quantities of all raw materials used in the poultry feed milling plant. All end products are to be "properly packaged and labeled for traceability and other label regulatory requirements."

Feed quality is regulated and monitored by the National Agency for Food and Drugs Administration and Control (NAFDAC). This includes monitoring feed imports. This is done to protect the industry from foreign exporters who may be shipping inferior raw materials. Stringent checks are made on the nutrients and micronutrients—vitamins and trace minerals—in concentrates before they are imported to Nigeria. The Agency prohibits that

any animal feed or pet food be manufactured, imported, exported, advertised, distributed, sold, or used unless it has been registered in accordance with the provisions in its regulations. In addition, the regulations state that anyone receiving a certificate of registration cannot lend, hire, sell, transfer, or otherwise dispose of the certificate of registration to any other person without the approval of the Agency.

2.2 FEED PRODUCTION PROMOTION

Livestock productivity, profitability, and animal health and welfare are affected by feed. About 70 percent of total variable costs in livestock production goes to feed cost. This may increase to 90 percent in intensive systems of production (Makkar 2016a). Globally, the value of purchased compound feed relative to the value of total animal output is 30 percent on average for all livestock production systems—10 percent for cattle, 40 percent for pigs, and 80 percent for poultry (FEFAC 2016). Among the limitations to livestock production and greater consumption by humans of nutritious animal source foods is the lack of access to sufficient livestock feed and other livestock feeding-related issues (ME 2018).

In Nigeria, imported feed mill equipment, like other agricultural equipment, is exempt from customs duties. Similarly, to ensure a regular supply of ingredients for the manufacture of animal feeds, the importation of raw feed materials, such as fishmeal, soybean, protein concentrates, and other premixes, is also duty-free. There is a ban on the exportation of locally produced feed ingredients, such as maize and wheat bran, groundnut cake, and palm kernel cake, among others. Under an Approved Users Scheme, concessions are granted to bona fide feed millers in respect of import licenses and foreign exchange allocations. Under the Industrial Development (Income Tax Relief) Act of 1971, the manufacture of animal feeds was placed on the list of pioneer industries (Coopers & Lybrand 1977). This ensures a five-year tax holiday for new feed millers entering the industry. These measures are aimed at stimulating investments in industrial animal feed production.

The livestock feed components of the Agricultural Promotion Policy (APP; 2016-2020) encourage livestock farmers to practice various forms of fodder conservation. In addition, the policy promotes the creation of adequate storage facilities for grains and strategic supplementary feed reserves as part of efforts to alleviate the constraints on feed available from drought and to ensure the proper utilization of all agro-industrial by-products and crop residues which are found to be suitable for livestock feed (FMANR 2016).

2.3 PROMOTION OF IMPROVED FEED TECHNOLOGIES

The increase in demand for livestock feed has led to the introduction of different sets of technologies that promise to increase the production of livestock feed under conditions of limited resources. These technologies can be categorized as i) feed quality enhancement; ii) enhancement of the nutritional status of animal feed; iii) feed productivity improvement; and iv) feed quality maintenance or preservation, Annex Table 1 summarizes the characteristics and objectives of each category of livestock feed technology.

Among the most commonly applied technologies is the production and utilization of processed concentrates and agro-industrial by-products (Balehegn et al. 2020). For instance, the transformation of cassava peel into nutritious animal feed has the potential to partially replace maize in animal feed while reducing environmental pollution, minimizing post-harvest losses, and being a valuable alternative feed ingredient. Cassava peel mash is now a viable industry in Nigeria and has the potential to be scaled out in other countries. Converting cassava waste into safe livestock feed will help address animal feed scarcity, reduce pastoralist-farmers conflicts over natural resources, and reduce the high costs of compound feeds in Nigeria, as well as in other cassava-producing countries in Africa.

To reduce clashes between herders and farmers and to ensure better feeding of livestock, the Nigerian Farmers Group and Cooperative Society has introduced a locally constructed greenhouse technology that involves hydroponics to produce cow fodder (Iyanda 2020). This is an innovation that allows growing grass with no soil using organic growing techniques.

2.4 ANIMAL FEED TRADE

The demand for feedstuffs in Nigeria is derived predominantly from the livestock and poultry feed industries and is met either through domestic production or imports (Fagbenro and Adebayo 2005). Domestic supplies to the feed industry are dependent upon overall agricultural production levels, the degree of industrialization, and the demand for refined food products. The feedstuffs used in the animal feed industry are derived from crop residues, mill by-products, food processing

wastes, and agro-industrial by-products. However, as a result of the stagnant or diminishing output of certain traditional crops, the country's feedstuff resources are in decline. To meet the feed needs of the expanding livestock and poultry industries, Nigeria has come to rely heavily on imports. Nigerian imports 96 percent of the fish meal used in the production of animal feeds, mostly from Europe (Nieuwsbrief 2021).

Feed imports have allowed some developed nations to support livestock production at a high intensity. Global trade in feed has increased during the last decade. Several reasons have resulted in increasing global trade in livestock feed. These include livestock feed imports being required when a country's agricultural land produces insufficient feed for the domestic herd, because imported livestock feeds may be of higher quality than domestically produced feeds, and when imported feeds are cheaper (Wang et al. 2018). However, the countries involved in feed exports and imports globally remain quite limited.

3. RESEARCH ON LIVESTOCK FEEDS IN NIGERIA

The animal feed production industry in Nigeria is underdeveloped, largely due to its high production costs. Between 70 and 90 percent of the cost of livestock production, including for aquaculture and poultry, goes to feed (Nieuwsbrief 2021). The escalating cost of maize and its seasonal scarcity has led to the high cost of raising monogastric livestock, such as pigs. Animal nutritionists are currently focusing on cheap but suitable alternative feedstuffs, especially crop residues and industrial by-products, to sustain livestock industries globally. These unconventional feed resources, if proven to be safe and effective for livestock production, would reduce pressure on conventional feed resources. The need to identify cheap and suitable alternative feeds from unconventional feed materials, such as farm wastes and agro-industrial by-products, has led to considerable research.

Due to the scarcity and seasonality of pasture in Nigeria, several efforts have been put into developing improved groundnut varieties that also can be used for fodder. These have been promoted among groundnut farmers in many parts of Nigeria under the Tropical Legume III project, a collaborative effort between the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) and the Institute for Agricultural Research. The project worked on solving the problem of dry season livestock feeding by releasing improved dual-purpose groundnut varieties that produce both grain for human use and haulms that remain green even at harvest for livestock feed. These varieties, which include SAMNUT 24, 25, and 26, have pod yields of 2.0 to 2.5 mt/ha instead of the pod yields of less than 1.0 mt/ha for local varieties. The haulm yields of these improved varieties are between 2.5 and 3.0 mt/ha (Vabi et al. 2019).

Ajiboso et al. (2000) conducted a study to determine the performance of grain residues as feed resources in chicks. This research revealed that chicks maintained on commercial feed had comparatively better performance in terms of body weight gain than if maintained only on grain residues. However, among grain residues, maize husk rations had better performance than rice husk and cowpea pod rations.

Adebowale (1992) in a study to assess the nutritive value of maize crop residues to develop feeding packages for farmers in Nigeria demonstrated that maize residues are a potentially valuable feed resources for ruminants. Adesehinwa et al., (2011) grew pigs fed a cassava peel-based diet supplemented with or without Farmazyme 3000 promix. The researchers found that the cassava peel meal, which is economically cheaper than maize and regarded as waste in some areas of Nigeria, can be used successfully to replace maize in conventional pig feed without any adverse effect on growth performance.

In grower rabbits, a research study was conducted to determine the effects of two fiber types—cowpea shell and maize cobs at 20 and 40 percent of the diet—on growth, nutrient intake, and digestibility, the results showed that dry matter intake, acid detergent fiber, daily weight gain, and feed conversion ratio were significantly affected by type and level of fiber in the rabbits' diets. Cowpea shells at a 20 percent level and maize cobs at a 40 percent level, both agro by-products, can be incorporated into rabbit feed without compromising the productive performance of rabbits (Doma et al. 1999). A similar study on rabbits incorporated yam peel meal at the rate of 0, 15, 30, and 45 percent as a replacement for maize in rabbits' diets (Alade et al. 2005). The results showed that yam peel meal can be included in the diets of weaned rabbits at the 30 percent level without any deleterious effects on blood parameters and performance characteristics. Omoikhoje et al. (2008) found that cassava root meal can serve as

an effective replacement for maize in rabbit diets and is profitable up to a 30 percent level in the total diet. Finally, the inclusion of maize milling waste in weaner rabbit diets up to a 20 percent level can serve as a replacement for maize grain with no adverse effect (Akinnusi et al. 2009).

The use of agro-wastes and other renewable resources is one of the means of reducing the cost of animal feeds. Agro-industrial byproducts and milling wastes have been identified as potential feed ingredients in livestock feeds. Milling wastes of rice, maize, and sorghum constitute a major alternative source of fibrous feed ingredients in Nigeria (Oso et al. 2006). Aruwayo et al. (2019) showed that farm residues, home remnants, and agro-allied waste help in alleviating the challenges of scarcity of ruminant feed, especially during the dry season of the year.

Livestock feed scarcity continues to be one of the most vital challenges to livestock production in Nigeria. However, there is a paucity of information on livestock feed development pathways for the country. This information gap is a major impediment to improving overall feed supply and livestock productivity. Therefore, a comprehensive assessment of livestock feed development pathways and the drivers, challenges, and opportunities for feed improvement is vital to enable stakeholders and policy-makers in the livestock feed subsector to design appropriate intervention strategies and practices for improving feed supply. Such an exercise will also identify knowledge areas around livestock feed in Nigeria that will require additional research in the future.

Good quality feed and proper feeding practices improve livestock productivity. The findings from this study will add to the existing limited literature on livestock feed and feeding practices in Nigeria and help smallholder farmers who raise livestock as part of their farming and pastoralists who focus on livestock to better understand which is the most productive and profitable feeding regime they might employ in their particular context. Lessons from this research can support the formulation and implementation of livestock feed interventions and policies to promote more productive and sustainable livestock feeding systems across Nigeria, particularly in those challenging contexts in which pastoralists and farmers are in conflict over feed resources.

4. METHODOLOGY

4.1 STUDY AREA

Livestock raising is an important area of economic activity in Nigeria. Among the livestock that farmers produce are poultry, primarily chickens, but also turkeys, guinea fowls, and ducks; cattle; goats and sheep (small ruminants); pigs; rabbits; and, in parts of the northern region of the country, donkeys, camels, and horses. The most common are chickens, cattle, goats, and sheep. The number of livestock produced annually in Nigeria is estimated at 180 million poultry birds; 76 million goats, 43 million sheep, 18 million cattle, 7.5 million pigs, and 1.4 million horses and donkeys (FMARD 2017). Poultry is distributed across Nigeria, with concentrations in the southwest and southeast zones. Poultry throughout the country is kept both in traditional backyard flocks and in modern intensive commercial production units. About 90 percent of the country's cattle population and 70 percent of the sheep and goat population are concentrated in the northern part of the country (World Bank 2017). Monogastric livestock, particularly pigs, are concentrated in the humid zone (+ 1500 mm rainfall/annum) in the southern part of Nigeria and in the Middle Belt between the humid and sub-humid zones.

Three livestock production systems co-exist in Nigeria:

- mobile pastoral or agro-pastoral systems that are mainly based on small and large ruminants and concentrated in the northern part of the country;
- traditional mixed crop-livestock systems that are sedentary in nature and primarily village-based and found throughout the country; and
- commercial semi-intensive peri-urban poultry and pig production.

Cattle production in Nigeria remains a traditional activity primarily carried out under pastoral and agro-pastoral systems in the north and in mixed farming systems in the south. Under the pastoralist system, animals are managed within nomadic, transhumance herding systems dominated by members of the Fulani ethnic group. Goat and sheep production methods vary from extensive, low-input systems based on free grazing in areas with low population pressure, to more intensive cut-and-carry feeding of confined animals in the intensively cultivated parts of the country. Most cattle, sheep, and goats, while primarily relying

on grazing for feed, are supplied with fodder harvested from rangelands and grazing reserves, since the amount of pasture available is receding quite significantly as the areas under crops and urban centers expand.

4.2 TYPES OF DATA AND METHOD OF DATA COLLECTION

The population for this study is made up of livestock farming households in Nigeria. The study made use of national-level data from the Food and Agriculture Organization (FAO) on livestock production in Nigeria for the period from 1990 to 2019.

However, the principal source of data for the main household-level analyses in this paper was data from the fourth round of the panel component of the Nigeria General Household Survey (GHS-Panel), collected in 2018/19. The GHS is the Nigeria component of the global Living Standards Measurement Study—Integrated Surveys on Agriculture program that is managed by the World Bank and funded by the Bill and Melinda Gates Foundation. In Nigeria, the program involves the National Bureau of Statistics, the Federal Ministry of Agriculture and Rural Development, and the National Food Reserve Agency. GHS-Panel is a nationally representative survey involving approximately 5,000 sample households. Survey results are also representative of the six geopolitical zones. Successive panel survey rounds were conducted in 2010/11, 2012/13, 2015/16, and 2018/19. In all four rounds, survey sample households were visited twice—first after the planting season, and then second after the harvest. The number of sample households with livestock in the fourth wave of the GHS-Panel Wave 4 is 2,267. However, after data cleaning and the removal of households with implausible information, 1,965 livestock households remained in our analytical dataset.

The fourth round of the GHS-Panel utilized three questionnaires for each visit. The Household Questionnaire was administered to all households in the sample. The Agriculture Questionnaire was administered to all households engaged in agricultural activities, including livestock rearing. The Community Questionnaire was administered to the community leaders and representatives to collect information on the socio-economic indicators of the enumeration areas in which the sample households reside.

4.3 ANALYTICAL TECHNIQUES

The data were analyzed using descriptive statistics, budgetary techniques on livestock enterprise costs and benefits, multinomial logit regression, ordered logit regression, and ordinary least square (OLS) regression models.

The analyses examined the drivers of the choice of livestock feeding regimes employed by livestock-raising households and the drivers of livestock productivity levels. Productivity implies a relationship between inputs and outputs (Pica-Ciamarra et al. 2014). Physical outputs of livestock can be considered as either end or intermediate products. End products include meat, milk, eggs, hides and skins, and live animals. Partial livestock productivity is the amount of output produced by one unit of a given production factor over a defined reference period. Due to data limitations, we were unable to compute individual livestock productivity for the production of milk or eggs—the dataset included just 48 reports of egg output and 148 reports of milk output. Therefore, the average value-cost ratio for livestock production by livestock-raising households in aggregate is used as a proxy of productivity in our analyses of the drivers of livestock productivity.

4.3.1 Determinants of the choice of livestock feedings systems

To analyze the determinants of the choice of a particular feeding regime by a household for its livestock, a multinomial logit (MNL) regression was used (Equation 1).

$$P\left(Y_i = \frac{m}{X_i}\right) = \frac{(\exp X_i\, \beta m)}{1 + \sum_{j=4}^{i} exp\,(X_i \beta_i)}, \text{ for m} > 1 \qquad (1)$$

where x_i are the unknown parameters, and m represents the different feeding regimes examined. The MNL model considers four unordered feeding regimes: only grazing (includes scavenging by poultry); mainly grazing with some feeding; mainly feeding with some grazing; and only feeding (zero-grazing). Our base category for the analyses is the only feeding regime. The unordered categorical property of the dependent variable distinguishes the MNL from traditional OLS regression models, in which the dependent variable is continuous, and from logit models, which are appropriate for binary (0/1) outcomes. The validity of the independence of irrelevant alternatives (IIA) assumption of the MNL, which states that characteristics of one particular choice alternative do not impact the relative probabilities of choosing other alternatives, was tested for the model of the choice of a particular feeding regime.

For our ordered logit analysis, the dependent variable also is the feeding regimes, but ordered. We assume that the various feeding regimes use

different levels of technology, with only grazing being low (categorical value of 1); mainly grazing with some feeding being intermediate (2); mainly feeding with some grazing being high (3), and only feeding (zero-grazing) being very high (4). In the ordered logit model, there is a continuous, unmeasured latent variable Y*, whose values determine the observed ordinal variable Y (feeding regimes) (Equation 2).

$$Y_i^* = \sum_{k=i}^{k} \beta_k X_{ki} + \varepsilon_i \qquad (2)$$

where Y* continuous latent variable, β_k is the vector of parameters to be estimated by the model, X_{ki} represents a vector of the explanatory or independent variables, is the random disturbance term reflecting those relevant variables may be left out of the equation, or variables that may not be perfectly measured. The probabilities of respondents being in any of the identified ordered categories are determined using the natural log of the cumulative distribution following Booroah (2002).

The explanatory variables used to explore the choice of livestock feed regimes using both the MNL regression and the ordered logit model are presented in Table 4.1. Our expectations drawn from the research literature on the likely direction of the relationship (direct or inverse) between each explanatory variable and the choice of feeding regime are also presented.

Table 4.1. A priori expectations of factors influencing the choice of livestock feeding regimes

Definition of variables	A priori expectations
Outcome variable: Feeding systems	na
Four categories:	
• Grazing only (low technology);	
• Mainly grazing with some feeding (intermediate technology);	
• Mainly feeding with some grazing (high technology);	
• Feeding only (zero-grazing) (very high technology).	
Explanatory variables for choice of feeding system	
Age of head of household, years	+
Male head of household,1 if male/0 if female	±
Level of education of head of household, years	+
Household size, number of persons	±
Farm size, square meters	+
Ruminant, 1 if yes/0 if no	±
Animals housed inside house, 1 if inside house/0 if outside)	+
Incidence of disease outbreak, 1/0	±
Access to extension, 1/0	+
Access to credit, 1/0	+
Use of labor for livestock, 1/0	±
Other related costs annually, such as veterinary services, Naira	+
Compensation paid to others for damage by livestock, 1/0	±
Urban, 1 if urban/0 if rural	-

Source: Author.

na = "not applicable".

4.3.2 Determinants of the productivity of livestock

Productivity reflects the output per unit of some combined set of inputs, so it reveals the joint effects of many factors including new technologies, economies of scale, managerial skill, and changes in the organization of production (Petrick and Kloss 2018). Productivity, therefore, is an indicator of the long-term performance of the agricultural enterprise as a whole in terms of how efficiently inputs are turned into output. In this study, we use value-cost ratios as a proxy of productivity. All outputs are converted to a Tropical Livestock Unit (TLU) basis because of the different types of livestock raised by livestock-producing households.[2]

2 Conversion factors used to compute Tropical Livestock Units (TLU): cattle in herd = 0.70 TLU; cow = 1.00; sheep = 0.10; goat = 0.08; pig = 0.20; donkey or horse = 0.50; camel = 1.25; chicken = 0.01; rabbit = 0.01; duck = 0.20.

Factors influencing productivity, proxied using value-cost ratios, were analyzed using OLS regression (Equation 3):

$$InVCR_i = \beta_0 + \beta_i InX_i + \beta_n InX_n + \varepsilon_i \quad (3)$$

Where $lnVCR_i$ is the natural log of the value-cost ratio of the i^{th} farmer, β_0 is the constant, β_i is the unknown parameters, X_i are the factors—the explanatory variables—influencing the value-cost ratio, which are described in Table 4.2, and ε_i is the error term.

Table 4.2. A priori expectations of factors influencing livestock productivity, proxied by value-cost ratio

Definition of variables	A priori expectation
Outcome variable: Value-Cost Ratio	
Ratio of average value of all output (meat, milk, eggs) to value of all inputs per Tropical Livestock Unit (TLU)	
Explanatory variables	
Age of head of household, years	+
Level of education of head of household, years	+
Household size, number of persons	±
Farm size, square meters	+
Ruminant, 1 if yes/0 if no	+
Animals housed inside house, 1 if inside house/0 if outside	+
Livestock owned, TLU	+
Slaughtered livestock in past year, TLU	+
Livestock deaths from disease in past year, TLU	+
Livestock dung, total annual sales of livestock dung, Naira	+
Vaccinations in past year, number	+
Access to extension, 1/0	+
Access to credit, 1/0	+
Feedstuff purchased in past year, total cost, Naira	+
Other livestock costs for household in past year, Naira	-
Intensive (zero-grazing) feeding regime, 1 if intensive/0 if not	+

Source: Author.
Note: The analysis reclassified the four livestock feeding regimes presented in Table 4.1 into two—intensive and not intensive—because of the small number of responses in some of the feeding regime categories. "Intensive" feeding is made up only of the only feeding (zero-grazing) regime, while the other three feeding regimes are categorized as "not intensive".

4.3.3 Gross margins analysis

Gross margin analysis is a simple financial accounting model that is used to estimate the financial returns to a production process (Abu et al. 2011). It is used as a simple proxy for the profitability of a production process. Because of its simplicity, particularly when data necessary to compute the profits of an agricultural enterprise are missing, gross margins analysis is widely applied as part of the evaluation of the economic performance of smallholder agricultural production systems (Benu et al. 2010).

Gross margin analysis provides a guide to the relative profitability of different productivity improvement options. It helps to decide whether a potential improvement is worth implementing and whether one option is better than another. The gross margin of a feeding regime is the gross income produced from the feeding regime option less the variable costs incurred in implementing it. It does not take into account fixed or overhead costs, such as depreciation, interest, or the costs of permanent labor.

The gross margin relationship is stated in Equation 4:

$$\text{Gross margin} = \text{TR} - \text{TVC} \quad (4)$$

where TR = Total Revenue from sales of live animals, slaughtered animals, dung, milk, processed milk, and poultry eggs, and income from providing services using livestock; and TVC = Total Variable Costs, which include the cost of purchasing livestock and feeds; livestock-related labor costs; cost of fuel and transport to take livestock or their products to market and to bring in inputs; electricity for livestock management; maintenance, such as the costs of maintaining feeding pens and animal housing, and animal health costs such as the costs of medicine or consulting with veterinary professionals.

5. RESULTS AND DISCUSSION

In this section, we first discuss the four feeding regimes used by livestock-raising households before considering the variables that may explain the choice of which regime a household uses to feed their animals. The results of an econometric analysis of the drivers of the choice of livestock feeding regime are then presented. We then turn to consider the costs of livestock production before undertaking a gross margins analysis for households that employ each of the feeding regimes. Finally, we conduct a second econometric analysis to explore the determinants of livestock productivity levels, as proxied by value-cost ratios on the livestock enterprise of livestock-raising households.

5.1 LIVESTOCK FEEDING REGIMES IN NIGERIA

Livestock feeding regimes differ in how they manage changes in fodder and feed availability between the dry season between November and March and the rainy season between April and October. The dry season is found to be the most challenging period for meeting the feed requirements of livestock in general. The major sources of feed in this period of the year are crop residues from just completed cropping season and leaves of trees and shrubs (Mohammed and Hoffmann 2006). Due to the limited supply of feeds in the dry season, farmers ration the crop residues they feed to their animals. During the rainy season, animals are allowed to graze on natural forage in the surrounding area, so long as they are kept from going into planted fields. This forage is usually supplemented by cut-and-carry of fresh grass and weeds, which are usually fed to the animals in the late evening.

Table 5.1. Feeding regimes of livestock in Nigeria, by livestock type, percentage share of animals using

	Only grazing	Mainly grazing with some feeding	Mainly feeding with some grazing	Only feeding (zero-grazing)	Total	Animals reported
Cattle	40.3	49.3	8.6	1.8	100.0	3,875
Sheep and goats	26.3	38.5	24.5	10.7	100.0	12,949
Poultry	39.6	22.2	15.0	23.1	100.0	20,472
Pigs	8.4	19.3	20.2	52.1	100.0	332
Donkeys and horses	26.3	52.6	15.8	5.3	100.0	57
Camels	25.0	37.5	0.0	37.5	100.0	8
Other	0.0	53.0	0.4	46.6	100.0	236
Total, by head	34.6	30.8	17.6	17.1	100.0	37,929
Total, by Tropical Livestock Unit	37.6	44.5	12.5	5.5	100.0	4,901

Source: Author's computation using GHS-Panel, wave 4 (2018/19)

This study considered feeding regimes under four scenarios in Nigeria: only grazing, mainly grazing with some cut-and-carry feeding, mainly feeding with some grazing, and only feeding (zero-grazing). Table 5.1 shows the percentage of each type of livestock reported in the survey that was fed using a particular feeding regime.

Grazing is a critical part of how most livestock obtains the feed they require—over 80 percent of animals on a Tropical Livestock Unit basis engage exclusively or primarily in grazing. Close to 90 percent of cattle and 65 percent of sheep and goats do so. On a TLU basis, somewhat more animals receive some feed in addition to grazing than are exclusively grazed.

Production methods for sheep and goats vary from extensive, low-input technology systems based on grazing only in areas with low population pressure, to more intensive feeding regimes involving the feeding of confined animals (zero-grazing) in intensively cultivated parts of Nigeria. In the semi-arid and sub-humid zones, pastoralists and agropastoralists keep sheep and goats as part of their cattle herds. Consequently, sheep and goats are more likely to rely on any of the four feeding regimes than are other livestock types, which tend to be more likely to rely either on grazing or on feeding, but not both.

Poultry production and pig production commonly is based on the only feeding (zero-grazing) regime as well as the feeding with some grazing regime. It is

common for poultry in backyard flocks to scavenge (graze) during the day, while when housed at night they are fed with domestic food scraps. The grazing of pigs is not common. Rather, they are fed harvested fodder and concentrates with some grazing or fed fodder and concentrates only. Pigs generally are housed in household compounds, so they commonly receive some domestic feed scraps as part of their feed.

5.2 DESCRIPTIVE STATISTICS FOR KEY EXPLANATORY VARIABLES USED IN THE STUDY

Table 5.2 presents descriptive statistics for the explanatory variables used in the econometric analyses. These are unweighted statistics drawn from the sample of 1,965 livestock-producing households in the GHS-Panel, wave 4 data set.

Table 5.2. Descriptive statistics of key explanatory variables

Variables	Mean	Standard deviation	Observations
Male-headed household, 0/1	0.869	0.337	1,936
Age of head of household, years	50.7	14.7	1,936
Educational level of head of household, years	7.0	5.60	1,385
Household size, number of persons	7.35	3.91	1,965
Access to credit, 0/1	0.166	0.373	1,965
Access to extension, 0/1	0.201	0.400	1,965
Farm size, square meters	14,780	20,279	1,786
Urban household, 0/1	0.129	0.336	1,965
Animals owned, total	8.86	17.00	4,282
Total animals owned, TLU	1.14	2.99	4,282
Ruminant, 1/0	0.652	0.476	4,282
Total annual livestock and livestock product sales, Naira	143,592	376,420	4,282
Live animal sales in last year, value, Naira	48,476	197,529	1,306
Slaughtered animals in last year, value, Naira	20,336	41,988	77
Total value of slaughtered and live animals, Naira	15,151	112,242	4,282
Earnings from providing services with livestock in last year, Naira	52,542	64,990	307
Earnings from dung or droppings in last year, Naira	20,703	47,632	69
Total revenue, Naira	163,914	438,511	4,282
Animals purchased in last year, value, Naira	50,978	457,640	666
Feed costs in last year, Naira	27,393	262,978	1,406
Labor costs in last year, Naira	53,796	132,479	142
Compensation costs in last year, Naira	6,001	4,956	81
Vaccination costs in last year, Naira	4,520	8,361	1,480
Water costs in last year, Naira	3,039	4,574	136
Other livestock-related costs in last year, Naira	6,719	14,549	247
Total cost, Naira	20,867	255,859	4,282
Animals milked in last 12 months, number	5.37	4.04	159
Total milk output in last year, liters	1,724	2,921	159
Total milk value in last year, Naira	347,399	584,521	159
Total eggs laid in last three months, number	324	5,383	879
Value of eggs laid in last three months, Naira	16,178	269,138	879
Animal housing inside house, 0/1	0.399	0.490	4,282
Livestock deaths from diseases in last year, number	7.8	134.7	888
Incidence of disease outbreak, 0/1)	0.207	0.405	4,282

Source: Author's calculations using GHS-Panel, wave 4 (2018/19)

Note: 1,965 households in the dataset reported owning livestock. 4,282 animals were reported owned by these households.

5.3 FACTORS INFLUENCING THE CHOICE OF LIVESTOCK FEEDING REGIME

Choosing a feeding system for one's livestock requires several considerations. These are explored in the multinomial regression model, for which the results are presented in Table 5.3. The model passed the minimum requirement for robustness. The choice of each alternative also is independent of other alternatives, meaning that the Independence of Irrelevant Alternatives assumption has not been violated in the MNL analysis.

Findings from the analysis show that the level of education of the head of the livestock-producing household was negatively related to the log-likelihood of households' choice of using only grazing, mainly grazing with some feeding, or mainly feeding with some grazing. The only feeding (zero-grazing) feeding regime is the base category for the analysis. These results indicate that an additional year of education for the head of a livestock-producing household will decrease the likelihood of using only grazing, grazing with some feeding, or mainly feeding with some grazing relative to only feeding (zero-grazing). This is in agreement with Idrissou et al. (2020) who observed that educated farmers prefer adopting other strategies to transhumance, such as feeding concentrates and the growing of forage fodder. Education leads to an increase in knowledge about the various feeding regimes (Alfredo 2014). Farmers with more education can better take into account the advantages of the various livestock feeding regimes they might employ to prevent conflict between them and other farmers.

Table 5.3. Determinants of choice of livestock feeding regimes, multinomial logit analysis

Variables	Only grazing		Mainly grazing with some feeding		Mainly feeding with some grazing	
	Coefficient	**Marginal effects**	**Coefficient**	**Marginal effects**	**Coefficient**	**Marginal effects**
Age of household head, years	0.0078	0.0023	-0.0027	-0.0011	-0.0053	-0.0012
	(0.0052)	(0.0024)	(0.0052)	(0.0014)	(0.0055)	(0.0014)
Male household head, 0/1	-0.2902	-0.1093	0.5601*	0.1615	-0.1799	-0.0498
	(0.2624)	(0.1267)	(0.2987)	(0.1602)	(0.2871)	(0.0693)
Education of household head, years	-0.0519***	0.0011	-0.0757***	-0.0076	-0.0505***	0.0011
	(0.0123)	0.0180	(0.0121)	(0.0136)	(0.0128)	(0.0137)
Household size, members	-0.0314*	-0.0029	-0.0125	0.0035	-0.0344*	-0.0028
	(0.0183)	(0.0046)	(0.0176)	(0.0122)	(0.0192)	(0.0032)
Land size, sq. meters	5.34e-06	-1.37e-06	0.0000***	3.18e-06***	6.05e-06	-8.53e-07
	(4.52e-06)	(0.0000)	(4.27e-06)	(0.0000)	(4.70e-06)	(0.0000)
Ruminant, 0/1	-0.4606***	-0.1852	0.4847***	0.1329	0.4076***	0.0628
	(0.1373)	(0.2224)	(0.1380)	(0.0960)	(0.1458)	(0.0431)
Animals housing, 1 if inside house/0 outside	-0.6444***	-0.1188**	-0.3371**	-0.0377	0.3396**	0.1336
	(0.1409)	(0.0540)	(0.1356)	(0.0534)	(0.1441)	(0.1926)
Livestock suffer from disease, 0/1	0.2023	-0.0218	0.2876*	0.0043	0.4563**	0.0422
	(0.1754)	(0.0990)	(0.1716)	(0.0963)	(0.1793)	(0.0300)
Access to extension, 0/1	0.0071	0.0091	-0.0346	-0.0045	-0.0539	-0.0069
	(0.1596)	(0.0281)	(0.1563)	(0.0243)	(0.1666)	(0.0200)
Access to credit, 0/1	0.0735	0.0572	-0.3574**	-0.0880	-0.0166	0.0203
	(0.1652)	(0.0974)	(0.1690)	(0.0584)	(0.1741)	(0.0510)
Cost of labor hired by household, Naira	1.2386**	0.2186***	0.4245	-0.0872	0.2303	-0.0824
	(0.4982)	(0.0703)	(0.5012)	(0.2432)	(0.5563)	(0.1627)
Other livestock-related costs, Naira	-0.1216	0.0234	-0.6991**	-0.1891	0.4587	0.1465
	(0.3797)	(0.0961)	(0.3539)	(0.1228)	(0.4341)	(0.1984)

Variables	Only grazing		Mainly grazing with some feeding		Mainly feeding with some grazing	
	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
Cost of compensation for damages, Naira	14.2938	0.1382	14.1968	0.1235	12.9443	-0.1358***
	(486.5890)	(0.0749)	(486.5890)	(0.0739)	(486.5892)	(0.0424)
Urban, 0/1	-1.0684***	-0.1457***	-0.3621*	0.0347	-0.2141	0.0581
	(0.2287)	(0.0540)	(0.2189)	(0.2605)	(0.2257)	(0.2101)

Note: Only feeding (zero-grazing) is the base outcome. ***, **, and * indicate 1%, 5%, and 10% significant levels, respectively. Figures in parentheses are standard errors
Number of observations: 2,674 livestock feeding system by animal type; Log-likelihood: -3308.9; LR $Chi^2(42)$: 452.10. Prob > Chi^2: 0.0000; Pseudo R^2: 0.0639.

Similarly, the household size of the household was negatively related to the likelihood of using only grazing or using mainly feeding with some grazing. This may be a result of the diverse contributions of alternative approaches to feed management that larger households can employ. This finding is in line with that of Belay et al. (2017) who found that household size had a favorable and substantial effect on improved animal feed regime adoption. Menghistu et al. (2021) concluded that larger households can draw on more diverse sources of knowledge in determining which feed regime is optimal to use for their livestock.

Land size was positively related to the probability of a choice of mainly grazing with some feedings. This is in line with Paul et al. (2021) who similarly found that farming households with larger landholdings are more likely to use grazing with some feeding. Land area is linked to this specific livestock feeding regime directly through access to grazing and forage resources and indirectly through crop residues and grain produced on the land.

An increase in the use of hired labor will lead to a 0.22 unit increase in the likelihood of choosing to use only grazing. However, there was a negative relationship between access to credit and the choice of mainly grazing with some feeding. This implies that an increase in access to credit by livestock households will lead to a 0.36 unit decrease in the likelihood of a choice of using mainly grazing with some feeding. Another implication of the result is that farmers' financial resources and ability to care for their livestock are a function of the choice of their livestock feeding regime. This implication is in line with Gedefaw et al. (2018). Similarly, the level of other livestock-related costs also had a negative and significant effect on the probability of using mainly grazing with some feeding. By implication, the result shows that an increase in other related costs to livestock production incurred by livestock households will lead to a 0.70 unit decrease in the likelihood of using this choice relative to feeding only (zero-grazing).

The results of the ordered logit analysis are presented in Table 5.4 using a latent dependent variable disaggregated by the level of technology used in the four feeding regimes. This analysis shows that the age of the head of the livestock-raising household, the level of education of the household head, types of animals, livestock housing system, use of hired labor, cost of damages paid, and whether the household is urban had a significant influence on the choice of feeding regimes. For example, the results of the marginal effects in Table 5.4 show that a one-year decrease in the age of the head of the livestock-producing household is expected to lead to 0.0014 and 0.0001 increases in the probability of adopting only grazing and mainly grazing with some feeding, respectively, while decreasing the probability of using mainly feeding with some grazing by 0.0008 and only feeding (zero-grazing) by 0.0007.

The level of education of the household head decreases the probability of choosing the only grazing and mainly grazing with some feeding regimes and increases the probability of choosing to employ the mainly feeding with some grazing and the only feeding (zero-grazing) regimes, both by 0.002. This relationship may be connected to education being anticipated to improve the household's capacity for acquiring, interpreting, and understanding information necessary to make wise decisions on what livestock feeding regime to use with their animals (Getachew et al., 2014). Knowledgeable farmers are more inclined than their counterparts to make proactive decisions regarding their livestock feeding options (Alemayehu and Bewket, 2017; Belay et al., 2017; Gedefaw et al., 2018).

Table 5.4. Determinants of the choice of livestock feeding regimes, ordered logit analysis

	Coefficient	Only grazing marginal effect	Grazing with some feeding marginal effect	Feeding with some grazing marginal effect	Only feeding marginal effect
Age of household head, years	-0.0070***	0.0014***	0.0001*	-0.0008***	-0.0007***
	(0.0027)	(0.0006)	(0.0001)	(0.0003)	(0.0003)
Male household head, 0/1	0.2115	-0.0451	-0.0004	0.0250	0.0206
	(0.1613)	(0.0355)	(0.0024)	(0.0189)	(0.0146)
Education of household head, years	0.0202***	-0.0042***	-0.0003**	0.0024***	0.0021***
	(0.0067)	(0.0014)	(0.0002)	(0.0008)	(0.0007)
Household size, members	0.0082	-0.0017	-0.0001	0.0010	0.0009
	(0.0097)	(0.002)	(0.0002)	(0.0011)	(0.0010)
Land size, sq. meters	-8.6E-07	1.76E-07	1.45E-08	-1E-07	-8.9E-08
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ruminant, 0/1	0.4797***	-0.1009***	-0.0029	0.0563***	0.0476***
	(0.0791)	(0.0171)	(0.0028)	(0.0094)	(0.0076)
Animals housing, 1 if inside house/0 outside	0.5691***	-0.1143***	-0.0134***	0.0662***	0.0615***
	(0.0743)	(0.0146)	(0.0039)	(0.0088)	(0.0085)
Livestock suffer from disease, 0/1	0.0396	-0.0081	-0.0007	0.0047	0.0042
	(0.0857)	(0.0174)	(0.0018)	(0.0101)	(0.0090)
Access to extension, 0/1	-0.0185	0.0038	0.0003	-0.0022	-0.0019
	(0.0859)	(0.0177)	(0.0013)	(0.0102)	(0.0089)
Access to credit, 0/1	-0.0412	0.0085	0.0006	-0.0049	-0.0042
	(0.0934)	(0.0194)	(0.0012)	(0.0110)	(0.0095)
Cost of labor hired by household, Naira	-0.7121***	0.1630***	-0.0250	-0.0804***	-0.0575
	(0.2039)	(0.0501)	(0.0174)	(0.0210)	(0.0126)
Other livestock-related costs, Naira	0.0929	-0.0191	-0.0016	0.0110	0.0097
	(0.1519)	(0.0312)	(0.0026)	(0.0180)	(0.0158)
Cost of compensation for damages, Naira	-0.5858**	0.1325**	-0.0162	-0.0671***	-0.0492***
	(0.2468)	(0.0599)	(0.0176)	(0.0264)	(0.0164)
Urban, 0/1	0.8056***	-0.1401***	-0.0527	0.0852***	0.1076***
	(0.1394)	(0.0120)	(0.0153)	(0.0123)	(0.0231)
/cut1:	-0.1133	/cut2:	1.4822	/cut3:	2.8009
	(0.3765)		(0.3778)		(0.3810)

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively. Figures in parentheses are standard errors. Number of observations: 2,674 livestock feeding system by animal type; Log-likelihood: -3451.4; LR $Chi^2(42)$: 167.02. Prob > Chi^2: 0.0000; Pseudo R^2: 0.0236.

As the cost of compensation by livestock-producing households increases, this is associated with the probability of the use of grazing increasing by 0.132, while the probability of use of mainly feeding with some grazing declines by 0.07 and only feeding (zero-grazing) declines by 0.05. This result is expected, as livestock fed through grazing alone are more likely to damage farmers' crops, requiring compensation to be paid to the affected farmers, if caught. This issue has been a major point of contention and conflict between pastoralists and crop farmers in Nigeria and requires urgent attention.

5.4 COSTS OF FEED AND OTHER LIVESTOCK INPUTS BY FEEDING REGIME IN NIGERIA

Table 5.5 shows the results of the analysis of the cost of feed by livestock types and feeding regimes in Nigeria. It is not surprising to discover that the average feed cost is highest (₦220,403) for poultry production under only feeding (zero-grazing). The only grazing feeding regime category does not feature in Table 5.5, as no livestock households using this feeding regime reported any expenditures on feed.

Table 5.5. Feed costs for livestock production by livestock types and feeding regimes, average per household, Naira

	Mainly grazing with some feeding	Mainly feeding with some grazing	Only feeding (zero-grazing)	Overall
Cattle	26,6579	19,592	16,828	21,019
	(29,230)	(31,356)	(22,846)	(30,534)
Sheep and goats	104,32	5,515	12,210	8,413
	(9,517)	(5,694)	(16,064)	(9,923)
Poultry	8,417	3,848	220,403	75,523
	(16,959)	(8,015)	(957,033)	(552,100)
Pigs	6,786	22,750	25,208	19,425
	(10,494)	(31,637)	(31,553)	(27,353)
Donkeys and horses	42,000	3,936	25,500	13,769
	(57,472)	(2,658)	(14,849)	(26,617)
Camels	--	4,000	8,400	6,640
		(1,414)	(6,023)	(4,944)
Other	30,000	3,000	--	12,000
	(0)	(2,828)		(15,716)
Total	13,573	11,109	98,351	27,393
	(19,154)	(21,962)	(618,094)	(262,978)

Note: Values in parentheses are standard deviations.
Source: Author's computation using GHS-Panel, wave 4 (2018/19)

Average annual costs for water for livestock and for veterinary services are relatively low under all the feeding regimes at less than ₦5,000 on average (Table 5.6). However, labor costs are much higher across all feeding regimes, except the mainly feeding with some grazing regime. Labor costs for cattle under all feeding regimes generally were higher than they were for other types of animals. However, labor costs are highest for poultry that is intensively produced under the only feeding (zero-grazing) feeding regime. The close regular attention that must be paid to poultry under such intensive production conditions is labor demanding, so the labor costs reflect this.

Table 5.6. Annual costs of water, labor, and veterinary service for livestock production by feeding regimes and livestock types, average per livestock-producing household, Naira

	Water	Labor	Veterinary services	Water	Labor	Veterinary services	Water	Labor	Veterinary services
	Only grazing			Mainly grazing with some feeding			Mainly feeding with some grazing		
Cattle	2,050	37,783	9,539	7,220	44,572	6,914	2,520	7,613	0
	(1,583)	(35,579)	(11,386)	(7,769)	(53,316)	(9,139)	(1,073)	(4,223)	(5,181)
Sheep & goats	1,438	--	2,375	1,855	7,814	2,127	1,611	4,880	2,609
	(775)		(2,555)	(1,577)	(8,476)	(1,761)	(1,369)	(3,735)	(3,610)
Poultry	1,400	9,391	725	--	--	822	750	--	--
	(283)	(9,341)	(1,034)			(977)	(672)		
Pigs	--	--	--	--	--	10,917	5,00--	--	4,075
						(19,184)			(2,560)
Donkeys & horses	--	--	--	--	--	--	--	--	6,000 --
Camels	--	--	3,000 --	--	--	5,000 --	--	--	--
TOTAL	1,724	32,398	5,345	4,724	40,354	4,536	1,680	6,562	2,958
	(1,230)	(34,102)	(8,808)	(6,330)	(51,553)	(7,328)	(1,408)	(4,119)	(3,905)
	Only feeding (zero-grazing)			All feeding regimes					
Cattle	6,075	--	2,847	4,861	38,932	7,278			
	(8,379)		(2,405)	(6,191)	(44,994)	(9,400)			
Sheep & goats	3,667	5,000 --	2,639	1,817	7,808	2,377			
	(2,338)		(3,377)	(1,514)	(7,906)	(2,776)			
Poultry	4,568	356,444	10,911	3,029	356,444	3,232			
	(7,843)	(411,605)	(23,199)	(6,147)	(411,605)	(11,800)			
Pigs	--	--	6,150	5,000 --	--	7,278			
			(8,274)			(12,053)			
Donkeys & horses	--	--	--	--	--	--			
Camels	--	--	--	--	--	4,000			
						(1,414)			
TOTAL	4,442	321,300	6,211	3,039	53,796	4,520			
	(6,333)	(403,665)	(15,533)	(4,574)	(132,479)	(8,361)			

Note: Values in parentheses are standard deviations.

Source: Author's computation using GHS-Panel, wave 4 (2018/19)

5.5 GROSS MARGIN ANALYSIS OF LIVESTOCK PRODUCTION BY FEEDING REGIMES IN NIGERIA

Results of the average gross margins of the livestock production of livestock-producing households are presented by different feeding regimes in Table 5.7. Total revenues are summed from the value of actual sales of live and slaughtered animals, payments received for services provided by livestock, sales of dung and droppings, sales of milk and processed milk, and sales of poultry eggs. Total variable costs are calculated as the sum of the costs of purchasing livestock, total vaccinations, purchasing water, purchasing feed, wages for hired labor, compensation costs, and other livestock-related costs. The gross margin is the difference between total revenues and total variable costs.

The grazing with some feeding regime is shown to provide the highest gross margins, with average gross margins per head of ₦36,399, followed by the only grazing regime with average gross margins of ₦13,714. The feeding only (zero-grazing) regime was estimated to provide a loss on average of ₦28,881 per head.

Table 5.7. Results of gross margin analysis on livestock production in Nigeria by feeding regime, average per head in Naira

	Only grazing	Mainly grazing with some feeding	Mainly feeding with some grazing	Only feeding (zero-grazing)	All feeding regimes
Cattle	51,938	110,379	14,513	-31,902	74,891
Sheep and goats	6,272	8,828	3,111	-1,111	5,372
Poultry	3,950	1,602	90	-7,267	-7,454
Pigs	10,114	13,644	13,847	4,620	9,409
Donkeys and horses	3,812	8,387	-16,700	-15,333	1,100
Camels	108,500	-60,667	-	-103,400	-34,400
Total	13,714	36,399	3,720	-28,881	14,605

Source: Author's computation using GHS-Panel, wave 4 (2018/19)

5.6 LIVESTOCK PRODUCTIVITY AND ITS DETERMINANTS IN NIGERIA

Table 5.8 presents the average value-cost ratios for livestock products associated with cattle, sheep and goats, and poultry. The average milk value-cost ratio for livestock-producing households that only graze their cattle or that mainly graze them is 0.81 for both, somewhat higher than the value-cost ratio for milk from cattle that are mainly fed with some grazing. The use of only grazing (scavenging) is somewhat more productive for poultry farmers producing eggs than the other feeding regimes. Livestock dung and dropping productivity is higher for sheep and goats and poultry than for cattle.

Table 5.8. Productivity of livestock products by feeding regimes for cattle, sheep and goats, and poultry, average value-cost ratio on a TLU basis

Feeding regime	Livestock type	Milk	Egg	Dung and dropping	Services provided
Only grazing	Cattle	0.81; (0.28)	--	0.23; (0.43)	0.79; (0.37)
	Sheep and goats	0.64; (0.28)	--	0.51; (0.46)	--
	Poultry	--	0.82; (0.30)	--	--
Mainly grazing, some feeding	Cattle	0.81; (0.30)	--	0.28; (0.29)	0.87; (0.28)
	Sheep and goats	--	--	0.37; (0.55)	--
	Poultry	--	0.79; (0.31)	--	--
Mainly feeding, some grazing	Cattle	0.59; (0.41)	--	0.05; (.)	0.81; (0.35)
	Sheep and goats	--	--	0.72; (0.37)	--
	Poultry	--	0.78; (0.32)	--	--
Only feeding (zero-grazing)	Cattle	--	--	0.15; (.)	--
	Sheep and goats	--	--	0.20; (.)	--
	Poultry	--	0.76; (0.35)	0.48; (0.43)	--
Total	Cattle	0.79; (0.31)	--	0.23; (0.32)	0.84; (0.32)
	Sheep and goats	0.64; (0.28)	--	0.62; (0.41)	--
	Poultry	--	0.80; (0.31)	0.60; (0.43)	--

Source: Author's computation using GHS-Panel, wave 4 (2018/19)
Note: Productivity is defined as the total value of output to inputs in Tropical Livestock Unit (TLU) equivalents. Values in parentheses are standard deviations.

It is important to note that when all the animal products are pooled together and values and costs are computed on a TLU basis, the grazing only feeding regime has the highest ratio of output value to input costs compared to the other feeding regimes (Table 5.9). Farm animals turn feed into added-value products, such as milk, meat, and eggs. Feed affects livestock productivity and profitability (Makkar 2016a). Lack of availability and access to quality feed at low cost continues to be the most important limitation to productive and profitable livestock production in Nigeria.

Table 5.9. Overall productivity of livestock product production by feeding regimes for cattle, sheep and goats, poultry, and all livestock, average value-cost ratio on a TLU basis

	Only grazing		Mainly grazing with some feeding		Mainly feeding with some grazing		Only feeding (zero-grazing)		All feeding regimes	
	Mean value	Observations	Mean value	Observations	Mean value	Observations	Mean value	Observations	Mean value	Observations
Cattle	1.247	188	1.761	413	0.504	106	0.103	29	1.383	736
Sheep & goats	0.422	191	0.538	435	0.305	353	0.151	149	0.394	1,128
Poultry	5.039	127	0.271	168	0.199	160	0.129	123	1.268	578
Total	1.882	510	0.980	1,039	0.312	637	0.129	327	0.883	2,513

Source: Author's computation using GHS-Panel, wave 4 (2018/19)
Note: Productivity is defined as the total value of output to input in Tropical Livestock Unit equivalents. "Total" row values are computed using the value of outputs and costs of inputs for all livestock, including pigs, donkeys and horses, camels, and other livestock, in addition to cattle, sheep and goats, and poultry.

Table 5.10 presents results from the OLS regression analysis on factors influencing the productivity of livestock in Nigeria. For the model, productivity is proxied by the value-cost ratio.

The coefficient of determination (R-squared) of 0.9305 indicates that much of what contributes to livestock productivity is explained by the explanatory variables included in the model. Eleven out of the 16 specified independent variables are found to be significant factors influencing livestock productivity. The education level of the head of the livestock-producing household, household size, level of sales of animal dung, whether any of the household's livestock are ruminants, the total number of vaccinations, the level of expenses on feeds, and the level of expenses on water purchased for livestock in the past year are positively associated with livestock productivity levels in Nigeria. This implies that the higher or increase in the number/size of these variables will lead to an increase in productivity. Several explanatory variables have significant negative coefficients: the age of the head of the livestock-producing household, the dominant housing system for livestock, the level of total sales from slaughtered and live livestock, and whether a household has access to credit.

Access to credit by livestock households has a significant negative coefficient contrary to the *a priori* expectation (Table 4.2). This implies an inverse relationship between farmers' access to credit. The reason for the negative association with livestock productivity might be due to an unreasonably small amount of credit being given to farmers or to scheduled repayment periods not coinciding with periods of positive cash flow from their livestock for livestock-producing households.

Table 5.10. Determinants of livestock productivity (value cost ratio) for livestock-producing households in Nigeria

Variables	Coefficients	Standard Error
Age of head of household, years	-2.0147**	0.8235
Level of education of head of household, years	0.7042**	0.2996
Household size, number of persons	2.0063***	0.4804
Farm size, square meters	-0.0854	0.1259
Ruminant, 1 if yes/0 if no	1.6052***	0.4057
Animals housed inside house, 1 if inside house/0 if outside	-2.1467***	0.46097
Livestock owned, TLU	-0.2954	0.1972
Slaughtered livestock in past year, TLU	-1.2284***	0.2144
Livestock deaths from disease in past year, TLU	0.2543	0.1577
Livestock dung, total annual sales of livestock dung, Naira	2.7624***	1.1089
Vaccinations in past year, number	0.3403***	0.1281
Access to extension, 1/0	-0.0412	0.4475
Access to credit, 1/0	-1.3062***	0.4173
Feedstuff purchased in past year, total cost, Naira	1.9870***	0.3860
Water purchased for livestock in past year, Naira	1.5652***	0.4218
Intensive (zero-grazing) feeding regime, 1 if intensive/0 if not	1.1211	0.7185
Constant	11.1203	2.8133

Prob > F: 0.0003; R-squared: 0.9305; Adj R-squared: 0.8295.
Source: Author's computation using GHS-Panel, wave 4 (2018/19)
Note: *** and ** represent 1% and 5% level of significance, respectively.

The results, in addition, suggest two important points. First, the coefficients (βs), represent elasticities. These suggest that for livestock-producing households if the education of the head, the size of the household, the incorporation of ruminants in the household's livestock holding, sales of animal dung, the number of vaccinations received, the amount spent annually on feed, and the amount spent on water for livestock annually each increased by 10 percent, these changes would result in an increase in livestock productivity by 7.0, 20.0, 16.1, 27.6, 3.4, 19.9, and 15.7 percent, respectively. Second, the sum of the elasticities of all the coefficients is 5.23, which is greater than 1.0. This suggests that the livestock enterprises of these households have increasing returns to scale. These results provide better opportunities for the area farmers and investors in Nigeria's livestock sector to invest more in the sector.

6. SUMMARY AND CONCLUSION

6.1 SUMMARY OF FINDINGS

Sourcing adequate feed for livestock, especially cattle, requires land that may also be used for the production of food or cash crops. This partly explains the poor uptake of forage crops in Nigeria. The small number of animals on the farms of smallholder farming households in Nigeria suggests that investments in improved feed technologies will result in relatively small returns. A gross margin analysis by animal type and feeding regimes in Nigeria revealed that the cost of feed was relatively high relative to the returns obtained.

The average milk productivity of farmers who only graze their cattle exceeds (value-cost ratio of 0.81) that of farmers using other feeding regimes. For eggs, poultry farmers that mainly use grazing (scavenging) with some feeding employ the most productive feeding regime (0.79), followed closely by the regime involving mainly feeding with some grazing (0.78). Across all livestock type and feeding regime combinations, livestock dropping productivity is highest for sheep and goats (0.72) under the regime involving mainly feeding with some grazing.

Factors such as the level of education of the head of the livestock-producing household, household size, level of sales of animal dung, whether animals are ruminants, the total number of vaccinations received in the past year, and expenses in the past year on feedstuffs and on water for livestock all are significant direct drivers of increased livestock productivity, as proxied by value-cost ratios. Additional influences on the choice by livestock-producing households of which feeding regime to adopt include whether livestock are housed in the household dwelling, the use of hired labor, and the level of damages paid to farmers as compensation for crop damage by a household's livestock.

6.2 CONCLUSIONANDRECOMMENDATIONS

Livestock farmers in Nigeria have several choices of feeding regimes. However, the lack of consistent policies related to the livestock sector in Nigeria remains a major constraint to improved feed regime development in the sector. There is a need for an effective policy and planning framework that will optimize development resources and provide the necessary support and economic environment to allow the country's livestock feed resources to efficiently be put into productive use. Escalating cattle, sheep, and goat populations operating on only grazing are putting an increasing strain on open-access feed resources, possibly leading to irreversible resource degradation in extreme cases. The conflict between communal ownership of land and private ownership of livestock—the classic "tragedy of the commons" scenario—has resulted in a disequilibrium that continues to threaten the ecological stability of fragile environments across Nigeria.

Nigerian ruminant production is predominantly done under extensive conditions, as opposed to using sown pasture or feed concentrates obtained from rangeland, crop residues, or collected fodder. One result of this reliance on extensive grazing is a lack of any records on livestock feed use. Without the ability to readily recognize where animals or their feed have come from, it is difficult to respond effectively when problems are found within livestock feed systems or with animal-source foods across Nigeria. This is particularly important for food safety. To ensure the safety of animal-source foods, traceability of feed and feed ingredients throughout the feed chain is essential.

Another critical constraint to the development of the Nigerian livestock feed sub-sector is that livestock farmers primarily depend on feeds from millers, but those feeds do not meet the necessary quality standards. This constraint may be connected to Nigerian livestock trade policies which selectively ban the importation of feed components and some livestock products. The production of feed ingredients that would be affordable for livestock-producing households is paramount—particularly those that make minimal use of chemical additives and use locally available feed resources. Alternative feed resources should be properly utilized and fully exploited. Finally, research to improve the nutritional quality of low-nutrient feeds, if successful, will provide important benefits for the many livestock-producing households that rely on such feeds for their animals.

Feed improvement should not be seen in isolation, but rather be assessed as part of larger livestock value chains. Decisions on the strategic steps that must be taken to expand the availability of high-quality livestock feed at prices that are affordable for smallholder livestock producers should involve all stakeholders in the livestock sector, including the livestock-producing households themselves. Decision-makers can use the insights generated by research, such as that presented here, to prioritize feeding technologies and target investments to expand their use.

Transformation of the livestock sector in Nigeria supported by an effective livestock feed sub-sector will require the promotion of efficient crop-livestock systems that are integrated with large-scale modern feed mills to reduce feed production costs, livestock feed value chain development, and the institution of feed safety standards, among others. Similarly, consideration should be given to providing subsidies on the price of feed to reduce the cost of feeding and increase the gross margins realized by livestock-raising households. Lower feed costs likely will enable greater adoption of zero-grazing, which will enhance milk productivity. These policies will require an expansion of fodder production in Nigeria and the facilitation of trade in feed concentrates.

The study on feed resource development in Nigeria is limited by a lack of consistent data on livestock feed inventories and use. The following are recommended as focal points for future research:

- Examine developments in the use of unconventional feed ingredients for livestock in Nigeria;
- Conduct a scoping review of feed interventions appropriate for small-scale livestock-raising households;
- Better trace seasonal variability in livestock feed availability across Nigeria by conducting repeated feed measurements across the year;
- Assess the quality and amount of both existing and potential feed resources for improving livestock productivity in Nigeria;
- Examine the likely impact of switching livestock feeding regimes on animal growth performance in Nigeria; and
- Better understand the relationship between the quality and value of Nigerian livestock and the quality and cost of the feed they receive.

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8. ANNEXES

Annex Table 1. Feed improvement technologies or promotion approaches for smallholder-based livestock production systems

Category	Technology	Description of technology	References
Feed quality enhancement	Biological treatment of crop residues	Treating of crop residue with enzymes or biological inoculants	Li *et al.*, 2010
	Chemical treatment of crop residues	Treating crop residues with urea and spraying or soaking in dilute acid and alkaline solutions	Sarnklong et al., 2010 Aruwayo et al., 2013 Aruwayo et al., 2019 Mubi et al., 2008
	Forage crop breeding	Selective breeding of forages for developing high-yielding and better-quality forage	den Hartog & Sijtsma, 2013 Lamidi & Ologbose, 2014
	Reducing the particle size of crop residues	Chopping and grinding crop residue	Hamed & Elimam, 2009
Enhancement of nutritional status of animal	Balanced and or phased rationing or ration formulation	Feeding a balanced ration formulated to meet the nutrient requirements of the animal or targeting rations to animals at specific levels of performance	Garg *et al.*, 2013
	Supplementation with feed additives	Enzymes, probiotics, yeast, and other products that are added to feeds to help improve the ability of an animal to digest and assimilate feeds.	Ramirez, 2014
	Supplementation with multi-nutrient blocks	Providing animals on low-quality diets with multi-nutrient blocks that provide needed supplementary nutrients	Makkar *et al.*, 2007
	Supplementation with concentrates	Supplementing low-quality diets with nutritious concentrates	Selemani & Eik, 2016
Feed productivity or availability improvement	Conservation-based forage development	Introduction of forage plants in natural resource conservation structures, such as gullies and terraces, which can serve as a source of feed, while reinforcing soil and water conservation	Mengistu *et al.*, 2017
	Silvopastures and agroforestry	Using pasture, farmlands, and degraded areas for growing trees that synergistically impact pasture productivity.	Balehegn *et al.*, 2014b
	Food-feed crop integration	Intercropping or alley farming to exploit synergies in pest protection and soil and water conservation, while increasing the availability of forage	Lenné *et al.*, 2003
	Use of underutilized locally available feed resources	Use of underutilized locally available feed resources, including indigenous fodder species and local brewery residues.	Balehegn et al., 2014a
	Improved forage plants	Introducing higher yielding and higher-quality forage species including legumes.	Foster *et al.*, 2009; Mengistu *et al.*, 2017
	Protected grazing, including enclosure zero-grazing, cut and carry, rotational grazing, deferred grazing	Protection or prescribed grazing on range and grazing lands to protect degraded areas and allow for natural regeneration of forage and improvement of forage production	Yayneshet et al., 2009
Feed quality maintenance, preservation, or conserva-tion	Using preservatives	Using microbes or chemicals that inhibit spoilage organisms and preserve the quality of fresh fodder	Wang *et al.*, 2018
	Correct timing of forage harvesting	Harvesting forages when the nutritional value and biomass yield are optimal	Makkar, 2016b
	Silage making	Storing fresh fodder under anaerobic conditions to preserve the quality	Titterton & Bareeba, 2000
	Haymaking	Reducing loss of nutrients from green fodder by drying	Klinner & Shepperson, 1975

Source: Compiled from different sources

Annex Table 2. Glossary of key terms related to livestock production and livestock feed

Agro-pastoralists	Farmers who also raise livestock and whose animal-keeping practices are similar to those of pastoralists, including transhumance.
Animal feed	Food given to domestic animals, especially livestock, in the course of animal husbandry.
Animal protein concentrates	Mixtures of meat and bone meals, fish meal, blood meal, feather meal, milk products such as whole milk, whey, skim milk, and some offal.
Commercial farms	These are specialized enterprises that maintain large homogenous herds, some permanent employees, and produce only for the market.
Extensive livestock production	Extensive livestock production is based on the use of existing natural resources (e.g., water, pastures), without significant improvements to the general habitat
Feeds	Naturally occurring ingredients or materials fed to animals to sustain them.
Feedstuff	This is a component of a ration or a diet that serves one or more functions. Examples are forages, concentrates, supplements, and additives.
Fodder	refers to food given to the animals (including plants cut and carried to them), rather than that which they forage for themselves
Forage	These are those crops grown mainly for the feeding of livestock or any vegetative part of a plant that is eaten by animals
Grassland-based Livestock Production System	Areas where more than 10% of dry matter fed to animals is produced at the farm and annual stocking rates are less than 10 livestock units per hectare of agricultural land
Grazing	Grazing is a method of feeding in which herbivores or ruminants feed on plants such as grasses and other multi-cellular organisms such as algae.
Grazing reserves	Areas set aside for the use of pastoralists and are intended to be the foci of livestock development
Grazing with supplementation system	In this system, the animals are housed and often released for grazing and to browse forages.
Landless Livestock Production System	Intensive/feedlot type system (defined as systems in which less than 10% of the dry matter fed to animals is farm-produced and where the annual stocking rates are above 10 livestock units per km^2
Livestock	Livestock refers to animals that are domesticated primarily for food
Livestock farming	Livestock farming is simply the management and breeding of livestock or farm animals to obtain their meat and products (milk, eggs, leather)
Mixed farmers	Farmers who also raise livestock.
Mobility	In the case of livestock production, mobility describes the seasonal or occasional movements of herds over shorter or longer distances.
Nomadism	Continuous movement of people with their herds. Very mobile production system, opportunistic movements according to pasture availability, often without own fields and without annual return to a fixed base.
Open grazing	The age-old practice of roaming about with animals in open fields, plains, and nearby bushes in search of pasture or food for the animals
Pastoral resources	Natural resources that allow the feeding of pastoral animals, including water, pastures, and salt licks.
Pastoralism	An economic system based on extensive livestock production, integrating various degrees of mobility of animals and/or people, encompasses nomadism, transhumance, and semi-transhumance.
Ranching	Ranches usually belong to a single owner and employ a minimum of laborers.
Smallholder livestock farmers	Livestock producers with limited resources
Transhumance	Livestock production system based on the seasonal movement of herds.

Source: Compiled by authors.

AKADEMIYA

Headquarters
Kicukiro/Niboye KK 341 St 22
KIGALI - RWANDA

Mailing address
P.O. Box 1855
kigali-contact@akademiya2063.org

Telephone
+250 788 318 315
+221 33 865 28 81

Website
www.akademiya2063.org

@AKADEMIYA2063

@AKADEMIYA2063

AKADEMIYA2063