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Animal Feed Policies and Feeding Practices in Ethiopia

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Contents

Abstract

Feed shortages, both in quantity and quality, are a major factor hindering the sustainable development of the livestock sectors in Ethiopia. This study assesses the availability and quality of animal feed in different livestock production systems, the feeding practices of smallholder livestock producers, and the policy actions adopted by the government to improve the availability and quality of animal feed in Ethiopia. The primary objective of this study is to identify development strategies to improve access to good-quality feed. The study is based on a desk review of the research literature and policy documents and key informant interviews to examine trends and gaps related to policy, strategies, and the establishment of an enabling environment for livestock feed development in Ethiopia. In addition, descriptive and inferential statistics, multinomial logit (MNL) models, and treatment effect models were employed to analyze the determinants of adoption of feeding regimes and their impact on milk productivity.

The results of the study show that livestock production systems in Ethiopia are largely mixed crop-livestock, pastoral, or agro-pastoral. Most are extensive in nature, relying on low levels of inputs and generating low levels of outputs. The quality, quantity, and feeding value of the major feed sources are primarily natural pasture or crop residues and are nutrient-poor, bulky, and of low density. The share of livestock producers using agro-industrial by-products and concentrates or improved forages remains negligible, with any use of such feeds concentrated in urban and peri-urban livestock production systems. The feeding regime employed by most livestock producers is only grazing (or scavenging for poultry) without supplementation of other feed types. Less than ten percent of livestock producers provide supplemental feed to their animals in addition to grazing. Very few feed their livestock using zero-grazing.

Investment to develop an adequate feed supply system for improving animal nutrition in Ethiopia would improve animal production and productivity and the livelihoods, income, and food and nutritional security of livestock producing communities. The study identified the major determinants of adoption of the various feeding regimes and milk productivity. Potential livestock feed investment options for various livestock production systems in Ethiopia were also identified. Transforming the feed industry and livestock sub-sector at large will require not only technological and knowledge-based interventions, but also institutional innovations and policy reforms. Efforts made so far in this regard have mostly been technology-push approaches, which lacked strategic marketing and value chain dimensions and have often been fragmented and inadequately implemented. Institutional innovations and policy support have generally been absent from these efforts. Tailor-made and context-specific technology packages and innovations, along with appropriate institutional and policy reforms, need to be designed and operationalized to ensure the development of the feed industry and the livestock sub-sector at large. Institutionalization of a secure livestock feed system will be necessary to make feed interventions effective in Ethiopia and elsewhere in the region.

Keywords: feed, fodder, Ethiopia, livestock, milk, productivity.

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1. INTRODUCTION

The livestock sector is an integral part of farming systems in all parts of Ethiopia. Livestock significantly contributes to rural livelihoods, the national economy, and foreign currency earnings (MoA and ILRI 2013). In 2017, livestock contributed 25.3 percent of Ethiopia's gross domestic product (GDP), 39 percent of the country's agricultural GDP (Shapiro et al. 2017), and about 20 percent of national foreign exchange earnings (World Bank 2017a). Livestock also has significant economic and social importance at the rural household level, both for highland smallholder farmers, lowland pastoralists, and agro-pastoralists. Their uses include being a major source of animal-source food, providing income through sales of live animals and livestock products, creating jobs in livestock husbandry, providing draught power for land preparation for crop production, offering means of transportation, providing export commodities through their manures supplying fertilizer for farmland and fuel (household energy), offering security in times of crop failure, and providing a means of wealth accumulation (Management Entity 2021). Livestock contributes to the livelihoods of between 60 and 70 percent of the Ethiopian population (Tegegne et al. 2013).

However, the productivity and economic contribution of the livestock sector is much below its potential due to various technical and non-technical constraints. These include the genetic makeup of the most common breeds of animals, sub-optimal animal husbandry practices, limited market and value chain integration, poor veterinary care, and poor nutrition and feed shortages (World Bank 2017b).

Among the technical constraints, inadequate feed supply, in terms of both quantity and quality, the high cost of purchased feed resources, and inefficient feed management and utilization of feed resources are the overriding production constraints limiting the realization of the full potential of livestock resources in Ethiopia (Tolera and Abebe 2007; Shapiro et al. 2017; Balehegn et al. 2020). Underfeeding and malnutrition limit the ability of an animal to reach its genetic potential, resulting in low birth weights, slow growth rates, high mortality rates, and low productive and reproductive performance (Shapiro et al. 2015). Despite these problems, smallholders' adoption of improved feed production and utilization practices remains low, partly due to lack of awareness about the potential merits of these practices, technology mismatches within local contexts, and market competitiveness (Baltenweck et al. 2020). Pastoralists lose a large number of their animals, sometimes the total herd, during recurrent droughts, mainly due to inadequate feed supply (Tolera et al. 2012b). It has been estimated that more than a two-fold increase in the productivity of tropical livestock could be attained if the animals were fed according to requirements and their feed was managed properly (Yami 2008; Tolera 2012a). Empirical evidence from Ethiopia demonstrates that improved forage and other feed sources and access to veterinary health services can significantly improve the productivity of livestock.

The livestock feed resources available in Ethiopia include natural pasture, crop residues, improved managed pasture and forages, agro-industrial by-products, and other by-products, like food waste. Of these, natural pasture and crop residues contribute the largest share of feed for livestock, accounting for 58 and 30 percent of the total feed, respectively (ESS 2022). However, crop residues are bulky and of low density, have poor nutritive value, and have many other competing uses, including for soil amendments, fuel, and construction purposes. Agro-industrial by-products and improved forages contribute only about 1.5 and 0.4 percent of the total feed, respectively, while the remaining feed sources are in the form of hay at 6.7 percent and other types of feed at 3.9 percent (ESS 2022).

Livestock grazing, primarily on communal landholdings, is the predominant form of land use in pastoral areas (FDRE 2018). However, these natural pastures are decreasing in extent

due to human population growth and cropland expansion (Mekasha et al. 2014; Mekuria et al. 2018). Overgrazing contributes to a decline in the quality of natural pastures across Ethiopia, affecting the composition and diversity of plant species in them (Alemayehu 2006; Amaha 2006). Moreover, increasing drought frequency and increasing floods have both been reported as critical factors adversely affecting pasture availability and quality in Ethiopia's dryland areas through rangeland degradation. Additionally, encroachment of invasive species, such as *Prosopis juliflora*, reduces rangeland quality (Gebremeskel et al. 2019). At the national level, competitive uses of crop residues and molasses, which is used in the production of liquor and ethanol as an additive to gasoline for fuel, and the massive export of oilseeds, soybean, and maize grain reduces the availability of high-quality feeds (FAO 2018a; Tegegne and Feye 2020).

Animal feed accounts for up to 70 percent of the cost of animal production (Bediye et al. 2018), thereby making access to feed an important consideration for households that raise livestock as part of their livelihoods. Improving the availability of good quality animal feed resources in all production systems and employing best handling and feeding practices have been identified as the most critical steps to achieve higher livestock productivity.

In addition, Ethiopia's livestock sub-sector is exposed to a large number of risk factors, several of which have already been mentioned. Livelihood diversification options for most agricultural households are scarce, so households have limited capacity to absorb shocks to their livelihoods, as there are limited social safety nets on which households can rely. These limitations contribute to livestock-owning households generally having low resilience in confronting and recovering from shocks. To develop strategies to improve the availability of quality feed and to accelerate growth in the sector, information is needed on farmers' current livestock feeding practices. In addition, a systematic analysis of the drivers of these practices will provide insights on how best to address feed-related constraints to improved livestock production in Ethiopia. This study assesses the availability and quality of feed in the Ethiopian livestock sector and the bottlenecks to the supply of adequate and more nutritious feed. The broad objective of the study is to identify strategies to improve livestock feed supply and feeding practices. The specific objectives of the study are 1) to assess livestock feed constraints in different livestock production systems, 2) to examine the feeding practices of smallholder livestock producers, and 3) to review the trends and gaps related to policy, strategic approaches, and the enabling environment for enhancing livestock feed development in the country.

The rest of the paper is organized as follows. The second section briefly describes livestock production systems in Ethiopia, their feeding regimes, and their constraints related to feed availability. The third section reviews policies, strategies, programs, and projects for livestock feed development in Ethiopia. The fourth section examines the feeding practices of smallholder livestock farmers and empirically identifies the determinants of the feeding regimes used, as well as the impact of feeding regimes on milk productivity. The final section consists of concluding remarks and policy recommendations.

2. LIVESTOCK PRODUCTION SYSTEMS IN ETHIOPIA

Ethiopia has three major livestock production systems—pastoral and agro-pastoral, mixed crop-livestock, and urban and peri-urban (Tegegne and Feye 2020). These can be further disaggregated based on moisture availability, market access, or production objectives. For instance, one analysis of the Ethiopian livestock sector identified three major livestock production typologies—lowland grazing, which includes the pastoral and agro-pastoral system; highland crop-livestock mixed rainfall deficient; and highland crop-livestock mixed rainfall sufficient (Shapiro et al. 2015; 2017). Considering market access, production objectives, scale of operation, and level of investment, other analysts have identified four types—extensive, semi-intensive, small-scale intensive, and medium to large-scale commercial or specialized farms (Abegaz et al. 2008; FAO 2019; FAO and NZAGGRC 2017). However, the extensive and semi-intensive production systems are the dominant forms of livestock production in Ethiopia (ESS 2022). The livestock sector is heterogeneous, comprising traditional pastoral and mixed crop-livestock systems, with slowly emerging more modern intensive market-oriented systems (FAO 2018c).

Pastoral and agro-pastoral systems are found in the arid and semi-arid lowlands at elevations below 1,500 meters above sea level in Afar, Somali, Oromia, and Southern Nations, Nationalities and Peoples (SNNP) regions. The pastoral areas in the south and eastern parts of the country are the major sources of animals for conditioning in feedlots for live animal and meat export. About 40 percent of

sheep, goats, and almost all camels are found in this system. The major feed base is natural pasture for extensive rangeland grazing on herbaceous vegetation composed mainly of grasses and forbs and browses, such as shrubs, tree leaves, and pods, while also including in agro-pastoral systems crop residues to a limited extent (FAO and NZAGGRC 2017; FAO 2018c). Under the pastoralist system, herds exclusively consist of indigenous breeds, the feeding regime is entirely based on grazing on rangelands, few inputs are used, and investment levels are low.

Major challenges in pastoral and agro-pastoral production systems include seasonality of rainfall, recurrent drought, deterioration of the range ecosystem due to overgrazing, and invasive plant species (FAO 2018b). The overgrazed natural rangelands make the agro-pastoral and pastoral systems most vulnerable to climate change. Natural pastures show marked seasonal variation in the quantity and quality they offer based on rainfall levels (Tolera and Abebe 2007). Acute feed shortages are common during the dry season. The problem is exacerbated by the recurrence of drought and the loss of key dry season and drought reserve grazing areas due to increasing population pressure, expansion of cultivation into pastoral areas, and other development interventions (Tolera et al. 2012b; Gebremeskel et al. 2019). Milk production, growth rates, and reproductive performance are generally low in pastoral and agro-pastoral systems. Average herd sizes range from 10 to 20, although large herds of indigenous cattle of up to 200 head are seen. However, the average milk yield in such systems is only about 1.5 kg per cow per day (FAO and NZAGGRC 2017; FAO 2018c).

The mixed crop-livestock system is mainly sedentary and village-based. It is dominant in the highlands and midlands of Ethiopia. About 80 percent of the country's cattle and 60 percent of the sheep and goats are concentrated in this production system. The system dominates milk output, encompassing about 65 percent of the total milking cows and producing around 72 percent of the nation's milk output (TRAIDE Ethiopia 2021). In this system, the feeding regimes include only grazing (or scavenging for poultry), mainly grazing with some supplemental feeding, and mainly feeding with some grazing. Grazing is obtained from extensive natural pastures, roadsides, crop residues, and field weeds. Feed is obtained from cutting and carrying green grass, crop thinning, and leaf stripping from crops such as maize, sorghum, enset, and sweet potato, depending on the locality. Meager investment occurs in the mixed crop-livestock system beyond land opportunity costs. Few, if any, external inputs are used. However, some producers will use supplementary feeds, such as traditional brewery by-products (*atela*) or agro-industrial by-products (AIBP), such as wheat bran or oilseed cake. Household food leftovers are also used to feed crossbred dairy cattle or to fatten other livestock with a low level of investment (Abegaz et al. 2008; FAO and NZAGGRC 2017; FAO 2018c). In general, the feed resources available in the mixed crop-livestock production areas are natural pastures, crop residues, and, to a lesser extent, improved forage, concentrates, and nonconventional feeds (Management Entity 2021).

Livestock production in the mixed farming system is constrained by the declining availability of grazing lands due to human population growth and increasing crop cultivation. Land for forage production is challenging to find. Most livestock producers in this system lack or have inadequate access to improved livestock technologies. The use of AIBPs is minimal due to the local predominance of subsistence-oriented production. In addition, AIBPs are challenging to access and are relatively expensive (Tolera et al. 2012b). Cattle in this system are primarily kept to supply draught power needed for crop production. Despite the contribution of livestock to the economy and smallholders' livelihoods, the mixed crop-livestock production system is not significantly market-oriented.

Urban and peri-urban production systems predominantly comprise smallholder and commercial dairy, feedlot, and poultry farms located near major towns (FAO 2018c; Tegegne and Feye 2020; TRAIDE Ethiopia 2021). In these systems, the feeding regimes include only grazing with some feeding, mainly with some grazing and zero grazing. Zero grazing is particularly seen in urban production. The available feed resources vary with the level of intensification.

In peri-urban farms under small-scale commercial dairy, the major available feed resources are crop residues, hay, and supplementary feed, like concentrate mixtures or homemade concentrates made of AIBPs, such as wheat bran, oilseed cake, and molasses, plus minerals and salts. However, grazing and improved forages may not be available due to land shortages in peri-urban areas. Indigenous, cross-bred, and grade dairy cattle are found in such systems. Investment levels are higher than in the other two main livestock production systems and are used to purchase improved breed animals and inputs, such as feed, veterinary drugs, specialized services, and labor.

In small-scale semi-intensive cattle fattening operations in peri-urban areas, the main feed type is crop residues. These are supplemented with traditional brewery by-products (atela), AIBPs, and household leftovers (FAO 2018c). Small-scale cattle fattening in peri-urban areas is an emerging livestock production system mostly practiced by landless households or unemployed youth or women's groups. The most critical challenges for such operators include shortage of land and feed, escalating feed prices, poor feed quality, and lack of rewarding market outlets (FAO 2018c).

In medium-scale commercial dairy systems, the major feed base is supplementary feed based on AIBPs, such as wheat bran, brewery by-products (grain and yeast), molasses, oilseed cake, and concentrate mixture. Purchased fodder (hay) and crop residues are also commonly employed. Silage may also be used by some livestock producers (FAO and NZAGGRC 2017). Crossbred, pure exotic, and grade dairy cattle are the usual animals in such dairy systems. Medium levels of investment are employed to purchase improved breeds, artificial insemination services, and inputs, such as feed, veterinary drugs and services, and labor.

The major feeds in commercial feedlots under intensive production systems are AIBPs, particularly oilseed cake and milling by-products, concentrate mixtures, or purchased hay or crop residues (FAO 2018c). Generally, the use of supplementary feeds like AIBPs or compounded feed increases with the level of intensification and commercialization. However, the specific feed ingredients used will vary from place to place depending on availability and price. Commercial feedlot producers generally have good access to inputs and veterinary services, and engage in more intensive and commercial management systems. This system accounts for over 50 percent of Ethiopia's cross-breeds and high-grade breed livestock (Getabalew et al. 2019). The commercial feedlot sub-sector recently attracted some foreign investors.

Intensive systems that rely heavily on purchased concentrates and roughages are often located in or near urban areas and utilize little natural grazing (McNamara and McKune 2018). Almost all the intensive urban and peri-urban dairy farm feed lots and poultry farms depend entirely on purchased feeds, as they do not have land for feed production or grazing (Tolera et al. 2012b).

Feed is scarce and expensive in all three livestock production systems, and concentrates are not very common. Lack of land to produce fodder is also a constraint on feed availability. The shortage of land for animal feed production, particularly in the highlands, is a critical constraint in livestock production (Shapiro et al. 2015). On the other hand, considerable land is available in the lowlands. However, it is situated in remote areas with limited services. Moreover, it has a lower productive potential for fodder than land in the highlands. Efforts are needed to ensure the availability of land for animal feed production (Shapiro et al. 2015). There is also little knowledge at all levels in these systems—industry, farmers, and experts—about how to make balanced rations to keep animals productive and healthy (Zijlstra et al. 2015).

Most livestock production is subsistence-oriented, with low productivity and production. A major technical constraint limiting animal productivity is the lack and poor quality of feeds. This problem is growing with increases in human and livestock populations, encroachment of crop farming into grazing areas, increasing incidences of drought in pastoral areas, and increasing demand for feed in export markets. All these factors have contributed to sharp increases in feed prices (Tegegne and Feye 2020). As a result, Ethiopia's current per capita consumption of animal-source foods is low. For example, per capita milk consumption in Ethiopia is only 19 liters per year. This is very low relative to neighboring countries Kenya (115 liters) and Uganda (65 liters) (TRAIDE Ethiopia 2021).

3. ANIMAL FEED DEVELOPMENT POLICIES AND STRATEGIES IN ETHIOPIA

The Government of Ethiopia (GoE) has introduced several policies and strategies focused on agriculture and livestock development. In this section, we review the policies and strategies and examine how livestock feed development is integrated into such initiatives. In all Ethiopian development policies and strategies, livestock development is a priority for stimulating economic growth, reducing poverty, and achieving food security (MoA and ILRI 2013). Along with changes in overall economic policy, there have been changes in the institutional and policy support to Ethiopia's feed sector over the years (Bediye and Alemu 2012).

To meet the long-term economic goals of poverty eradication and transitioning into a middle-income country by 2025, Ethiopia's national development plans (NDPs) have emphasized export-led growth to drive rural development and transformation. Ethiopia's NDPs have steered progress in the livestock sector through improved extension and financial support, liberalization of markets, and

a more supportive macroeconomic framework. The NDPs have also formed the basis for a Livestock Master Plan, developed in 2015 (Malabo Montpellier Panel 2020). This includes a roadmap and a set of prioritized investment interventions aimed at satisfying the projected demand for crossbred cow dairy development, red meat,-milk, feedlot development, and poultry development from 2013 to 2028 (Shapiro et al. 2015). Policy and incentive packages have further catalyzed foreign direct investment in the livestock sectors, mostly concentrated around the capital city and Rift Valley areas (Malabo Montpellier Panel 2020).

3.1 Animal feed development actions in rural development policies and strategies

Since 1992, GoE has introduced a range of policies and strategies to guide economic development and address the food insecurity problem. The Agricultural Development Led-Industrialization (ADLI) strategy was the first comprehensive strategy launched by GoE which has influenced successive policy, strategy, and development plans, including the Rural Development Policies and Strategies (RDPS 2003), the Plan for Accelerated and Sustainable Development to Eradicate Poverty (PASDEP 2005/06–2009/10), Growth and Transformation Plan I 2010-2015 (GTP I) (MoA and ILRI 2013), and Growth and Transformation Plan II 2015–2020 (GTP II) (NPC 2016). In addition, GoE signed in 2009 the Comprehensive Africa Agriculture Development Programme (CAADP) compact, committing to prioritize agricultural transformation and development (FAO 2020). Key government strategies providing the framework for the agriculture transformation agenda include the Agricultural Sector Policy and Investment Framework (PIF 2010-2020) (MoARD 2010; Chipeta et al. 2015) and the Livestock Master Plan 2015-2020 (Shapiro et al. 2015).

Policies relevant to feed development in Ethiopia, as well as the key objectives and focus areas of each, are presented in Table 1.

In most rural development policies (RDPs), livestock development-related strategies have been detailed in relation to development paths in different agroecological zones as one element of integrated development efforts. The policies also address issues of drought, livestock marketing, veterinary services, livestock feed, water development, and environmental protection and management to ensure pastoral livelihoods and their asset bases while also taking into account land and labor resources (MoA and ILRI 2013).

Table 1: Policies and strategies relevant to feed development in Ethiopia and their key objectives

Policies and Strategies	Main Objective/Focus Areas Relevant to Feed Development
Rural Development Policies and Strategies – RDPS (2003)	Increasing animal feed production (both in terms of variety and quality); Developing and disseminating relevant technologies; Livestock-focused development in pastoral areas; Development of water sources for both human and livestock use, to be integrated with pastureland administration (MoA and ILRI 2013).
Plan for Accelerated and Sustained Development to End Poverty – PASDEP (2005/06–2009/10)	Introduction and promotion of improved forages/fodder crops production at household level; Improvement of community grazing land; Strengthening livestock extension services in mixed farming and pastoral areas with a special focus on small ruminants and chickens. A secondary component is focused on cattle for their export potential and contribution to the commercialization of agriculture (MoA and ILRI 2013).
Agricultural Growth Project (2011–2015)	Aimed at increasing agricultural productivity and market access for key crops and livestock products in targeted high-potential woredas, including through increased participation of women and youth (MoA and ILRI 2013).
Growth and Transformation Plan I (2010/11-2014/15 (GTP I)	Seeks to bring about improvement in the livestock sector by enhancing the quality and quantity of feed; Improvement of pastureland and development of irrigation schemes; Support to the private sector for investment in pastoral areas, such as through investment in slaughterhouses and quarantine stations (MoFED 2010).
Growth and Transformation Plan II – 2015/16-2019/20 (GTP II)	To transform the livestock subsector by scaling up the best practices and experiences gained so far and improving productivity and production in both mixed and pastoral and agro-pastoral systems; To improve the total feed dry matter from 68 million tons to 184 million tons with an annual growth rate of 22 percent; Contribute to reducing poverty, food and nutritional security, economic growth, and exports and foreign exchange earnings (NPC 2016).
The Livestock Master Plan (2015/16-2019/20)	To support the development of a livestock sector that improves the livelihoods of smallholder farmers, reduces poverty, increases food security in both rural and urban areas, and sustains industrialization and inclusive economic growth (Shapiro et al. 2015).
National Feed Resources Development Strategy (2020-2035)	Facilitate technology and knowledge transfer and utilization of innovative approaches that will contribute to an adequate and sustainable supply of high-quality, safe feed for improving the productivity, product quality, sustainability, and competitiveness of Ethiopia's feed and livestock industry (MoA 2019b).
Ten-Year Development Plan: A Pathway to Prosperity (2021-2030)	Aims to achieve higher incomes, reduce poverty, transform the economy, and promote competitiveness through human capital development and private sector involvement. It provides a roadmap for Ethiopia's long-term prosperity. Specifically for livestock development, the plan seeks to increase the quantity, variety, and productivity of livestock and fisheries by improving animal husbandry, fodder development, and animal health (FDRE 2020)
Pastoral Development Policy and Strategy	Aims at realizing improved and sustainable livelihoods for people in pastoral areas through integrated development centered on animal resources, local knowledge, and other reliable endowments (FDRE 2018).
National Dairy Development Strategy (2022–2031)	Contributes to enhanced livelihoods, food and nutrition security, access to healthy and nutritious diets, economic growth, and environmental sustainability through improved dairy production, value addition, and marketing (Legese et al. 2023).
Yelemat Tirufat Development program (2023 – 2026)	Aims at achieving food self-sufficiency, nutritional security, job creation, import substitution, and increased agricultural exports through enhancing productivity of dairy, eggs, chicken meat, fish, and honey and related hive products. It seeks to increase the total feed dry matter sourced from improved natural pasture grazing and increased cultivated forage production, enhance crop residue quality and utilization, and improve the supply of quality and affordable concentrate mixtures (MoA 2023).

Agriculture-based institutional and policy support for the feed sector, particularly the livestock sector, emanates from the 2006 PASDEP (Bediye and Alemu 2012). During PASDEP 2005/06–2009/10), meat (including goat and camel) production rose by 39,000 mt, achieving 72 percent of the plan target, and milk production (including goat and camel) rose by 1.43 million mt, achieving 96 percent of the plan target. However, scarcity of improved breeds, inadequate results in the area of pasture development, and a shortage of animal feed were noted as the leading causes of low performance (Malabo Montpellier Panel 2020). Each successive NDP—PASDEP, GTP I, and GTP II — sets out ambitious targets for production—quantity of meat, milk, eggs, and other animal products—with

specific attention to feed and veterinary health value chains to achieve those targets (Malabo Montpellier Panel 2020; MoFED 2010).

However, there are some policy and strategy gaps in the livestock subsector. Generally, the livestock policy has not been clearly stated in Ethiopia's agricultural policies and strategies (CAADP 2009). In addition, policy coverage of the pastoral and agro-pastoral development issues has been inadequate. There is a need for a clear policy and strategy, particularly for land use and administration, animal feeds, animal breeding, and transboundary livestock diseases (MoA and ILRI 2013).

Subsequently, the Policy Investment Framework –PIF (2010–2020) highlighted the need for a focused approach to the livestock subsector as one of its priority investment areas. Prior to this, the livestock sector had received minimal coordinated policy focus (Malabo Montpellier Panel 2020). The PIF set targets to increase livestock production and productivity annually by 8 and 4 percent, respectively (MoA and ILRI 2013). The PIF contributed to the development of the Livestock Master Plan (Chipeta et al. 2015).

By the end of GTP I (2014/15), it was anticipated that the volumes produced annually by Ethiopia's livestock sector would have reached 1,383,000 tons of meat, 4,976,000 liters of milk, and 137 million eggs. Similarly, it was projected that there would be almost 1.5 million crossbred cattle, of which close to 36 percent would be cows. The actual number of crossbred cattle and milk cows more than doubled to nearly 300,000 by 2014/15, so the country achieved about 60 percent of the target set for GTP I. However, egg and milk production recorded significant achievements above the plan target. Meat production rose to 96 percent of the target set for GTP I. It was anticipated that forage seed supply would reach 14,500 mt in 2014/15 to increase the production of forage and feed required to support the growing number of improved dairy production. However, only 15 percent of this goal was achieved.

Although quite a number of activities were undertaken during the plan period to enhance livestock productivity, the performance of the sub-sector fell short of the target set by GTP I, partly due to the limited participation of the private sector (Abate 2020). Generally, the efforts made were fragmented and lacked integrated or innovative approaches. There was limited participation of the private sector and other stakeholders from planning to implementation. Institutional support was weak due to the lack of supportive livestock development policies and institutional frameworks. Other factors explaining the poor performance include weak research and extension linkages, inadequate resources allocated along livestock value chains, the dominance of subsistence orientation among livestock producers, inefficient and low-quality service and input delivery systems, and poor implementation, partly due to capacity gaps. Improved implementation was needed to realize the potential of the livestock sub-sector during the GTP I period.

During the GTP II period (2016-2020), total feed dry matter production was planned to improve from 68 million mt to 184 million mt, reflecting an annual growth rate of 22 percent (NPC 2016). Some of this increase was to come from improving the 1.32 million hectares of communal grazing lands through replanting, over-sowing, fertilizer application, restricted grazing, and weed control. In addition, crop residue production was planned to improve from 25 million tons of dry matter to 55 million tons through proper collection, storage, and efficient utilization. These planned efforts included improving the quality and palatability of crop residues through urea, urea molasses, or microorganism treatment. Feed dry matter from sugar factories and other industrial by-products increased to more than 3.3 million mt annually through improving supply and utilization (NPC 2016). To fulfill these targets, the Livestock Master Plan — developed by the Ministry of Agriculture in partnership with ILRI — presented a series of five-year budgeted roadmaps that identified priority investments, such as better genetics, feed, and health services, to meet projected demand in the poultry, red meat, and dairy value chains while ensuring that higher livestock production remains compliant with climate ambitions (Shapiro et al. 2015).

Although there have been various efforts towards achieving the targets, there was not much success under GTP II. For instance, by 2018/19, one year before the planning period elapsed, only 78 percent of the feed production target was achieved — annual dry matter production of 139 million mt as opposed to the planned 179 million mt (MoA 2019b). According to MoA (2019a), cow milk, red meat, chicken meat, and egg production only increased by 11, 13, 8, and 10 percent, respectively. Hence, the production and productivity of the sector remained low, partly due to the challenges in the feed sector (MoA 2019b).

Inadequate extension services on feed development, limited use of inputs and technology, poor engagement of investors on forage

development and rangeland management due to a lack of incentives, recurrent drought, the need for high investment for control and eradication of invasive weeds, the continuing replacement of grazing land by crop production, and capacity gaps among extension workers on feed development challenged the full achievement of the GTP II targets (MoA 2019b). The overall assessment of the two consecutive GTP plans was that their implementation was unsatisfactory. As a result, a new ten-year prosperity plan was prepared (Abate 2020).

Both the GTP I and GTP II initiatives promoted feed production as a strategic objective of the government to improve the livestock sector. There exists some policy commitment to transform the livestock sector from the existing traditional and less sustainable free grazing system to a more intensive stall-feeding system with adequate and sustainable feed production and supply system. There is also policy demand for transforming pastoral systems, which mainly depend on free grazing and transhumance, to more sedentary and intensive livestock production systems. However, since the 1990s, the GoE's view on pastoralism has shifted from its former top-down approach toward a more inclusive approach focusing on poor livestock-holders and poverty reduction rather than only focusing on the livestock (Desta 2006). There has also been a shift away from forced sedentarization to voluntary settlement (Anbessa 2015) through the provision of livestock-related public services in specific locations. Thus, all the RDPs—from PASDEP starting in 2005/06 through GTP I to GTP II ending in 2019/20—have promoted the provision of veterinary services, access to water resources (water points), enhancing extension services, and improving access to markets for live animals and livestock products in pastoral and agro-pastoral areas. In addition, early-warning systems have been established to make pastoralist communities more resilient to a changing climate (FAO 2018b).

Another important lesson of this policy review is that Ethiopia has made substantial efforts to integrate livestock and livestock feed development in its development strategies and policies. Ethiopia's experience offers valuable lessons for other African countries. However, the implementations of these strategies and policies were not effective and, hence, were unable to achieve the stated targets and goals because of implementation capacity limitation and inconsistency of policy interventions over time and space. Having a solid and inclusive strategy is the first step towards change. However, the most critical step is building strong and effective implementation capacity and keeping the strategic interventions focused and consistent over time. Ethiopia was not effective in building these implementation conditions.

3.2 Livestock development programs and projects implemented in Ethiopia

In order to implement the different strategies and policies of the country, several programs and projects have been developed and implemented. A summary of the major livestock development projects and programs implemented in Ethiopia is presented in Annex Table 1, with their key objectives, components or focus areas, and achievements or lessons learned.

Livestock improvement in the Ethiopian highlands started with the launching of the First Livestock Development Project in 1971 with the goal of supporting commercial dairy development enterprises around the capital city, Addis Ababa. The Second Livestock Development Project went into operation in 1973, establishing slaughter facilities for provincial towns and cities and improving stock routes and marketplaces for livestock. Feed sector development in pastoral areas was a major component of the different pastoral development initiatives, though mainly linked to feed provision during drought emergencies. The main other activities were the rehabilitation of degraded rangelands with an emphasis on bush management (Bediye and Alemu 2012). A development program for pastoralists was initiated in 1976 when the Third Livestock Development Project was launched (Annex Table 1). This was designed to develop rangelands, including water and roads, in the pastoral areas. The focus of the Fourth Livestock Development Project that started in 1988 was on feed and forage improvement and increased coverage of veterinary services in the highlands.

Recently, MoA has envisaged transforming Ethiopian agriculture through the implementation of ten national programs in ten years (10 in 10). Among the livestock programs, special attention is given to raising the production and productivity of dairy, poultry, and red meat, along with improving the enabling environment, including through policy reform. In addition, the *Yelemat Tirufat* program ("Bounty of the basket") was launched with the objective of improving household food and nutrition security through increasing production and productivity of dairy, poultry (both meat and eggs), fish, and honey (Table 2). For improving milk production and productivity, the major planned

interventions are breed improvement of dairy cattle, improving feeds, and improving the feeding, nutrition, and husbandry of local and improved breeds of cattle and camels.

Table 2: *Yelemat Tirufat* targets, 2023 – 2026

Commodity	Unit	Base Year (2022)	2026 Target
Milk (all sources)	Liters, billions	6.9	11.2
Eggs	Number, billions	3.2	9.2
Chicken meat	MT, thousands	90.0	240.0
Honey	MT, thousands	147.0	296.0
Fish	MT, thousands	78.0	215.0

Source: MoA (2023).

3.3 Institutional and policy support to enhance the involvement of the private sector

As noted, the limited involvement of the private sector has been one of the critical limitations of the different strategic plans for livestock development in Ethiopia. As a result, the government has adopted several incentives to involve the private sector in livestock feed production and processing (TRAIDE Ethiopia 2021). For instance, GoE aspires to increase investments in the dairy sector and provides several incentives for foreign investors. These include:

- Exemption from income tax: 8 to 15 years for investments in agro-industrial parks (differs by location); 2 to 6 years for investment outside of agro-industrial parks;
- Duty-free imports of agricultural and irrigation equipment and feed production inputs;
- Zero percent tax on exports; access to agricultural land at premium rates with lease periods of up to 30 years.

Through the Ministry of Agriculture's 10-year comprehensive plan, the government also supports investors interested in investing in the fodder and feed supply chain. According to the plan, land and other facilities will be made available for investment to address the livestock sector's prevailing feed shortage and low productivity. MoA specifically plans to make available 6,000 ha for feed and fodder, including fodder seed production, 14,000 ha for ranch development, particularly for lowland dairy investments, and 6 ha per investment for dairy cattle breeding. However, the implementation of these plans and ambitions is not as effective as expected. The involvement of the private sector has not yet improved, being primarily concentrated on a few non-agricultural sectors and locations.

3.4 Regulations for forage and feed quality and standards

There are a number of regulations and regulatory bodies that set and enforce forage and feed standards and implement a regulatory system that includes putting in place a sustainable forage seed system in Ethiopia (See Annex Table 2). The government's 2011 Proclamation No. 728/2011 provided for Veterinary Drug and Feed Administration and Control.

In 2018, directives were formulated for 'feed risk assessment, management, and communication' and 'the registration and issuance of certificate of competence for business enterprises engaged in the production, import, wholesale, export, and retail trade of commercial animal feeds and feed ingredients.' These were developed under the leadership of the then Veterinary Drug and Animal Feed Administration and Control Authority, the functions of which now fall under the feed regulatory activities of the Ethiopian Agricultural Authority (EAA). In 2023, a seed proclamation was formulated by EAA under its plant regulatory function to supply improved varieties and quality seed in the required amount and quality to producers. The regulations and proclamation issued by EAA under its feed regulatory functions seek to ensure that:

- No feed or feed additive may be put into use unless it is ascertained by the appropriate organ that it complies with the quality standards issued or adopted by the competent organ.
- Any feed, feed raw material, or additive shall be produced, stored, and transported in a manner that prevents contamination and deterioration.

- Any producer, importer, or distributor of feed or a feed shop may not supply feed to the market or distribute it otherwise unless it is duly packed and labeled.
- The label of any feed shall be written conspicuously either in the Amharic or English language.
- Records shall be maintained and readily available regarding the inputs, process, and distribution of any feed.
- The record shall be kept to facilitate tracing suppliers of the inputs and consumers of the final product when any adverse effect of the product is identified.
- Any imported feed shall be accompanied by a certificate of quality authenticated by the concerned organ of the country of origin.
- Any feed to be exported shall be accompanied by a certificate of quality issued by the Authority.
- No person may engage in feed trade without obtaining a certificate of competence from the appropriate organ.

However, the enforcement of quality and standards remains weak due to the lack of a solid regulatory system, limited monitoring capacity, and poor implementation strategies, coupled with limited awareness of livestock farmers about feed quality, policies, and regulations. Regulators should invest more in effective implementation by strengthening law enforcement mechanisms for translating policies into action and achieving desired outcomes in the feed and livestock sector at large. Addressing this constraint requires improved coordination, capacity building, and awareness creation campaigns to enhance compliance with feed standards and monitoring mechanisms. Moreover, the available quality standards are not exhaustive. Hence, the existing standards need to be updated.

3.5 Analysis and summary of the policy reviews

The availability of various policies, strategies, guidelines, and extension manuals dealing with animal feed development in Ethiopia can be considered as encouraging initiatives to support the livestock sector. Particularly, the feed development strategy, the new pastoral development policy, and the production of extension materials, such as guidelines on forage development, crop residue improvement and utilization, and AIBP and compound feed utilization, are valuable. However, the overall analysis of government policy on livestock feed development suggests that the implementation of available policies and strategies is low compared to other agricultural sub-sectors. The primary reasons for this are limited participation during the formulation process of relevant policies and strategies of relevant stakeholders at both regional and federal levels, limited implementation capacity, weak law enforcement mechanisms, the absence of a national land use policy and innovative approaches for accelerating the growth of the livestock subsector at large.

Various efforts have been made through government and donor-driven projects to address the bottlenecks of livestock production associated with feed supply. However, such efforts have been scattered, lacked sustainability, received weak institutional support, and had limited private sector participation in overcoming forage and feed shortages in various livestock production systems. Most of Ethiopia's livestock improvement programs and projects (Annex Table 1) are donor-financed and driven. Sustainable livestock development cannot be achieved while depending on short-term and generally intermittent donor support (Kebede 2019). All livestock development projects had some limited success, but their achievements had been affected by socio-economic and political circumstances (Mengistu 2002). Typically, such efforts focused on technical solutions to improve breeding, feeding, and animal health. Still, the promotion of these technologies by different projects did not result in their wide adoption. Organizational and marketing issues were treated lightly or neglected by most projects and programs (Annex Table 1) (Ergano et al. 2013; Tegegne and Feye 2020). Also, little attention has been given to research to look at the organizational requirements for innovation in the livestock sector and to suggest new institutional arrangements to translate technological inputs and services into farmers' practices and to induce innovation in the livestock sector (Ergano et al. 2013). As a result, livestock production and productivity remain low, with the inadequate supply of quality feed being an important contributor to this poor performance (Ahmed et al. 2003; MoA 2019b; Balehegn et al. 2020).

In summary, based on the review of existing policies, strategies, and project reports, the remaining major challenges related to feed development include:

- Low livestock productivity is partly due to limited access to adequate quality feed. This is the case in both the highlands, where grazing land is scarce, and the lowlands, where rangeland degradation and extensive

encroachment of invasive species have reduced grazing resources.

- Lack of supportive livestock development policies and institutional frameworks. Policy gaps exist in animal feed resource development and feed handling and utilization. Inadequate resources, including limited government budget allocations, investments in research and technology development, workforce, capacity building, and commitment, all pose a barrier to improving access to high-quality feed in all livestock production systems in Ethiopia (MoA and ILRI 2013; MoA 2019b; Kebede 2019).
- Poor implementation effectiveness adversely impacts the success of efforts to solve pressing feed-related problems.
- Despite good awareness of national feed standards, most are not enforced due to capacity limitations. There are few enforcement mechanisms for proper management of communal grazing lands. The implementation of seed certification for quality seeds of improved forage species is week. Few livestock producers are able to access supplementary feed ingredients and compound feeds for which the quality is assured. In addition, food safety regulations for concentrate feeds are not applied to forage and crop residues. Further strengthening of institutions and policies for the enforcement of feed quality standards is required. This will require greater collaboration between The Ethiopian Standards Agency, MoA, and feed manufacturers.
- Insufficient incentives have been offered to motivate the private sector to actively engage in the livestock feed value chain. Strengthening the support to the private sector in the feed industry is required. This can be done in part through institutional and policy support for feed sector development and offering economic incentives and land access for private firms to invest in feed production.
- Absence of public-private partnerships and innovation platforms around livestock feed development. These mechanisms would bring together relevant stakeholders for planning, implementation, and establishing monitoring and evaluation systems to advance the livestock feed sub-sector.
- The available policies, strategies, guidelines, and manuals are fragmented.
- There are inefficient and low-quality service and input delivery systems, including for extension, feed, credit, and access to land, etc.). Public-private partnerships have proven to enhance service delivery in many sectors and may be similarly effective in improving livestock feed quality. However, feed quality controls must be strengthened. In addition, it is important to consider reducing VAT on raw materials and ingredients for feed, including vitamins, amino acids, and mineral premixes. Finally, the rules governing the allocation of agricultural land should be revised to facilitate the allocation of land for forage and feed production and the establishment of intensive livestock farms (Shapiro et al. 2017).
- There are few policies or legal and institutional frameworks to support sustainable pastoral and agro-pastoral production and to mitigate the effects of drought. Efforts to strengthen the requisite institutions to better meet these functions are needed.
- Policies to support timely and reliable livestock and feed market information are required, including modalities for cross-border livestock marketing. Adequate resources also are needed to build water points, feed storage facilities, and other livestock production infrastructure. These efforts should be based on processes that empower and actively involve the local communities that will be affected (Shapiro et al. 2017).

4. FEEDING REGIMES OF SMALLHOLDER LIVESTOCK PRODUCERS

In this section, we explore the feeding regimes of smallholder livestock producers in Ethiopia using farm household survey data obtained from different sources, primarily the Ethiopian Socioeconomic Surveys conducted by the Ethiopian Central Statistics. The 2018/19 Ethiopian Socioeconomic Survey, the fourth round of the survey (ESS4), was employed for the analysis. This survey covers all nine states, including Addis Ababa and Dire Dawa. ESS4 interviewed 6,894 households from 541 enumeration areas. Since the study here focuses on feeding practices and technologies, we used the livestock questionnaire to examine drivers of the livestock feed sub-sector and opportunities and challenges in the sub-sector.

Using this dataset, we describe the status of livestock feeding regimes and examine the factors affecting the adoption of the four types of regimes. We also assessed the impact of specific feeding regimes on livestock productivity at household level.

A feeding regime is defined as a feeding practice that may combine grazing (including scavenging for poultry) and stall-feeding. The four feeding regimes examined in this study are:

1. Only grazing
2. Mainly grazing with some supplemental stall feeding
3. Mainly stall feeding with some grazing, and
4. Zero grazing—fully stall-feeding with no (or rare) grazing

4.1 Animal feeding regimes in Ethiopia

Table 3 shows the share of livestock-raising households that reported utilizing a specific feeding regime for each type of livestock that they raise. Only grazing dominates. Less than ten percent of households provide any feed to their livestock in addition to grazing. Zero grazing is the rarest form of livestock feeding, reported even less than an undefined "Other" regime of livestock feeding. This pattern suggests that uncontrolled free grazing, particularly during the dry season, is Ethiopia's dominant livestock management system.

Table 3: Feeding regimes of livestock, by animal type, percent of animal-raising households in Ethiopia

Feeding regime	Cattle	Sheep and goats	Poultry	Camels	Donkeys and horses	Other	Total
Only grazing	92.0	93.0	94.1	89.1	91.5	96.4	92.8
Mainly grazing with some feeding	4.5	4.0	3.4	5.8	4.7	2.4	4.1
Mainly feeding with some grazing	2.0	1.7	1.3	2.6	2.1	0.5	1.7
Zero grazing	0.4	0.4	0.3	0.5	0.4	0.2	0.4
Other	1.1	1.0	1.0	2.0	1.3	0.5	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Households reporting	13,370	5,348	8,022	2,674	8,022	5,348	42,784

Source: Author's analysis of Ethiopian Socioeconomic Survey (ESS4).

However, other evidence shows that controlled livestock grazing on communal and private pastures is also an expanding feeding practice. This means that, even though more than 90 percent of livestock producers depend on grazing only, the type of grazing may vary from free grazing to controlled grazing. Based on key informants' interviews and experts' observations, the latter is becoming more common due to a growing shortage of open-access grazing or rangelands. As part of the ongoing land rehabilitation scheme, many formerly open-access rangelands are increasingly becoming protected areas for natural regeneration.

There are variations in grazing practices both between and within livestock production systems and over time. For instance, based on the results of field surveys carried out in East African dairy systems, including Ethiopia, the distribution of feeding regimes and production systems in 2010 and the predicted distribution in 2030 shows that grazing will decline from 64 percent in 2010 to 35 percent in 2030 (World Bank 2012). This change will involve increasing reliance on cultivated fodders. Those relying on cultivated fodder for stall feeding will increase from 36 percent to 65 percent of livestock-producing households (Table 4).

Table 4: Estimates of small-scale dairy households in East Africa practicing grazing or stall-feeding with low or high supplementation for 2010 and a projection for 2030

East Africa Small-scale Dairy		% Households	
Feeding System		2010*	2030**
Grazing	Low supplementation	64	35
Stall-feeding	Low supplementation	35	25
Stall-feeding	High supplementation	1	40

Source: World Bank (2012).
Note: *rainfed; **irrigated

4.2 Factors affecting the choice of animal feeding practices

We hypothesize that a livestock producer's choice of a feeding regime is strategic. Therefore, it is critically important to shed light on the production constraints and opportunities guiding livestock producers' behaviors and actions. Factors affecting the choice of feeding regimes were estimated using a multinomial logit (MNL) model. Farmers' decisions on the use of improved feed practices involve a polychotomous response in which the dependent variable is made up of a set of discrete choices. Consequently, it is appropriate to treat factors that are supposed to determine farmers' decision on the use of a particular feed practice as a multiple-choice decision. Farmers' decision to select a given feed practice or not is made by evaluating the returns in expected utility, taking into account related investment and transaction costs (Kelsey 1994; Lazear and Rosen 1981). It is expected that farmers will select the technologies that show the most positive utility.

$$(1)\quad U_{ij} = \pi_{ij}^{A} - \pi_{ij}^{0} = X_a^A B_a + \varepsilon^A$$

where *Uij* is the expected utility difference, π_{ij}^{A} is the utility derived from feeding regime *i* if selected by farmer *j*, and π_{ij}^{0} is a stream of utility if feeding regime i is not selected. Farmers will choose a feeding regime option 1, 2, or 3 when it is perceived to provide a higher potential return (i.e., higher profit) than the alternative options. Therefore, the MNL regression estimates the technology selection decision specified as

$$(2)\quad Y_{ij}^{A} = \begin{pmatrix} 1if\pi_{ij}^{A} - \pi_{ij}^{0} \geq 0 \text{ if } X_a^A B_a \geq -\varepsilon^A \\ 0if\pi_{ij}^{A} - \pi_{ij}^{0} < 0 \; if \; X_a^A B_a < -\varepsilon^A \end{pmatrix}$$

The selection of feeding regime option i by farmer j is Y_{ij}^{A}, defined as the choice of farmer j to select technology i if

$$(3)\quad Y_{ij}^{A} = \begin{pmatrix} 1if Y_{ij}^{A} = \pi_{ij}^{A} - \pi_{ij}^{0} \geq 0 \equiv X_{ij}^{A} B_{ij} + \varepsilon^A \geq 0 = X_{ij}^{A} B_{ij} \geq -\varepsilon^A \\ 0if Y_{ij}^{A} = \pi_{ij}^{A} - \pi_{ij}^{0} < 0 \equiv X_{ij}^{A} B_{ij} + \varepsilon^A < 0 = X_{ij}^{A} B_{ij} < -\varepsilon^A \end{pmatrix}$$

where B_{ij} is a vector of estimators, ε^A is a vector of error terms under the assumption of normal distribution, Y_{ij}^{A} is the dependent variable for feeding regime option 1, 2, or 3, and X_{ij}^{A} is the combined effect of the explanatory variable

We assume that the various feeding regimes use different levels of technology, with only grazing being low, mainly grazing with some feeding being intermediate, mainly feeding with some grazing being high, and only feeding (zero-grazing) being very high. Thus, the base category for MNL model estimation was the only grazing feeding regime. As potential determinants of the choice of feeding regime by farming households in Ethiopia, 19 demographic, socioeconomic, institutional, and environmental variables were included as explanatory variables. The results of this analysis are presented in Table 5. The overall Chi-square test rejects the null hypothesis that the coefficients on all explanatory variables are zero. Hence at least one of the explanatory variables affects the feeding regime adoption decision of smallholder farming households. This inference is supported by the Wald Chi-square test being statistically significant.

We consider each feeding regime in turn relative to the base regime of exclusive grazing (no stall-feeding). The results show that the decision to supplement grazing with some feeding, mainly feeding with some grazing, or zero grazing, rather than grazing exclusively is significantly associated with several factors, both positive and negative.

For instance, the education level of the household head was positively related to the likelihood of households' choice of using mainly grazing with some feeding or mainly feeding with some grazing. The marginal effect in Table 5 shows that a unit increase in the number of years of education for the head of a livestock-producing household could increase by 1 percent the likelihood of adopting mainly grazing with some feeding or by 0.7 percent mainly feeding with some grazing, other things remaining constant. This is in agreement with Feyissa et al. (2023), who observed that the education level of the household head was found in the central highlands of Ethiopia to positively and significantly influence farmers' decision to adopt improved feed, such as the use of concentrate as supplementary feed and growing improved forages as fodder, and improved feeding conditions, such as stall feeding and seasonal grazing. Similarly, Menghistu et al. (2021) reported that farmers with better education levels were 1.7 percent more likely to adopt animal feed development strategies compared to illiterate farmers in the drylands of northern Ethiopia. Education could have a positive effect on the probability of agricultural technology adoption because the higher the education level of the household head, the better their awareness and understanding of the potential benefits of alternative livestock feeding regimes. Such heads are more likely to adopt a new technology (Belay and Mengiste 2021). This suggests that with no education, a farmer will be less likely to be aware of the opportunity costs of foregoing the use of technologies on livestock productivity (Korir et al. 2023).

Table 5: Factors affecting adoption of different feeding practices in Ethiopia, multinomial logit regression results

	Mainly grazing with some feeding			**Mainly feeding with some grazing**			**Only zero grazing**		
Explanatory variables	Coeffi-cient	Robust std. error	Marginal effect	Coeffi-cient	Robust std. error	Marginal effect	Coeffi-cient	Robust std. error	Marginal effect
Sex of HH head	0.058	-0.079	0.003	0.050	-0.094	0.002	0.253	-0.265	0.001
Education level of HH head	0.175***	-0.019	0.010	0.169***	-0.023	0.007	-0.170	-0.121	-0.001
Marital status of HH head	-0.084***	-0.030	-0.005	0.023	-0.032	0.001	-0.087	-0.119	-0.000
Household size	-0.088***	-0.028	-0.005	0.017	-0.026	0.001	-0.157	-0.121	-0.001
Father's educ. level	-0.023**	-0.012	-0.001	-0.035***	-0.013	-0.001	-0.112**	-0.053	-0.000
Mother's educ. level	-0.004	-0.013	-0.000	0.008	-0.014	0.000	0.023	-0.044	0.000
Vaccination costs	0.010***	-0.003	0.001	0.010***	-0.003	0.000	0.009***	-0.003	0.000
Working family members	0.101***	-0.036	0.006	0.215***	-0.037	0.009	0.045	-0.125	0.000
Crop residue cover	-0.049*	-0.030	-0.003	-0.031	-0.029	-0.001	-0.345***	-0.133	-0.001
Borrowed money	-0.433***	-0.123	-0.023	-0.003	-0.124	0.001	-0.646	-0.467	-0.002
Field under extension prg.	-0.252**	-0.111	-0.014	-0.274**	-0.127	-0.011	-0.780*	-0.411	-0.002
Irrigated field	-0.149	-0.197	-0.008	-0.430*	-0.250	-0.016	0.148	-0.597	0.000
Livestock owned	-0.009	-0.011	-0.001	0.024***	-0.009	0.001	0.016	-0.024	0.000
Income from animal sales	-0.014	-0.023	-0.001	0.038*	-0.020	0.002	-0.003	-0.056	-0.000
Milking animals	0.091**	-0.043	0.006	0.039	-0.044	0.001	0.024	-0.133	0.000
Credit services	-0.064	-0.132	-0.007	0.768***	-0.122	0.046	0.598*	-0.342	0.003
Extension service	-0.143	-0.090	-0.009	-0.097	-0.104	-0.004	0.652**	-0.295	0.003

Subj. soil fertility assessment	-0.255***	-0.080	-0.017	0.316***	-0.091	0.015	0.487*	-0.278	0.002
Field farmed before	-0.325***	-0.0823	-0.019	-0.249***	-0.095	-0.010	-0.156	-0.289	-0.001
Constant	-1.978***	-0.173		-3.890***	-0.214		-5.607***	-0.624	

Source: Author's analysis of Ethiopian Socioeconomic Survey (ESS4).

Note: Only grazing (no feeding) regime = Base category. Observations: = 10,636; Wald Chi-square (57): 478.88***; Prob > Chi-square: 0.0000. Log pseudo-likelihood: --= -5047; PseudoR^2: 0.0509. ***, ** and * implies significant at 1%, 5%, and 10% probability levels, respectively.

The marital status of the household head is negatively associated with the decision to supplement grazing with some feeding. Households with married heads are less likely than households with unmarried heads—that is, single, widowed, or divorced—to supplement grazing with some feeding. Meanwhile, married heads of households are more likely to exclusively use grazing to feed their livestock. The marginal effect shows that being married has less probability of supplementing grazing with some feeding by 0.5 percent compared to their counterparts, keeping other things unchanged. This is consistent with previous findings (Ojo et al. 2021; Neway and Zegeye 2022). This is probably associated with the larger household size as a result of marriage leading to more responsibilities and financial pressure, limiting the adoption capacity of the farm household relative to ones with unmarried heads (Neway and Zegeye 2022).

The adoption of supplemental feeding with mainly grazing was negatively associated with farmers' household size. This implies that an increase in the number of persons in a household will decrease the adoption level. This is in agreement with the findings of Olorunfemi et al. (2023), who reported a negative relationship between household size and the adoption of improved sheep and goat production technologies in Nigeria. This might be associated with large households being a burden, especially where the members are underage or otherwise not working and economically dependent (Hussein et al. 2015). However, this is contrary to the findings of several other researchers. The adoption of livestock technologies was positively associated with the household size of the farmer in Bangladesh (Quddus 2022). Similarly, the adoption of animal feed development-related adaptation strategies was positively associated with the farmer's family size in the dry lands of Northern Ethiopia (Menghistu et al. 2021) and in the Central Rift Valley of Ethiopia (Belay et al. 2017) – the researchers suggest that this was associated with the availability of more labor force as a result of large family size. A meta-analysis result (Bassa 2021) indicated that the active labor force played a significant and positive role in livestock technology adoption in Ethiopia. This implies that the choice of an improved livestock feeding technology is promoted by a livestock-producing household having sufficient labor to use in land preparation for forages and adopting other labor-demanding improved livestock feeding practices, compared to smaller households, holding other explanatory variables fixed.

Heads of households whose fathers were better educated are less likely to use feeding regimes involving supplementary feeding. Increased educational attainment by the father discourages the adoption of feeding practices other than solely grazing. However, earlier reports indicated that farmer characteristics, such as level of education or extent of contact with extension services, are important determinants of adoption (Gebremedhin et al. 2003). In addition to the biophysical, household demographics, and farm level factors, it is important to account for the importance of value chain level or institutional factors and regional or national policy issues that hinder technology adoption, entrepreneurship, and commercialization (Klerkx et al. 2010).

Vaccination costs were positively related to the household's choice of using mainly grazing with some feeding or mainly feeding with some grazing. Although the cost of livestock vaccination is an important barrier to adoption (Kappes et al. 2023), the indirect effects of livestock vaccination would positively impact the adoption of improved practices, like the use of improved forages and feeding. For instance, based on a cross-sectional study of Kenyan pastoralist households, Marsh et al. (2016) found that vaccination provides significant net income benefits as a result of reduced livestock mortality, increased milk production, and savings by reducing antibiotic and acaricide treatments. In this case, households directed the increased income resulting from vaccination into forage development or purchase of concentrates so as to supplement feed on their mainly grazing system or feed their livestock with some grazing. In another study in Tanzania on a willingness to pay for

Newcastle disease vaccines in poultry, Campbell et al. (2019) found that on-farm income would likely be sufficient to cover vaccination costs, and those low-income households valued the vaccines more. In addition, farmers practicing semi-intensive production systems are willing to pay 20 percent more than the current vaccine prices, as are users who believe in the beneficial effects of vaccination, users who consider the prices of vaccines as fair, and those who believe that some vaccines are more important than others (Wane et al. 2020).

Households with more working members are more likely to use the feeding regime that relies primarily on grazing with some feeding and mainly feeding with some grazing with their livestock. With each additional working member, the probability of using these feeding regimes increased by 0.6 percent and 0.9 percent, respectively. This could be associated with labor availability since intensive and semi-intensive feeding regimes require relatively more labor than exclusively grazing feeding regimes. For instance, cut-and-carry feeding of individually tethered animals requires more labor compared with only grazing feeding (FAO 2018c). This finding is consistent with the results of Khasay et al. (2023), who reported that households with more working members were more efficient in livestock production.

A greater amount of crop residue on a household's fields was found to positively and significantly influence farmers' decision not to adopt zero grazing or mainly grazing with some feeding, both at the one percent probability level. The farm household having greater amounts of crop residue in its fields reduced the probability of using these feeding regimes by 0.13 percent and 0.30 percent, respectively, and other things remain constant. This implies that when there is a considerable amount of crop residue, households prefer to let their livestock graze the crop residue rather than convert to zero grazing or mainly grazing with some feeding.

Households with irrigated fields are less likely to use this feeding regime that relies primarily on feeding, with some grazing, than to exclusively graze their livestock. Previous studies indicated that an increasing proportion of area irrigated in the Ethiopian highlands was associated with a declining likelihood of a community having restricted grazing land (Benin and Pender 2002). This probably was due to an increase in alternative feed sources associated with irrigation that can alleviate the feed-shortage problem through increased production of crop residues and the development of private pastures.

Households with greater numbers of livestock are more likely to use the mainly feeding regime with some grazing than to exclusively graze their animals. This is probably associated with improved technologies relevant to feeding with some grazing rather than exclusively grazing as a result of the income generated by smallholder farmers who own a greater number of livestock. The marginal effect shows that when the number of livestock owned increases by one unit, then the probability of the farmer adopting the mainly feeding regime with some grazing increases by 0.1 percent, other things remaining constant. This is in agreement with the study by Feyisa (2020), who reported that households with large livestock holdings have a better financial standing to afford and possess new agricultural technologies.

Increased income from animal sales was found to positively and significantly influence farmers' decision to adopt mainly feeding with some grazing rather than only grazing. The marginal effect shows that when income from animal sales increased by one unit, then the probability of the farmer adopting the mainly feeding regime with some grazing increases by 0.2 percent, other things remaining constant. This implies that when income increases through animal sales, households have more money and an increased ability to purchase new technologies, like purchasing improved forages or concentrates to employ mainly feeding with some grazing rather than exclusively grazing their livestock.

Households with greater numbers of milking animals are more likely to use mainly grazing with some feeding than to exclusively graze their animals. This is mostly associated with income generation through sales of milk and milk products. Quddus (2022) reported that higher levels of technology adoption are associated with better milk yield, so that improved dairying has a direct impact on income generation, poverty alleviation, and availability of animal protein. The marginal effect shows that when the number of milking animals increased by one unit, then the probability of the farmer adopting mainly grazing with some feeding increases by 0.6 percent, other things remaining constant.

Access to credit services positively and significantly influences the probability of using the feeding regimes of relying mainly on feeding with some

grazing and zero-grazing (only feeding) rather than only grazing. If the household reported access to credit services, this is associated with their being more likely to be able to purchase supplemental inputs to employ mainly feeding with some grazing and zero grazing than to exclusively graze their livestock. The marginal effect shows that the probability of using these feeding regimes increased by 4.6 percent and 0.26 percent, respectively, other things remaining constant.

If the household had access to extension services, it would have a higher probability of using zero grazing rather than relying only on grazing to feed its animals. As expected, adequate extension services would advise livestock farmers to use high-quality feeds for optimal productivity. Such farmers are more likely to adopt agricultural technology as they learn about the benefits and applications of improved technologies through extension services (Neway and Zegeye 2022). The marginal effect suggests that an improvement in the extension services will increase the probability of adoption of zero grazing by 0.26 percent.

Farm households having fertile soil in their fields have a higher probability of using mainly feeding with some grazing and only feeding regimes by 1.5 percent and 0.19 percent, respectively, other things remaining constant. This implies that livestock primarily relying on feeding for their nutrition will tend to be located in quite fertile areas in Ethiopia that are conducive to cut-and-carry feeding systems (semi-intensive and intensive systems).

Households that have fields that were used for farming in the past year are less likely to use mainly feeding with some grazing and zero grazing than only relying on grazing to feed their animals. This could be associated with the availability of crop residues on the farm, implying that a household may prefer to let their livestock graze the crop residue on these fields, rather than mainly feeding with some grazing or zero grazing.

In summary, several characteristics of the livestock-producing household or their farming practices are significant direct determinants of the choice of which feeding regime to adopt by these households. However, none are positively associated with improved adoption of technologies relevant to a livestock-producing household using mainly grazing with some feeding, improved feeding with some grazing, or zero-grazing (only feeding) regime to feed their livestock rather than exclusively grazing. Some characteristics are seen to be disincentives to adopting feeding regimes other than grazing.

The available evidence indicates that, in addition to biophysical, household demographics, and farm-level characteristics, it is important to account for the importance of value chain level or institutional factors and regional or national policy issues that hinder technology adoption, entrepreneurship, and commercialization (Klerkx et al. 2010). Low-quality crop residues and natural pasture are the main sources of feed in Ethiopia, accounting for 94 percent of the feed biomass in Ethiopia (ESS 2022). Supplementary feeding strategies involving semi-grazing or zero grazing could use improved forages, AIBPs, homemade concentrates, or commercial concentrate mixtures. However, all these feed sources are in short supply and, so, are expensive. Their cost hinders the adoption of supplementary feeding systems. Commonly introduced strategies to alleviate these problems, such as the introduction of improved forages, improving crop residue quality, supplementary feeding, zero grazing, and grazing land re-habilitation, have not been very successful due to low adoption by livestock producers (Gebremedhin et al. 2003). For example, cultivated improved forages in Ethiopia make up only 1.5 percent of total feeds (ESS 2022) despite more than 50 years of research and development activities on cultivated forages in the country (Balehegn et al. 2020).

4.3 Effects of feeding regime on milk productivity

Ethiopia's current level of livestock productivity is one of the lowest in the world. It can mainly be attributed to poor nutrition, feed shortages, and low input–low output livestock production systems. Table 6 shows recent data on livestock productivity levels in Ethiopia. For instance, animal carcass weights for Ethiopia in 2019 were below the average carcass weights of cattle (123.3 kg), goats (10.0 kg), sheep (14.5 kg), chicken (1.1 kg), and camel (222.3 kg) for all least developed countries (FAO 2021). Milk yields in Ethiopia are also very low compared to other developing countries, though there has been some progress recently. While milk productivity increased between 2014 and 2019 by 18.5 percent, meat productivity was stagnant (FAO 2021).

Table 6: Estimates of livestock productivity in Ethiopia by animal product, 2019

Livestock Product	Mean
Egg, number/year/hen	121.0
Milk, liters/year/cow	286.1
Cattle, carcass weight, kg	108.5
Goat, carcass weight, kg	8.5
Sheep, carcass weight, kg	10.0
Chicken, broiler, carcass weight, kg	0.80
Camel, average carcass weight, kg	197.0

Source: FAO Statistical Database, 2021

Analysis of the ESS4 survey data shows that the average quantity of milk produced per dairy cow per day was 1.24 liters (Table 7). This value is lower than the Agricultural Sample Survey 2021/22 estimates of average milk yield per cow per day of 1.45 liters (ESS 2023). This suggests that milk yields may be increasing over time but remain very low. This is not surprising since 93 percent of livestock-producing households are subsistence-oriented and rely on low input—low output systems primarily involving feeding their livestock only using grazing without supplemental feed (Table 3).

Table 7: Average dairy productivity of cows by feeding practice, liters of milk per cow per day

Feeding Regime	Mean	Standard deviation	Minimum	Maximum	Observations
Only grazing	1.0	1.3	0.02	16	1,680
Mainly grazing with some feeding	1.3	1.2	0.3	8	69
Mainly feeding with some grazing	1.2	0.9	0.3	5	37
Only feeding (zero grazing)	1.0	0.5	0.3	2	7
Other	1.7	2.7	0.2	12	18
Overall	1.24	1.31	0.22	8.60	1,811

Source: Author's analysis of Ethiopian Socioeconomic Survey (ESS4).

In order to substantiate the role of feeding practices in increased livestock productivity, we analyzed the effects of the different feeding regimes on milk productivity using a mixed MNL endogenous treatment effect model. This method provided a well-fitted model for the estimation. The overall Chi-square test suggests that the null hypothesis of all explanatory variables is zero and is rejected, so at least one of the explanatory variables affects the impact of the feeding regime on milk productivity. This is supported by the statistically significant Wald Chi-square value.

The analysis used 19 potential explanatory variables plus three feeding regimes—the base feeding regime for the analysis is 'grazing only.' The dependent variable is the average milk yield per animal per day in liters expressed as a natural logarithm.

The results are shown in Table 8. Consistent with the statistics presented in Table 7, the effect of the feeding regime on milk productivity is insignificant. In terms of magnitude, zero grazing shows a relatively positive and higher effect but is still not statistically significant. Several reasons could explain such a negligible effect, including the insignificant difference in the amount of feed supplied to zero-grazing and free-grazing animals. Farmers may stall animals for zero grazing. However, if the stall animals are not fed with an adequate quantity and quality of feed, the effect on milk productivity remains insignificant. Therefore, zero grazing *per se* is not enough to improve milk productivity. Improving the amount and quality of feed provided to the stall-fed animals would be critically important. Another possible explanation could be a poor milk productivity response in indigenous cattle breeds to feeding regime improvement. The majority of smallholders in Ethiopia own indigenous cows. These cows may not respond to improved feed quality with higher milk productivity.

Six out of 19 of the other independent variables are found to be significant factors influencing milk productivity. Milk productivity levels in Ethiopia are

positively associated with the age of the household head, the mother's education level, and the number of milking animals owned by the household. The age of the household head is usually associated with more experience, which may result in improved milk productivity. Most dairy farmers in Ethiopia usually offer good quality forages and locally available supplements (concentrates) to milking cows to increase milk production and, accordingly, higher income (Yigrem et al. 2008; Duguma et al. 2016).

Increased educational attainment by the mother of the household head results in increased adoption of improved feeding and other management practices, leading to improved milk productivity. Most of the dairy operations in Ethiopia are managed by women.

Table 8: Effects of feeding regimes on cattle milk productivity based on multinomial endogenous treatment-effects regression

Dependent variable: **ln (average milk yield per animal per day in liters)**	Coefficient	Robust standard: error
Mainly grazing with some feeding livestock feeding regime	0.0199	0.0142
Mainly feeding with some grazing livestock feeding regime	-0.0007	0.0129
Zero grazing livestock feeding regime	0.0274	0.0310
Sex of household head	0.0027	0.0054
Age of household	0.0004**	0.0002
Marital status of household head	0.0002	0.0020
Household size	-0.0031**	0.0014
Father's education level	-0.0003	0.0006
Mother's education level	0.0026*	0.0014
Vaccination costs	-0.00004*	0.00003
Working family members	0.0001	0.0026
Crop residue cover	0.0021	0.0018
Area of the field	-0.0006	0.0017
Borrowed money	0.0054	0.0074
Field under extension program	-0.0096	0.0074
Irrigated field	0.0084	0.0135
Livestock owned	-0.0073***	0.0015
Milking animals	0.0975***	0.0139
Credit services	0.0042	0.0107
Extension service	0.0026	0.0062
Subjective soil fertility assessment	0.0026	0.0058
Field used for farming in past year	0.0027	0.0057
Constant	0.0173	0.0137
/lnsigma	-1.4490***	0.0793
/lambda_catego~2	0.0116***	0.0041
/lambda_catego~3	0.0107***	0.0038
/lambda_catego~4	-0.0240***	0.0057
Sigma	0.2348	0.0186

Source: Author's analysis of Ethiopian Socioeconomic Survey (ESS4).
Note: Observations: 8,262. Wald Chi-square (50): 247.75***; Prob > Chi-square: 0.000. Log pseudo-likelihood: 4781.57.
***, ** and * implies significant at 1%, 5% and 10% probability levels, respectively.

On the other hand, household size, vaccination costs, and the number of livestock owned by the household are negatively associated with milk productivity levels in Ethiopia. Large household members could be a burden, especially where the members are dependents and not working (Hussein et al. 2015), limiting the adoption capacity of the farm households towards using improved feeds and fodder and keeping milk productivity low (Neway and Zegeye 2022).

The cost of livestock vaccination is an important barrier to adoption (Kappes et al. 2023). If animals are not properly vaccinated, milk productivity will be reduced. Households that practice improved livestock management methods are more likely to own fewer but more productive animals, like crossbreeds or exotics. In contrast, households with greater numbers of livestock are less likely to improve milk productivity. This could be associated with a greater share of their animals not producing milk, unimproved livestock management practices, or inefficiency (Boka 2020).

In summary, Ethiopia's current milk productivity level is one of the lowest in the world (FAO 2021). Factors such as the age of the household head, the mother's education level, and the number of milking animals owned by the households are all important drivers of increased milk productivity. None of the feeding regimes employed with the dairy animals were significant determinants of milk productivity.

5. CONCLUSION AND RECOMMENDATIONS

The current research has reviewed animal feed policies in Ethiopia and analyzed feeding practices adoption and their impacts on milk productivity. The policy review showed that Ethiopia has made efforts to integrate animal feed development into its major development policies and strategies. Though progress has been achieved in increasing the production of feeds and improving feed quality, the performance lags behind the planned stated targets and the expected result for transforming the sector. This is mainly because of poor implementation of the strategies and policies, which is associated with the lack of adequate capacity and consequent inconsistency in implementation. A number of potential interventions to overcome the feed shortage in various agro-ecologies and production systems are suggested in Annex Table 3.

Coordination of public-private partnerships with international partners to improve the feed trade would improve livelihoods in livestock-producing communities in Ethiopia. Organizing youth and women into cooperatives will also be beneficial for managing feed resources to improve the production and productivity of livestock. The research and development community can contribute by developing new feed technologies to help livestock-producing households adapt to changing environmental conditions. Such research would improve access to and efficiency, equity, and effectiveness in the feed industry.

Livestock farmers in Ethiopia have several choices of feeding regimes. The major feeding regime employed is only grazing (scavenging for poultry) without supplementation of other feed types. Less than ten percent of households provide any supplemental feed to their livestock in addition to grazing. Very few households feed their livestock using zero-grazing. However, inadequate access to input and output markets, the steady price hike of purchased feed, subsistence-oriented livestock production systems, and the lack of institutional innovations and consistent policies related to the livestock sector in general and the feed sub-sector, in particular remain major constraints to improved feed regime development in the sector. Investment in adequate feed supply systems for improving animal nutrition would facilitate efficient trading of feed and fodder – this would be a feasible investment option for enhancing the production and productivity of livestock. However, the intervention strategies needed to produce and maintain adequate and affordable livestock feed would vary depending on the livestock production system. For instance, the efficient use of pasture, grazing areas, and other rangeland requires provision of water sources. Harvesting practices, including fodder banks in pastoral and agro-pastoral areas of Ethiopia, may also prove to be a feasible investment pathway for improving livestock production and productivity. Sedentary livestock production systems are similarly limited by poor-quality feed and limited uptake of improved feed utilization practices. Additional feed supplements may be required to improve livestock's nutrient intake in these systems.

The results also suggested that the impact of stall feeding on milk productivity is low. One possible option to enhance the effects of intensive feeding would be to promote technologies that generate the greatest net welfare effects for livestock-producing households. These include promoting improved breeds. Local breeds are less productive and less profitable than exotic breeds. Improved breeds are most productive when improved feed, fodder, and efficient veterinary services are provided.

However, transforming the feed industry and livestock sub-sector at large requires not only technological and knowledge-based interventions, but also institutional innovations and policy reforms. Context-appropriate technology packages and innovations and necessary institutional and policy reforms need to be formulated and operationalized to realize the desired changes in Ethiopia's feed industry and livestock sub-sector. Hence, the results of the study suggest several policy implications and other key feed-related recommendations:

- The adoption of a given livestock feeding regime is not an isolated fact. Still, it needs to take into account complementary and supplementary factors among different feed types and feeding regimes as well as types of breeds. Thus, a broader systems perspective should be adopted to understand different livestock production systems in order to promote feed technology packages.
- The majority of livestock producers use grazing, possibly supplementing with crop residues, hay, or AIBPs. This shows that the best technologies will be those adapted to each livestock and agroecological zone. Therefore, to better assist livestock producers, the government should provide adequate training to livestock-focused extension agents to improve their knowledge of feeding practice options that can be used by livestock-producing households to supplement zero grazing with increased feed supply and the right type of feeds.
- All the policy and research documents reviewed in this paper acknowledge the urgency of increasing feed availability and quality to improve livestock productivity across Ethiopia. Therefore, public-private partnerships in the feed sub-sector are needed to overcome forage and feed shortages in various livestock production systems in the country. Additionally, efforts should be made to establish national and local innovation platforms relevant to forage seed multiplication and forage and feed development and marketing.
- Promote private sector involvement in the production of forage seed, forage, and livestock. This includes the large-scale production of soybean and maize as feed processing inputs, as stated in the National Feed Resources Development Strategy (2020-2035). Private-sector-led livestock industry in Ethiopia can be supported through capacity building and by ensuring an appropriate enabling environment for their engagement. Elements of an enabling environment include economic incentives, such as reforming the tax system to avoid any double taxation, duty-free imports of feed production inputs, exemption from income tax for livestock enterprises, reducing or eliminating taxes on exports, easing constraints on access to agricultural land, and providing comfortable lease periods for any land obtained for feed and fodder production.
- Strengthen the capacity of institutions engaged in livestock feed-related extension, research, and education. Build the capacity of livestock feed regulators so that they can more effectively oversee the operations of the livestock feed sector.
- Promote the establishment and use of oil extraction and flour milling factories so locally produced oil seed by-products can be made available for feed and discourage, through the use of taxes and quotas, their export (see Annex Table 3).
- Institutionalization of a feed security system will be necessary to make feed interventions effective in Ethiopia and the Horn of Africa region.

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7. ANNEXES

Annex Table 1 Summary of major livestock development projects and programs implemented in Ethiopia

Timeline	Policies, Programs and Projects	Key Objective, Major Components and Achievements, Lessons Learned
1964	The Livestock and Meat Board	-Improving marketing infrastructure for livestock and livestock products
1964	National Veterinary Institute	-Producing animal vaccines and disseminating them
1967	Support for National Artificial Insemination (AI) Service (SNAIS)	-Providing (AI) services
1967–84	Chilalo Agricultural Development Unit; Arsi Rural Development Unit	-To improve and promote meat and milk production in Chilalo *awraja* and Arsi (Staal 1995). Including -Production and distribution of crossbred heifers -Artificial insemination services -Animal health services -Forage production and marketing
1971	First Livestock Development Project	Supported commercial dairy development and milk processing around Addis Ababa. This led to the flourishing of dairy farms, both small and large. However, it later suffered from lack of sustainability and weak institutional support.
1972–1981	Addis Ababa Dairy Development Project	To increase milk supply for the Addis Ababa market through: -Developing commercial dairy production -Provision of dairy stock, marketing, and AI services -Expansion of Shola dairy plant -Providing support for smallholder producers through credit, imported cattle, and technical services in and around the Addis Ababa milk shed
1973–81	Second Livestock Development Project	-Market modernization of meat production through establishing slaughter facilities for provincial towns and cities -Constructing or improving stock routes and marketplaces for livestock -Facilitating livestock marketing -Integrating pastoral production with markets to enhance offtake (Gebremeskel et al. 2019). However, it suffered from lack of sustainability and weak institutional support.
1975-1984	Third Livestock Development Project	-To develop rangelands, including water and roads, in the pastoral areas. Investment for modernization and intensification aimed at transforming the livestock industry at large. -Opened underutilized grazing areas -Reduced livestock mortality -Improved market awareness and engagement -Addressed localized range degradation -Increased offtake of animals -Enhanced mobility in some areas (Gebremeskel et al. 2019) -Followed the Western ranching and feedlot/fattening model. However, it suffered from heavy losses during the years of drought. Overall, the project lacked sustainability, as it had weak institutional support.

Timeline	Policies, Programs and Projects	Key Objective, Major Components and Achievements, Lessons Learned
1986–1992	Dairy Rehabilitation and Development Project	-Cooperative dairy farm development through the introduction of crossbred cows, state farm development, and health services -To improve rural incomes and nutritional status of livestock producers and other smallholders -To improve operational efficiency and financial performance of the state dairy sector -To increase the supply of butter and milk to urban centers
1987–1991	Selale Peasant Dairy Development Pilot Project	-Dairy stock distribution and cooperative development -To increase sustainable smallholder dairy production in the highlands of Ethiopia (former Selale Awraja)
1987–90	Second phase SNAIS	-To provide efficient and reliable artificial insemination services -Strengthening of AI services at field level
1988–1994	Fourth Livestock Development Project	-To increase livestock and agricultural production in the major highland areas by improving animal health services and nutrition through feed and forage improvement. -To improve animal nutrition through activities such as improved forage production, intensive small-scale fattening, and adaptive research. -Improve range management and utilization by agro-pastoralists. -Successful introduction of several exotic herbaceous and tree legumes that provide high-quality fodder for livestock and enrich the soil. -Forage seed quality was a concern when produced by contract growers, as there was no quality control. -Small-scale fattening activity was based on feeding crop by-products supplemented with molasses and urea in block form. The approach was technically sound, but encountered practical difficulties in the supply of molasses (Mengistu 2002). -Cost sharing to sustain water points and animal health services. -Improve market linkages that increase offtake (Gebremeskel et al. 2019). -Later suffered from lack of sustainability and weak institutional support.
1991–1994	Selale Dairy Development Pilot Project (phase II).	-Enhancing milk processing and marketing aimed to organize small milk processing and marketing units that could raise income and the nutritional standards of smallholder farmers in two *woredas* in Oromiya and SNNP regions.
1995–98	Smallholder Dairy Development Project	-Aimed to improve the standard of living of smallholder farming families through a friendly development approach -Dairy stock distribution in 16 *woredas* in three regions -Distribution of breeding bulls -Milk marketing and processing -Fodder production -Agroforestry -Water development

Timeline	Policies, Programs and Projects	Key Objective, Major Components and Achievements, Lessons Learned
1999–2002	National Livestock Development Project	-Aim of livestock health and breed improvement and integration of livestock in mixed farming systems -Production of leguminous fodder crops on arable areas and other types of underused land -Livestock production improvement support -Establishment of seven regional AI sub-centers, a bull dam farm, and training of artificial insemination professionals -Animal health services expanded -Forage pasture improvement throughout the country
2005–2011	SNV Ethiopia's Value Chain Development Program	-Aimed to enable small farmers in Ethiopia to adapt their production and arrange for more profitable market outlets for their produce through improving business-to-business relations based on vertical linkages in value chains.
2005–2011	Improving Productivity and Market Success of Ethiopian Farmers (IPMS) project	-Aimed at developing a more efficient system for market-oriented agricultural development. -Adopted and adapted best practices from across the world to transform subsistence cattle, small ruminants, and poultry production into more commercial systems. -Interventions focused on core segments of the value chains, including inputs (feed and veterinary products and services), production (breeding and fattening), and marketing (clustering, quality improvement, and storage and processing) (CIDA 2005). -Improved fodder production, greater use of crop residues, credit supply, and linkages with input and output markets resulted in close to doubling the number of animals undergoing fattening. -Growth in revenue from ETB 46 million (US$5.3 million) to ETB 120 million (US$8.9 million). -Adoption of exotic chickens combined with improved feed and management practices led to a 29 percent increase in egg productivity and a revenue increase from ETB 1 million (US$116,000) to nearly ETB 4 million (US$295,000) (Gebremedhin et al. 2012).
2009-2013	Feed Enhancement for Ethiopia Development (FEED-I) project	The aim of the project was: -To boost access to and use of high-quality feed for livestock. -To stimulate additional animal feed production and increase its availability and affordability through training and technical assistance. -Trained 18,000 model farmers and established 13 cooperative union-based feed manufacturing enterprises. The cooperative union-led feed enterprises increased national finished feed production capacity by 50 percent. -Ninety percent of trained smallholder farmers adopted better ways to grow and preserve forage on their own land. -Improving feed quantity, quality, and management increased milk production per household by 80 percent, supporting more milk per cow, and more cows per household. -Project reduced the time needed to fatten cattle for market by 28 days, reducing the amount of feed needed by 10 percent. -Household egg production increased over seven-fold. -Value of household livestock and forage-related sales increased by 48 percent (ACDI/VOCA 2021).
2012–2015	Agriculture Growth Program–Livestock Market Development Project	Aimed to improve smallholder farmer incomes and nutritional status through investments in livestock value chains, including beef, dairy, and hides.

Timeline	Policies, Programs and Projects	Key Objective, Major Components and Achievements, Lessons Learned
2013-2017	Feed Enhancement for Ethiopia Development (FEED-II) project	-To scale up the success of the first phase of the FEED project -Trained 40,000 model farmers -Established 12 additional cooperative union-based feed manufacturing enterprises (ACDI/VOCA 2021)
2013–2018	Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) Project	-To contribute to the enhanced income of smallholders and other value chain actors through increased and sustained markets to off-take high-value livestock and irrigated crop commodities. -To scale out successful approaches and interventions in high-value livestock value chains for income generation in a gender-balanced and environmentally sustainable manner (ILRI 2014). -Interventions in cattle, sheep, poultry, and feed value chains resulted in several outputs highlighting lessons learned and implications for scaling out. For instance, the use of choppers needs to be a priority in irrigated areas where the availability of stover and other coarse green feeds is abundant. Linking chopper services with cooperatives, cooperative unions, and youth groups can be an effective option. Silage and urea treatment using plastic bags needs to target farmers with a small number of animals (Mekonnen et al. 2019).
2018-2022	Feed Enhancement for Ethiopia Development (FEED-III) project	-To scale up feed production by strengthening capacity and improving coordination with the private sector. -Trained 42,000 model farmers. -The number of retail feed outlets grew to 395, putting almost 1.8 million agriculture households within 10 miles of a sales point (ACDI/VOCA 2021).

Source: Ahmed et al. (2003); Ergano et al. (2013); Malabo Montpellier Panel (2020) and authors literature review.

Annex Table 2 Ethiopian feed-related regulatory institutions

Timeline	Regulatory institutions	Objectives
2010	The Ethiopian Standards Agency (ESA)-Regulation No. 193/2010	To enable manufacturing and service-providing organizations to be competitive in internationally accepted management systems. The ESA specifies the requirements for the different animal feedstuffs for use as animal feed ingredients and compound feeds. However, the standards have not yet been implemented.
2012	Veterinary Drug and Animal Feed Administration and Control Authority (VDAFACA) Regulation no. 272/2012	To regulate the delivery of safe and quality feed and effective veterinary drugs and to register manufacturers, importers, and wholesalers of veterinary drugs, equipment, and feed, thereby ensuring a clear role for private entrepreneurs in the livestock sector.
21 April 2022	Ethiopian Agricultural Authority (EAA)-regulation no. 509/2022	Accountable to the Ministry of Agriculture to establish and implement a strong regulatory system in the agricultural sector to improve international and national competitiveness and to minimize or eliminate harmful impacts on human, animal, and plant health and the environment (Federal Negarit Gazette, April 21, 2022).
24 July 2023	Ethiopian Agricultural Authority (EAA)-Seed Proclamation no. 1288/2023	To supply improved varieties of quality seed in the required amount to producers by putting in place a sustainable seed system. The purpose is to enhance the contributions of seed systems to ecosystem services and to ensure that private and public seed companies can participate and be competitive in global markets. Additionally, the proclamation seeks to strongly enhance the seed sector`s contribution to research, introducing improved technology to farmers and its adoption by them to enhance crop production, productivity, and product quality (Federal Negarit Gazette, July 24, 2023).

Source: Compiled by authors

Annex Table 3 Potential intervention options to overcome forage and feed shortages in various livestock production system in Ethiopia

Potential Intervention Options to Overcome Forage and Feed Shortages in Highland Areas	Potential Intervention Options to Overcome Processed Feed Shortages in Highland Areas	Potential Intervention Options to Overcome Lowland Pastoral and Agro-pastoral Feed Shortages
1. Facilitate the adoption of more productive forage production technologies, including over-sowing with improved grass and legume species, bush clearing, and thinning from grazing fields. Use improved forage varieties with better management techniques. Enhance crop residue quality using urea and urea-molasses mixture treatment. Improve forage and feed handling and storage. Improve ration formulation for supplementary feeding and cattle fattening practices.	1. Make large plots of land and credit available to investors at reduced rates to encourage them to invest in large-scale commercial animal feed production and processing operations.	1. Provide herd management training to pastoralists on camel, sheep, goats, and cattle husbandry, pasture production and management, feed storage practices, and crop residue improvement and utilization.
2 Make forage seed production training available and encourage regional Bureaus of Agriculture and other actors to train development agents in the use of forage production technologies.	2. Revisit the animal-feed tax policy to avoid double taxation; grant periodic tax exemptions for feed ingredients and compound feeds to nurture industry growth; and encourage increased private investment.	2. Promote ecologically sound water point development in lowland areas to avoid localized range degradation, soil erosion, and gully formation that reduces the potential to produce good quality forage.
3. Support MoA and state research institutes to provide capacity-building support to research centers and seed enterprises.	3. Implement the Ethiopian Proclamation on feed quality standards, feed safety control, and import, export, and feed trade.	3. Promote herd mobility as a strategy to utilize temporal and spatial variability in forage availability.
4. Encourage federal and regional government officials and investment agencies to make land—that is fertile, irrigable, and close to markets—and credit services available to investors interested in forage seed and feed production. Doing so will ensure sufficient supply for emerging market-oriented livestock operations, e.g., feedlots and peri-urban dairy.	4. With policymakers and other stakeholders, establish accreditation of private analytical service laboratories to ensure quality feed production.	4. Promote bush clearing and thinning and the use of controlled burning as a range management technique to increase the production of good quality forage.
5. Improve the linkages between crop and livestock production by promoting the use of crop residues for animal feeding and manure recycling as fertilizer on crop farms.	5. Promote the establishment and use of oil extraction and flour milling factories so oil seed by-products are produced locally for feed and discourage, through the use of taxes and quotas, their export.	5. Raise awareness on the development of feed reserves to help minimize seasonal feed shortages and mitigate the effects of drought on livestock.
6. Encourage collaborative, systems-orientated research in which crop, livestock, and natural resource researchers participate in the development of multipurpose crop varieties with high grain and good quality stover yields. Multi-purpose crop varieties will have a high potential for adoption, scaling, and impact.	6. Promote private investment in large-scale production of soybean and maize as inputs for feed processing. This can be done by facilitating land acquisition and providing tax incentives for both large- and small-scale feed formulation and processing companies.	6. Improve early warning systems to reduce climatic-induced hazards related to feed shortages.
7. Integrate natural resource management (NRM) activities with livestock feed production by growing species on degraded land to rehabilitate degraded grazing lands. The biomass in these systems can be used as cut-and-carry fodder to support the recent initiative related to controlled grazing systems in Ethiopia.	7. Organize policy dialogues for relevant stakeholders and policy-makers to raise awareness of the critical importance of livestock feed.	

Potential Intervention Options to Overcome Forage and Feed Shortages in Highland Areas	Potential Intervention Options to Overcome Processed Feed Shortages in Highland Areas	Potential Intervention Options to Overcome Lowland Pastoral and Agro-pastoral Feed Shortages
8. Integrate reforestation activities with livestock production by incorporating multipurpose tree species, like *Leucaena*, *Sesbania*, and *Tagasaste*, with NRM interventions. Fodder from these species can be used as a protein supplement for livestock subsisting on low quality crop residues and grasses.	8. Encourage key stakeholders involved in the feed supply chain to organize visits to other countries to learn from their experiences in developing efficient feed processing industries.	
9.Improve the quality and quantity of planted fodder in high-potential areas and natural grazing in low-potential areas. Increase the use of low-cost, high-quality feed combined with continued genetic improvements and expanded animal health services (World Bank 2012)	9. Encourage relevant state and non-state actors to organize awareness-raising meetings on the development of storage for processed feeds and related ingredients to help minimize seasonal price fluctuations.	
	10. Support Development Agents to offer farmers training on animal husbandry, forage production and management, crop residue treatment and utilization, feed handling and storage, ration formulation, and cattle fattening practices.	

Source: Shapiro et al. (2015); Literature review by authors.

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