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Poultry Production and Consumption True-Price Accounting in Ethiopia

Getachew Legese Feye[1], Tamrat Gebiso Challa[2], Tadele Mamo[3], Samuel Diro[4] and Temesgen Jembere[4]

[1]International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia
[2]Private Consultant, Addis Ababa, Ethiopia
[3]Ethiopian Institute of Agricultural Research, Socioeconomics Research Directorate, Addis Ababa, Ethiopia
[4]Ethiopian Institute of Agricultural Research, Holeta Agricultural Research Center, Holeta, Ethiopia

Abstract

In Ethiopian agriculture, poultry farming plays a significant role in balancing nutrition and creating jobs. The structure, production methods, economic performance, and externality costs of poultry farming in Ethiopia are analyzed in this study, with a particular emphasis on broiler and layer production in four urban and peri-urban areas surrounding Addis Ababa. Almost half of the poultry farms are located in Addis Ababa, while the rest are found around Bishoftu and Adama. Large-scale operations are uncommon in broiler production, which is dominated by medium-sized farms (58%) that use deep litter systems (96%). Ethiopian egg production is comparatively animal welfare-friendly when compared to caged systems that are prevalent elsewhere, since layer production is primarily small-scale (67%), with less than 1,000 birds per farm and a similar predilection for deep litter housing. The result further shows that both broiler and layer (table-egg) production farms are financially viable. Emissions of greenhouse gases (GHGs), mostly from the production of feed and the handling of manure, are the main source of external costs. GHGs are responsible for 71% of environmental costs in egg production, while manure management alone is responsible for 59% in broiler farming. The second biggest environmental burden is air pollution. Despite being lower, social costs are nevertheless substantial and are mostly caused by health hazards and underpayment. The cost shares of gender discrimination and child labour are negligible. Current prices understate the full social cost of poultry products when market and external costs are taken into account. Market pricing only makes up a portion of the true price, which is $0.199 per egg and $4.99 per kilogram of chicken meat. Though it has high hidden environmental and social costs, Ethiopian poultry production is often characterised by small- and medium-scale, welfare-friendly systems. Sustainable sector development requires reducing these externalities through better management of feed and manure, energy efficiency, labour standards, and market openness.

Keywords: *Broiler; Layer; True cost, True price, Environmental cost; Green gas emission; Social cost*

Introduction

Raising chickens plays a vital role in reducing poverty and promoting economic development, particularly for resource-poor households. In Ethiopia, especially in cereal-producing regions where protein deficiency is common, poultry farming contributes significantly to addressing malnutrition (Dessie et al., 2003). Beyond its nutritional benefits, poultry production is crucial for national economic growth. It serves important social, cultural, and religious purposes and enhances food security, generates income, creates jobs, and lifts households out of poverty (Alemayehu et al., 2018).

Poultry products, particularly meat and eggs, are nutritionally rich and represent some of the most balanced sources of animal protein essential for human health (Perić et al., 2011). Driven by population growth, urbanisation, and rising living standards, Ethiopia's demand for poultry products is steadily increasing. Despite this growing demand, the poultry sector remains small and underdeveloped, though promising signs of expansion are evident.

According to FAOSTAT (2025), Ethiopia recorded its lowest poultry population ever in 2021, with around 41 million birds. Since then, the population has rebounded to approximately 55 million, primarily consisting of scavenging chickens along with commercial layers and broilers, with broilers making up the majority of the commercial segment. Furthermore, the poultry population has been growing at an accelerating rate since then (see Figure 1).

Poultry farming is accessible to a wide range of socioeconomic groups, from landless rural residents to urban entrepreneurs, due to its relatively low capital investment and space requirements (Wilson, 2021). However, national consumption of poultry remains extremely low, with per capita chicken meat consumption at just 0.6 kg per year, significantly below the Sub-Saharan African average of 2.3 kg (USDA Foreign Agricultural Service, 2017). Likewise, per capita egg consumption is only 0.34 kg (WorldAtlas, 2025).

Poultry production in Ethiopia is almost exclusively limited to chickens (*Gallus domesticus*), with other domesticated birds such as ducks, turkeys, and geese rarely present. Indigenous breeds dominate the sector, accounting for more than 90% of the chicken population, while hybrid and exotic breeds make up only 4.7% and 4.3%, respectively (Fekadu et al., 2022). Backyard production remains the dominant system, involving more than 95% of national output, with most households keeping between five and six chickens (Sime, 2022).

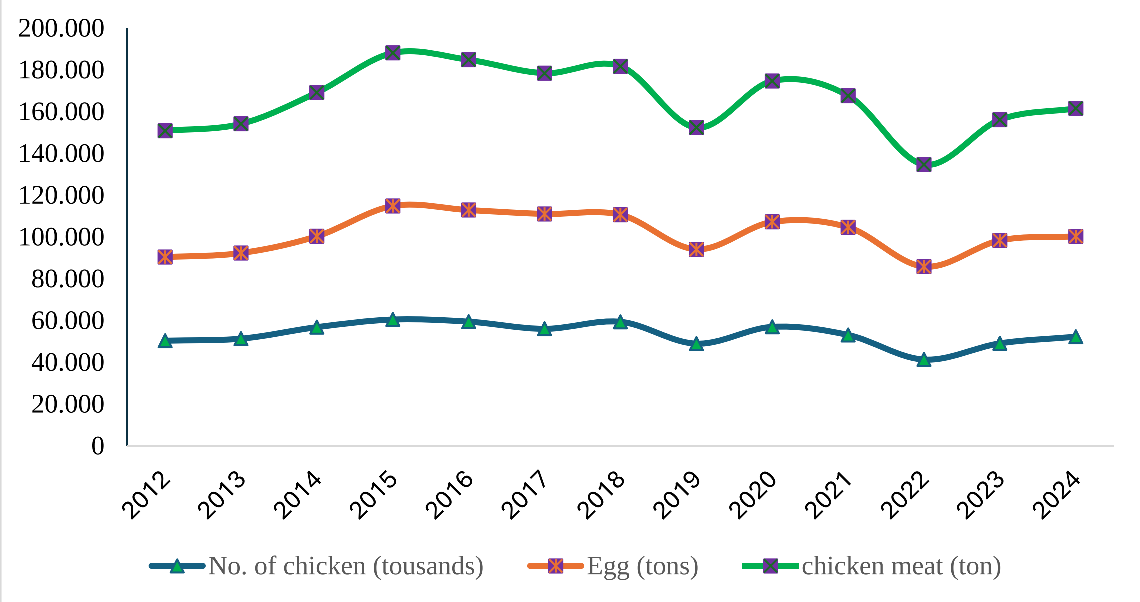

Figure 1. Poultry population, chicken meat, and eggs production trends in Ethiopia

Poultry production systems in Ethiopia are categorized into four types based on scale and management intensity (Urgesa, 2023):

1. **Large-scale commercial systems**: Intensive operations with exotic breeds, advanced housing, structured feeding, health care, and strict biosecurity.
2. **Medium-scale commercial systems**: Moderate flocks, improved breeds, structured housing, and basic veterinary services.
3. **Small-scale commercial systems**: small flocks, dual-purpose breeds, minimal inputs, and limited access to health and technology services.
4. **Village/backyard systems**: Low-input, scavenging-based systems relying on indigenous breeds with limited or no formal management.

These classifications reflect the diversity and complexity of poultry farming in Ethiopia (FAO, 2019; Woldegiorgiss et al., 2017).

Despite its growth, the poultry sector faces sustainability challenges. Conventional intensive systems are resource-intensive and associated with environmental degradation, water pollution, and the development of antimicrobial resistance due to the widespread use of antibiotics (Bist et al., 2024; Bourn et al., 2005; Gržinić et al., 2023). Globally, concerns about the sustainability of intensive poultry production have led to calls for more ecologically sound, economically viable, and socially responsible production systems (Castro et al., 2023; Leinonen & Kyriazakis, 2016). Sustainability in chicken production systems is vital not only for preserving natural resources and reducing environmental impact, but also for ensuring animal welfare and poultry farmers' livelihoods (Castro et al., 2023; Jez et al., 2011; Vaarst et al., 2015). The health of humans and animals is threatened due to antimicrobial resistance that is developed by the growth promoters of antibiotics (Castanon, 2007; Ma et al., 2021).

Sustainable poultry farming is defined by the integration of environmental stewardship, economic resilience, and social responsibility (Brundtland & Khalid, 1987; Vaarst et al., 2015). It aims to harmonize four interdependent pillars:

- Environmental sustainability: Reducing ecological footprints, conserving resources, and managing waste and emissions effectively.
- Economic viability: Ensuring profitability, market adaptability, and financial resilience for producers.
- Social responsibility: Upholding animal welfare, fair labor practices, and community engagement (Bist et al., 2024; Valentin & Spangenberg, 2000).
- Technical sustainability: Ensuring efficient and effective production systems (Lynch et al., 2021; Vaarst et al., 2015).

Sustainable poultry farming promotes the welfare of present and future generations by addressing four interrelated foundations (Figure 2).

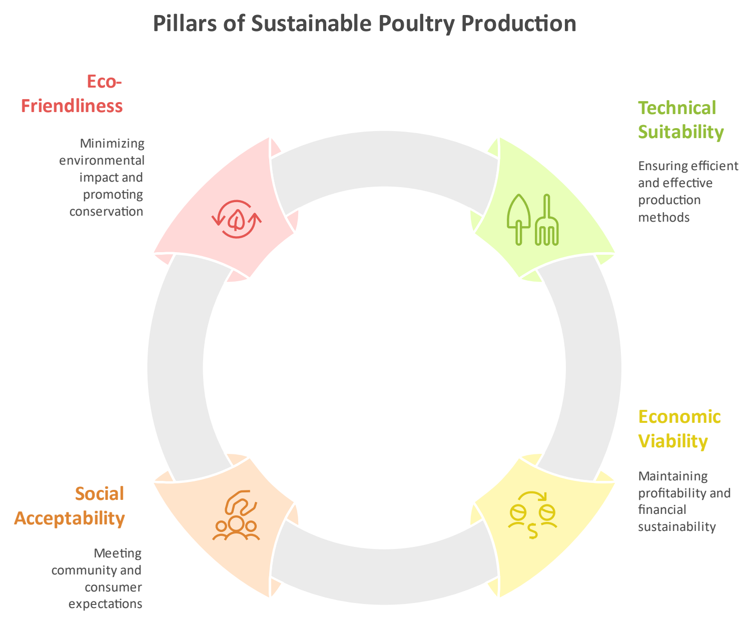

Figure 2. The four pillars of sustainable poultry production (Lynch et al., 2021)

Poultry production generates relatively low greenhouse gas (GHG) emissions compared to other livestock systems, contributing only 0.64% of agricultural GHG emissions due to its efficient feed conversion rates. However, it still poses significant environmental threats (Vaarst et al., 2015). This is because large-scale poultry operations produce significant amounts of waste, including ammonia and nitrous oxide, which can pollute water sources and contribute to global warming (Seidavi et al., 2019; WANG et al., 2017).

To address these multifaceted challenges, a more comprehensive evaluation framework is required, one that extends beyond productivity and profitability. Recent scholarship increasingly emphasizes holistic tools that account for ecological, social, and human health impacts when assessing food systems (Baker et al., 2020). A promising approach in this regard is True Pricing, which quantifies the externalities of production, such as environmental damage or labor violations, and incorporates them into the final product cost (Davidsen et al., 2021; Galgani, Woltjer, De Toorop, & De Groot Ruiz, 2021). Unlike conventional market pricing, true pricing seeks to internalize costs currently borne by society or the environment, thereby aligning prices more closely with a product's actual impact.

Building on a rights-based interpretation of the UN Guiding Principles on Business and Human Rights, true pricing monetises environmental and social externalities, such as GHG emissions, air pollution, scarce water use, land degradation, underpayment, and health and safety risks, and adds them to market prices to obtain a “true price” of products (Galgani et al., 2023; True Price Foundation & Impact Economy Foundation, 2020). Although TCA has been applied to several food commodities, to our knowledge, there are no empirical true pricing assessments of poultry products in Ethiopia and very few in sub-Saharan Africa.

This study addresses this gap by applying a cradle-to-grave true cost accounting framework to commercial poultry production in central Ethiopia, following Life Cycle Assessment, among other methodologies (Arendt et al., 2020). Using primary data from broiler and layer farms and secondary data on emission factors and monetization coefficients, we quantify environmental and selected social externalities of broiler meat and egg production and express them as product-level true prices. Specifically, we (i) characterise the structure and economic performance of commercial broiler and layer farms; (ii) quantify environmental footprints for key impact categories (GHG emissions, air pollution, scarce water use, land occupation and land transformation, and fossil fuel depletion) alongside social externalities (underpayment, insufficient income, health and safety risks, child labour and gender discrimination); (iii) monetise these externalities and compare true prices with observed market prices; and (iv) identify priority leverage points to reduce external costs in Ethiopia and in similar rapidly expanding poultry sectors in low- and middle-income countries.

Research methodology

A rights-based approach, which assesses external costs using accepted frameworks and principles about social and environmental justice, is the foundation of the true pricing methodology. The concept of monetizing the environmental and social externalities is embedded in Article 22 of the Guiding Principles on Business and Human Rights (UN OHCHR, 2011). The "true price gap", which accounts for external costs not currently included in market transactions, is added to the market price to determine the true price of a good or service. The following four categories of remediation costs are taken into consideration when evaluating external costs using a systematic framework: (1) Restoration: the expenses necessary to return social or environmental circumstances to their pre-crisis level. (2) Compensation: expenses incurred to fairly compensate impacted communities or individuals. (3) Prevention of recurrence: measures or investments to stop comparable injuries in the future, and (4) Retribution: punishments or corrective actions taken in reaction to transgressions or injuries inflicted. By ensuring that pricing accurately accounts for the entire social and environmental impact of production and consumption, this all-encompassing strategy fosters more equitable and sustainable economic systems.

According to Galgani et al. (2023), a true pricing has nine steps that are implemented in four stages. A previous study specially done on broiler production (Harmens, 2023) have been used as an example. The stages and steps we followed in True Price Assessment are given in Figure 3 based on their order.

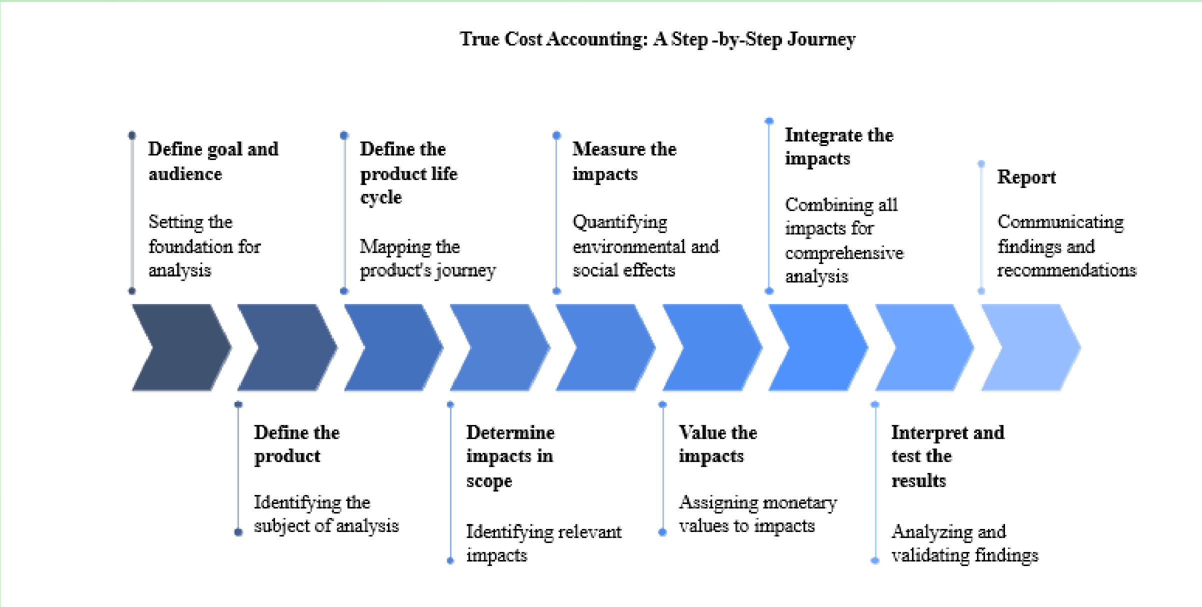

Figure 3. True Cost Accounting: A Step-by-Step Journey

The first stage has only one step at which the goal and audience of the research are defined. The second stage consists of three steps (steps 2 to 4), including defining the product, defining the product life cycle, and determining the impacts in scope. The third stage of true cost accounting is the measure and value stage. The steps 5 to 7 included under this stage are measuring the impacts, valuing the impacts, and integrating the impacts. The last stage, the reporting stage, consists of steps 8 and 9, which are the interpreting and testing the results and reporting steps. Each step of true cost accounting is discussed and explained below for this study.

Stage one

This stage has one step, which is defining the goal and audience of the study. The objective of this True Price Accounting (TPA) activity is to estimate the True Price of poultry products, specifically broiler meat and eggs, in Ethiopia. In general, the study aims to provide a comprehensive overview of the environmental and social impacts associated with poultry production, thereby informing stakeholders such as investors, policymakers, and consumers about hidden externalities and enabling more sustainable decision-making.

This study was conducted by administering a brief survey to medium and small-scale producers in Adama and Bishoftu (East Shewa Zone of the Oromia Region), and the capital city, Addis Ababa. Quantitative data were collected using a structured questionnaire from the sampled households, and the interview was conducted in person, face-to-face. The COBO TOOLBOX program, which simplified data entry, monitoring, and supervision, was used for data gathering. The accuracy and dependability of the data were guaranteed by skilled enumerators who adhered to a rigorous training regimen. An intensive desk review of published journal articles, guidelines, production manuals, and websites was conducted to collect secondary data on standardized and specific emission factors, emission monetization values, and other relevant information.

A true pricing study can be a stand-alone or comparative assessment. A stand-alone assessment focuses on a single product, while comparative assessments are designed to compare the true price of two or more products (Galgani et al., 2023). In this study, the true cost for two distinct poultry products (meat and egg) is assessed separately. Hence, this analysis follows a stand-alone analysis procedure that focuses on poultry meat and eggs.

Stage two

The second stage includes three steps: defining the product, defining its life cycle, and identifying the impacts in scope. Under the product specification step, the functional unit, reference year(s) for data, and currency of results are specified (Table 1). As discussed in the introductory section of this document, four major poultry production systems are found in Ethiopia, including backyard household systems. However, this study is restricted to intensive poultry production systems, encompassing broiler and layer enterprises at large, medium, and small scales. Hence, the products are chicken meat measured in kilograms (kg) and egg measured in number of eggs. So, the functional units used are kg for meat and the number of eggs, while the true cost assessment is calculated based on kg of meat and the unit egg. The reference year for the data employed in this assessment is 2025. The data were collected from 271 commercial poultry farms in central Ethiopia. The financial, monetized environmental and social costs were first estimated in Ethiopian Birr and then converted into USD.

Table 1. Overview of the product definition

Item	*Classification*
Product type	Broiler meat and egg
Functional unit	A kilogram of chicken meat and an egg
Currency	US dollar
Monetary unit	USD/kilogram
Production location	Ethiopia
Reference year data	2025

Following the product definition, the next step is to define the stages included in the product's lifecycle analysis (LCA), specifically the system boundaries. This involves two main activities: mapping the product lifecycle and selecting the relevant lifecycle stages. LCA typically follows one of two main approaches: cradle-to-grave or cradle-to-gate. In this study, a cradle-to-gate approach is adopted for the sake of simplicity. As outlined by Kang et al. (2025), the stages involved in broiler meat production include feed production, broiler production, slaughtering, meat processing, and transport for distribution. This analysis focused only on feed production, raw materials transportation, and meat/egg production processes.

The assessment stops at the point where the finished product exits the production site, before it is transported to retailers or consumers. Therefore, the retail and consumer-use phases are excluded from this analysis. This exclusion assumes that these later stages contribute minimally to the overall environmental externalities associated with broiler meat and eggs. Furthermore, broiler meat consumption in Ethiopia is more common in one's own house than in cafeterias and hotels. Hence, the cost of externalities can be assessed along the three main sectors' value chain- the input sector, production, and processing of the outputs (meat and eggs) (Figure 4).

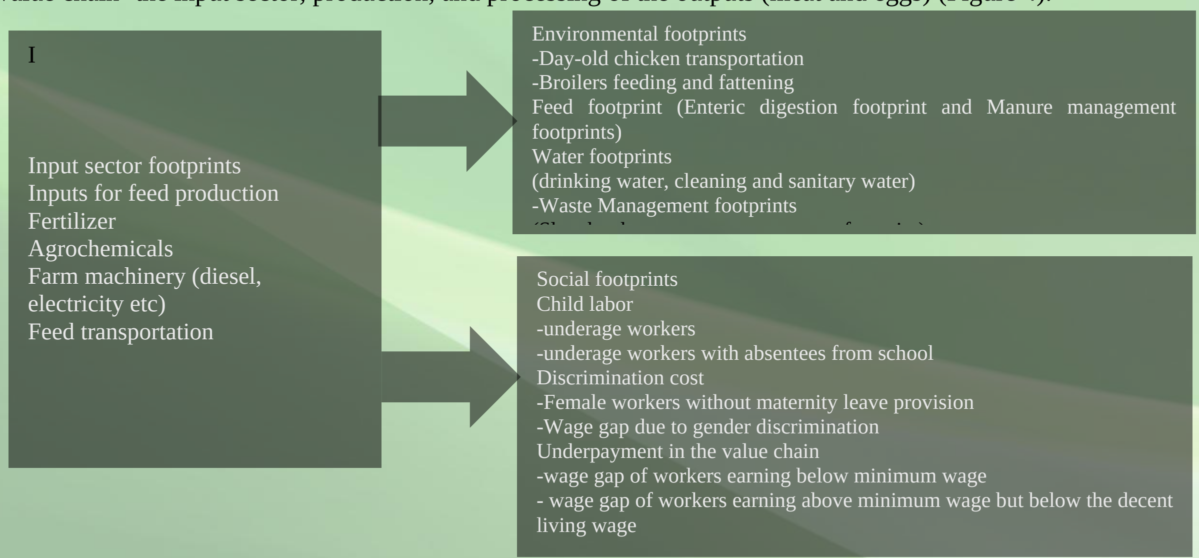

Figure 4. System boundary for chicken meat and egg production: true cost accounting

The final step in the second stage is to determine the impacts within scope. Environmental impacts are broadly associated with resource consumption, land use, and greenhouse gas emissions. Social impacts refer to the adverse consequences of economic activities for workers and their families, for communities and entire regions, for the global community, and for consumers. This step specifies which societal effects are to be included in the TPP valuation and at which points in the value chain these effects are considered material. A standardized list of social and environmental impacts to be considered in true pricing—applicable to any product, sector, or country- is provided by Galgani et al. (2023) and summarized in Table 2.

True Price Foundation Indeed, based on the Global Reporting Initiative (GRI, 2021), material impact is a negative effect that represents a 'violation of internationally recognized responsibilities of businesses in relation to human rights, labour rights, or environmental rights (and other stakeholder rights)' (True Price Foundation & Impact Economy Foundation, 2020). Moreover, as the true price assessment is a ranking of impacts, we can determine that an impact is material if and only if it is likely to make a significant contribution to the true price gap. An important relevant list of impacts in poultry (meat and eggs) production is listed as follows (Table 2).

Table 2. List of impacts relevant for true pricing.

Environmental impacts	*Social impacts*	*Animal welfare*
Contribution to climate change	Child labour	Breach of indigenous rights
Air pollution	Gender discrimination	Breach of land rights
Water pollution	Underpayment in the value chain	Occurrence of corruption
Soil pollution	Lack of social security	Tax evasion
Land use/occupation	Excessive and underpaid overtime	Deliberate misinformation/lack of transparency
Land transformation	Living income	Negative effects of consumer health & safety
Fossil fuel depletion	Occurrence of harassment	Breaches of privacy
(Other) non-renewable material depletion	Negative effects on workers' health and safety	
Scarce water use	Negative effects on community health and safety	

Stage three measure and value stage

Measuring the impacts comprises three steps (Steps 5–7). The first step is to measure and quantify the in-scope impacts per functional unit, i.e., per kilogram of broiler meat or eggs in this study. This step involves four sub-steps: (1) identification of footprint indicators (quantified social or environmental impacts expressed in equivalent units). In this sub-step, all footprint indicators for each impact are listed; for example, contribution to climate change is an impact, whereas greenhouse gas emissions represent its footprint indicator. (2) Collection of process data, (3) quantification of the footprint indicators, and (4) scaling of the results to the functional unit.

The following environmental and social impacts associated with true pricing are described in terms of their definitions, indicators, and monetization factors, which are primarily derived from the ReCiPe life cycle assessment methodology.

Environmental impacts of poultry production

Contribution to climate change: This impact is characterized by greenhouse gas (GHG) emissions, expressed in kilograms of CO_2 equivalents (kgCO_2e). Although per-animal GHG emissions from poultry are relatively small compared with other livestock species, the large global poultry population results in a substantial contribution to overall GHG accumulation. Studies indicate that 30–50% of the live weight of slaughtered poultry consists of by-products that are wholly or partially wasted. The poultry industry is also expanding worldwide, creating employment opportunities and contributing to poverty reduction; however, this growth is accompanied by the generation of considerable amounts of waste. Poultry waste includes significant volumes of wastewater and solid waste such as bedding, feathers, hatchery waste, blood, offal, eggshells, and manure/litter. In this study, CH_4 and N_2O emissions were converted to CO_2 equivalents (CO_2e) using their global warming potentials (GWP), namely 1 for CO_2, 25 for CH_4, and 298 for N_2O. The contribution to climate change was calculated based on the CO_2e of methane and nitrous oxide emissions from poultry manure (litter) and slaughterhouse waste management, which have considerable potential for value-added utilization similar to large-animal slaughterhouses. Poultry litter refers to the mixture of poultry manure with feed waste, feathers, and bedding materials such as wood shavings or sawdust (Gržinić et al., 2023).

Hence, in this study, the GHG emission from poultry was calculated from CO_2 emissions from land use change, fertilizer production, and machinery use, electricity and fossil fuel use for heating, lighting, and processing, processing plants and transportation of feed, birds, and products, Methane (CH_4) from anaerobic decomposition of manure, Nitrous oxide (N_2O) from nitrification and denitrification in manure storage. In calculating the feed intake for the layers, we considered the point of lay (week 20-72), which is the egg production phase. The period from day-old chick to point of lay (week 20) is considered an investment cost. We set the assumption that layers serve only for the egg. However, feed intake for broilers is considered from the first day of the chicks' hatch. To estimate the footprint from the transportation of inputs by animal-drawn cart, a horse was considered. We assumed a horse can travel an average of 25 km/day and emit CO_2 equivalent emissions of 4233 kg per year or 0.48 kg CO2 eq. per hours (Huisman et al., 2025). The total CO_2 emissions cost per egg or kg of broiler meat was calculated based on the distance covered or hours spent by a horse cart on the farm.

The emission factor for poultry composite feed is considered based on the findings of Kim et al. (2022) since the feed ingredients are not uniform throughout the sample farms. Accordingly, it was estimated that a layer consumes a total of 42.46 kg/year from the day it starts laying an egg, and a broiler consumes 6.52kg of composite feed through its lifetime (Capital Foods, 2023). Based on Kim et al (2022), the average CO_2eq emission per edible weight of a broiler is 5.5 kg, where the total feed consumption per 42 days is 6.52 kg, and the mean edible weight of a broiler in Ethiopia is estimated to be 2.54 kg. This implies that the CO_2eq emission per kilogram of composite poultry feed is 0.84 kgCO_2eq, while the average kgCO_2eq emissions per a broiler bird throughout its lifetime and that of a layer bird per year are 5.5 kgCO_2eq and 35.84 kgCO_2eq, respectively. The average egg production of a layer hen is also estimated to be 267 eggs per year. Hence, based on these assumptions, the respective kg CO_2eq emission per egg and per kilogram of broiler meat are 0.13 and 2.17 kg CO_2eq, respectively. The monetization factor for CO_2 emission is 0.05US$, and hence, the cost per egg and kg of meat is 0.007US$ and 0.108US$, respectively.

Water footprint: This is another important source of emissions in poultry production. In poultry production, water is consumed at feed production, poultry farming, and processing (for broiler) stages, while feed production accounts for 98% of the whole water consumption (Mekonnen & Hoekstra, 2012), and the emission by this amount (the 98% of total water) is considered under the feed production. Hence, we calculated water consumption footprint emissions at the farming and processing (broiler meat) stages. Based on Mekonnen & Hoekstra (2012), the total water consumption throughout the lifetime of a broiler bird and a layer bird per year is 6m^3 and 33m^3, while the 2% we considered here are 120 liters and 660 liters, respectively. This implies that the water footprint per egg and per kg of broiler meat is 2.47 liters and 47.24 liters, respectively.

Hence, the restoration cost, which represents the yearly desalination charges, is referred to as scarce water consumption. Along with costs associated with covering and repaying the initial capital investment and operational expenditures for desalination, these also include expenses for electrical and thermal energy, as well as expenditures for operation and maintenance (World Bank, 2012).

Slaughterhouse waste management: It is one of the contributors to climate change. The survey results in our study show that slaughterhouse waste disposal in the study areas is mainly done by landfilling. Research by Hyvärinen (2024) shows that there is a substantial amount of methane emissions from the landfilling method of disposal. The value of methane emission ranges from 0.27 – 0.34 m3/kg of waste, which is equal to 6.75 – 8.5 kg CO_2 eq/kg of poultry by-product from the slaughterhouse. We took the average of the ranges, which is 7.63 kg CO_2 eq/kg of poultry by-product (Salminen et al., 2003).

Air Pollution: This includes human toxicity and various pollutants, measured in Disability Adjusted Life Year (DALY) and kilogram (kg) of specific pollutants. However, in this study, particulate matter (PM) formation is considered to estimate the air pollution effects of poultry farms. The unit for the impact is kg $PM_{2.5}$ equivalent. In addition to this nitrogen deposition from Animal Husbandry (in stables) and the use of poultry litter as manure. Based on European Union central damage cost for NH_3 emissions which is 11US$/kg NH_3, and the fact that true pricing studies usually scale Value of a Statistical Life (VSL) proportionally to GDP per capita (PPP); where EU GDP per capita (PPP) ≈ $45,000, Ethiopia GDP per capita (PPP) ≈ $3,300 (according to 2024 IMF estimate), then the ratio is 3,300 / 45,000 ≈ 0.073. The scaled factor will be 0.073*11US$ = 0.8 per kg of NH_3. This can be adjusted for ecosystem exposure and become 0.78 US$ per kg of NH_3**.**

Pollution of the living environment (water and soil pollution): Emissions contributing to ecotoxicity and eutrophication, measured in kg of pollutants and DALY. Poultry production (broiler or egg) can contribute to water and soil pollution through its value chain, particularly at the poultry feed production stage, by leaching of nutrients such as phosphorus and nitrogen into soil and water bodies. Similarly, direct water pollution by poultry can be assumed to be contributed to by waste disposal into water bodies. In this study, we tried to consider the pollution due to poultry waste disposal in water bodies. However, the survey result shows that there is no waste disposal directly to water bodies. In addition, since we estimated emissions of composite feed, we didn't consider water pollution due to the feed separately. Hence, there is no water and soil pollution considered in this analysis.

Land Degradation: Includes land occupation and land transformation (land use change), measured in Mean Species Abundance per hectare per year (MSA*ha*yr) and Mean Species Abundance per hectare (MSA*ha), respectively. Overall Impact, commercial poultry farming has negative effects on Mean Species Abundance (MSA), especially when the farming is intensive and unregulated. The commercial poultry production system lowers MSA by reducing habitat quality and availability, increasing pollutants and disease, and causing direct and indirect mortality to native species. According to the GLOBIO model, which estimates MSA under different land-use scenarios, intensive agriculture and livestock production (including poultry) are among the top contributors to global biodiversity loss (Alkemade et al., 2013). MSA value for intensive poultry farming type is estimated from 0.1 – 0.3, where the production system is characterized by high-density production, heavy land transformation, significant pollution, and feed demands. For extensive (small-scale farming) characterized by lower density, some integration with local ecosystems, and less land clearing, the same value ranges between 0.4 and 0.6 (Alkemade et al., 2013). Hence, the highest value of degradation (0.2), where about 80% loss in species abundance or 80% of the ecosystem is lost, is considered.

Depletion of scarce abiotic resources: Fossil fuel depletion is one of the footprint indicators for the depletion of scarce abiotic resources. Fossil fuel depletion in poultry production refers to the consumption of non-renewable energy resources—such as coal, oil, and natural gas—through various stages of poultry farming and processing. These fuels are finite, and their excessive use contributes to environmental degradation and climate change.

Key areas in which fossil fuel can be used in poultry farms are: 1) feed Production stages, such as growing grains, feed milling, and transportation; 2) farm operations stages, such as heating, ventilation, and lighting in poultry houses and water pumping, waste handling, and automatic feeders; 3) Transport stage where fossil fuels are used to transport feed to farms, birds to slaughterhouses, and products to markets; 4) Processing and Packaging stages, such as slaughterhouses and meat processing facilities for refrigeration, machinery, sterilization, and packaging; and 5. Waste Management stage, such as disposal or treatment of manure and byproducts where often involves fossil fuel-driven equipment or processing systems. The depletion of fossil fuels includes the extraction of crude oil, hard coal, and natural gas which bear external costs to society (Huijbregts et al., 2017). In this study, we considered petroleum fuel depletion and charcoal use for heating broiler chicks and transportation of chicks and other inputs like feed in both broiler and layer production. The mean range of values in Bhattacharya et al. (2002), which is 2,361 g kg-1 of charcoal, was taken as the charcoal combustion emission factor.

Social Impacts of Poultry Production

The following are details of social impacts identified, aligned with labor rights and corporate responsibility standards included in this study.

Child Labour: Defined by various categories of underage workers, with costs for education and reintegration expressed in US$/child Full Time Equivalent (FTE). However, data from our survey indicates that there is insignificant child labor involvement in poultry production.

***Discrimination**:* Focuses on gender discrimination and its impacts, with costs for denied maternity leave and wage gaps expressed in US$.

Underpayment in Value Chain: Covers wage gaps for workers below minimum and decent living wages, expressed in US$. The minimum decent living wage in Ethiopia is estimated to be 10,380 Birr (98.72US$ at 105Birr/1US$ exchange rate).

Insufficient income cost: This refers to the gap between the total income the household earned and the minimum decent income. The total income is calculated from the total income from all sources of income, like crop production, livestock production, poultry production (meat/egg), and non-farm income. It is a compensation cost that represents the restitution of the income gap, corrected for an increase in consumer prices (annual inflation) due to delayed income and valued at 1.06US$/Int.$.

Occupational Health and Safety Risks: Includes costs associated with workplace harassment and health impacts, expressed in US$/worker and US$/incident.

Monetisation Factors for Environmental and Social Impacts

Each social impact has associated costs for restoration, compensation, prevention, or retribution, expressed in US$. Hence, the monetization value for some of the environmental and social externality costs considered in this study is discussed and expressed in US dollars (US$) (Table 3).

Climate Change: This refers to the contribution of greenhouse gas (GHG) emissions—such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—to global warming. These emissions increase atmospheric GHG concentrations (measured in parts per billion, ppb), enhance radiative forcing, and consequently raise the global mean temperature. The associated cost is a restoration cost, which is estimated at 0.05 US$/kg CO_2-equivalent (CO_2-eq) for GHG emissions (Tubiello et al., 2015).

Air Pollution: Refers to environmental and health impacts caused by emissions to the air, excluding climate change. These impacts include acidification, photochemical oxidant formation, particulate matter (PM) formation, nitrogen deposition, ozone layer depletion, terrestrial and aquatic ecotoxicity, and human toxicity from airborne pollutants. The cost considered here is based on a compensation rate of 125,000 USD per DALY for human toxicity specifically related to the formation of Particulate Matter with a diameter of 2.5 micrometers ($PM_{2.5}$). An emission of 0.003 kg/bird/flock is assumed for the PM2.5 of poultry emission (Wang-Li, n.d.).

Resource Depletion: This category includes the depletion of both energy and material resources. The estimated cost for fossil fuel depletion is 0.54 US$/kg oil equivalent (oil-eq), while the cost for non-renewable material depletion is approximately 0.273US$/kg copper equivalent (Cu-eq).

Child Labor: Like other social impact categories, the cost associated with child labour is a composite of restoration, compensation, prevention, and retribution components. The restoration cost reflects the expenses involved in providing quality education for children who are not attending school, as well as the implementation of reintegration programs for those engaged in hazardous labour(ILO, 2004). The compensation cost accounts for the loss of future earnings resulting from a child's inability to attend school during their formative years (ILO, 2004). The prevention cost covers the setup and operation of generic auditing systems designed to prevent future occurrences of child labour. The retribution cost represents a penalty for child labour violations, calculated as a weighted global average of national penalties imposed for such infractions. The estimated cost is 3470US$ per child full-time equivalent (FTE) for non-hazardous work.

Discrimination: This includes female workers without maternity leave provision, the value of denied maternity leave, and the wage gap from gender discrimination. The respective associated costs are US$2560, US$1.09, and US$1.09 per FTE.

Underpayment: We included the wage gap of workers earning below minimum wage, and the wage gap of workers earning above minimum wage but below a decent living wage. The wage gap for workers earning below the minimum wage is valued at 1.56US$ per legal wage, indicating the ratio between actual and fair wage. Similarly, the wage gap for workers earning above the minimum wage but below a decent living wage is valued at US$1.09 per day. The minimum wage and a decent living wage are estimated at 10,380 ETB or 98.72 USD, respectively. The exchange rate of 105 Ethiopian Birr per US dollar is considered during the period of data collection.

Health and Safety Risks: Here, we included uninsured non-fatal occupational incidents. The compensation cost represents the average cost of medical expenses for occupational injuries not covered by the employer. These costs are estimated at US$4,550 per non-fatal occupational incident.

The sixth step is valuing the impacts, where a monetization factor is used to represent each impact as an external expense/cost. The difference between market prices and the actual cost of a good or activity is known as external costs, and it includes social and environmental effects. These expenses are determined by multiplying footprint indicators, which measure social or environmental effects, by monetization factors that give such a monetary value (1). They are essentially monetary indicators. The physical effects are translated into economic terms by monetization factors, which represent the societal cost. In certain instances, these variables may differ by nation and even by stage of a product's lifespan. Depending on where the damage occurs, different external costs may result, for instance, adjusting damage cost coefficients based on local income levels. The external costs are given in equation 1:

$$External\ cost\ =\ footprint\ indicator \times\ monitization\ factor \qquad (1)$$

At step seven, integrate the impacts, implying that the different social and environmental costs are summed up, resulting in the true price gap of the product, including all parts of the life cycle that are included in the system boundaries (equation 2).

$$True\ price = \sum(External\ costs) + Market\ price \qquad (2)$$

Stage four reporting

Steps eight and nine make up this stage. The process of making inferences from the results and assessing their quality includes step eight, which is known as the interpretation and testing of the results step. Reporting the actual price assessment is part of the last step (number nine). This should be open and comprehensive, clearly stating the findings as well as the supporting information, presumptions, procedures, steps in the calculation, and limits.

Literature review

Environmental impacts of poultry production

Greenhouse gas (GHG) emissions: According to global life cycle assessment (LCA) research, chicken meat produces around 5.4 kg of CO_2 eq per kilogram of carcass weight (CW) (eggs emit about 3.7 kg of CO_2 eq/kg) (MacLeod, 2013). Approximately 78% of poultry's GHG emissions come from the production of their feed, with on-farm energy coming in second at 8% and processing/transport at 7% in chicken meat production. On the other hand, in layer hens' egg production, feed production accounts for 69% of egg emissions, while direct on-farm energy usage accounts for 4%, and post-farm processing, transport accounts for 6%, and manure storage and processing accounts for 20% (FAO, 2013). The global feed conversion ratio of broilers is estimated to be 2.87 kg feed/kg live weight (FAO, 2013). However, emissions in Ethiopia may probably be greater than the global norm of 5.4 kg because Sub-Saharan African systems have lower feed efficiency than the global average. Given local inefficiencies, this is a lower-bound estimate, but Ethiopia's yearly poultry output (~22 kt) so "embodies" on the order of 0.1 Mt CO_2e annually (if using 5.4 kg CO_2e/kg). Feed conversion ratios (FCR) are higher (worse) in Sub-Saharan Africa than the world average, implying Ethiopian poultry likely uses >3 kg feed per kg live weight. Feed and manure emissions dominate the GHG and water footprints (Mekonnen & Hoekstra, 2012).

Table 3. Overview of monetization factors

Impact category	*Impact indicator*	*Unit*	*Type of costs*	*Monteziation factor*	*Source*
Contribution to climate change	Greenhouse Gas Emissions	kg CO_2 eq	Abatement cost	0.05 US$/kg CO_2 eq	Tubiello et al., 2015
Air pollution	Fine particulate matter formation	kg $PM_{2.5}$ eq	Damage cost	78.50US$/kg PM2.5 eq	(Galgani, Woltjer, et al., 2023)
Nitrogen deposition NH_3	Poultry husbandry plus manure use	Kg NH_3 eq	Cost of the abatement measures	0.78US$/kg NH_3 eq.	
Water scarcity	Scarce water use	M^3	Restoration cost	1.49/m3	(World Bank, 2012)
Land use	Land occupation	m^2a crop eq	Compensation cost	3470$/MSA.ha. yr	de Groot et al., 2012
	Land transformation (Grassland to poultry)	Mean Species Loss	Compensation cost	313US$/ MSA*ha	
Depletion of fossil resources	Fossil resource scarcity	kg oil eq	Remediation cost	0.54US$/kg oil-eq	(Galgani, Woltjer, De, Toorop, & De Groot Ruiz, 2021)
Child labour	Underage workers below the minimum age (12 or 13)	Full Time Equivalent (FTE)	Restoration, prevention, and retribution cost	25,300US$/child FTE	(ILO, 2004)
Discrimination	Value of denied maternity leave	-	Cost of restoration, prevention, and retribution	2450US$	
Discrimination	Denied payment due to gender difference		Restoration, prevention, and retribution cost	1.09US$	
Underpayment in the value chain	Wage gap of workers earning below minimum	-	Restoration, prevention, and retribution cost	1.56US$	
Insufficient income	Living income gap		Cost for the restitution of the income gap	1.06US$	
Health and safety absence	Uninsured non-fatal occupational incidents	Incidence	Cost of restoration, prevention, and retribution	4470US$/incidence	

Water use: Poultry production is water-intensive via feed. Mekonnen & Hoekstra (2012) estimated a global water footprint of around 4,325 liters of water per kg of chicken meat, while by comparison, beef has around 15,400 L/kg (Mekonnen & Hoekstra, 2012). This reflects water to grow feed crops, plus drinking water. Feed crops for Ethiopia's poultry (e.g., maize, soybean) compete with human food and may drive irrigation and land use. Globally, around 41% of agricultural water goes to livestock production only (Heinke et al., 2020).

Land and biodiversity: Rising poultry feed demand can put pressure on land. For instance, a decline in biodiversity can occur as a result of deforestation due to farm expansion to produce poultry feed like maize and soybeans. The government of Ethiopia put a strategic plan for the poultry sector development (Fekadu et al., 2022). Hence, while Ethiopia's poultry feed demand is small today, any large-scale expansion (e.g., an ambitious industry program) risks converting marginal land. Even though no Ethiopia-specific LCA for land-use has been published, global studies note that around 33% of arable land is devoted to livestock feed globally. Moreover, intensive poultry housing can also concentrate waste and ammonia (which may acidify soils and waters), though exact data for Ethiopia are lacking.

Pollution: Poultry manure and litter emit ammonia and nitrous oxide, and release nutrients into soil and water. Runoff from poultry farms (especially poorly managed small farms) can contaminate waterways and pollute the air. Unless controlled, NH_3 concentration kept below 25 ppm, the poor air quality will impair the health and welfare of animals and their caretakers (EPA, 2021; Frank et al., 2004). Moreover, veterinary drugs (antibiotics, coccidiostats) frequently appear as residues: a review found oxytetracycline detected in many Ethiopian meats and dairy samples (Tegegne et al., 2024). These residues in farm runoff pose ecological risks (antibiotic pollution and resistant bacteria in the environment).

Human health impacts

Antibiotic use and resistance: Ethiopian poultry farms heavily rely on antibiotics. Surveys (mainly backyard flocks) report 70–100% of farmers routinely use antimicrobials (tetracyclines and sulfonamides are common) for treatment and growth promotion (Sarba et al., 2019). Drug misuse leads to resistant bacteria. For instance, a study in Ambo found 78% of *E. coli* isolated from chickens were multidrug-resistant; 100% were resistant to amoxicillin/cefotaxime and ~46% to tetracycline (Sarba et al., 2019). A recent study in Addis Ababa found 34% of *Salmonella* isolates from poultry farms resistant to streptomycin and 28% to tetracycline, with 40% of isolates being multidrug-resistant (resistant to ≥2 antibiotics), (Akalu et al., 2024). These resistant pathogens can be transmitted to humans through the food chain or the environment. Indeed, *Salmonella* prevalence was 36.2% at the farm level, and 4.5% of farm workers' stool samples tested positive (Akalu et al., 2024). The widespread antibiotic contamination and the emergence of resistant microbes pose growing public health risks (e.g., untreatable infections).

Foodborne disease: Poultry and eggs are major sources of foodborne illness in some African countries. (Havelaar et al., 2022). In Ethiopia, Campylobacter and non-typhoidal *Salmonella* from chicken cause a high burden of disease. One quantitative risk study estimated ~1.8 million cases of foodborne illness per year in 2017 attributable to chicken (Campylobacter + Salmonella), causing ~850 deaths (approximately 65,000 DALYs) (Havelaar et al., 2017). Campylobacter infections were almost four times more common than Salmonella, though Salmonella caused four times more deaths (Havelaar et al., 2017). In practical terms, that means roughly 1 in 50 Ethiopians fell ill from contaminated poultry that year (Havelaar et al., 2017). These illnesses include diarrhea, sepsis, and long-term sequelae. (For comparison, beef and dairy in Ethiopia cause comparable burdens, while the burden from chicken was higher than vegetables (Havelaar et al., 2017). Poor on-farm hygiene, lack of cold chain, and informal slaughter practices exacerbate these risks.

Nutrition: Poultry products are nutritionally valuable sources of protein, vitamins, and minerals. Interventions increasing egg consumption in Ethiopia have shown clear benefits: in a rural trial, children given at least one egg/day had 42–54% lower odds of being underweight or stunted after 6 months (Omer et al., 2022). Thus, improved access to poultry/eggs can reduce childhood malnutrition. On the other hand, poultry meat is relatively low in saturated fat compared to beef (a modest health "plus") and can help meet protein and micronutrient needs in a country with high rates of stunting. The balance of health impacts is complex, but the nutritional benefits of poultry (especially eggs) for a protein-deficient population are significant (Omer et al., 2022).

Labor and Working Conditions

Employment and wages: Agriculture (including poultry) is Ethiopia's largest employment sector (≈80% of the workforce). Poultry farming is labor-intensive (feeding, cleaning, slaughtering). However, wages on farms are extremely low and unregulated: Ethiopia has no national minimum wage, leaving farm workers vulnerable. Salary surveys show 80% of agricultural workers earn between ~3,696 and 9,320 ETB per month (gross). (As of 2024, 3,700 ETB ≈ $60 USD; 9,300 ETB ≈ $150 USD) (Salaries in Ethiopia - Paylab.com, n.d.). These figures include all agri workers, so poultry workers are likely in the lower part of this range, often earning well below a living wage. Many works informally (no contracts or benefits). ILO analysts stress that without wage protections, farm labor in Ethiopia is poverty-level.

Occupational safety: Farming in Ethiopia is hazardous. One study of a large state farm found 783 injuries per 1,000 workers per year (i.e., ~78% of workers injured annually) (Kumie et al., 2016), with each injury causing 11 lost workdays. Common hazards include handling heavy poultry feed bags, using sharp implements for slaughter, exposure to animal waste, and heat stress. Poultry houses may be poorly ventilated, risking respiratory problems. Formal safety training is rare. Thus, poultry farm workers face high rates of cuts, musculoskeletal injuries, and potentially zoonotic infections (like avian influenza, salmonellosis).

Gender and labor: Women play a major role in Ethiopia's poultry sector, especially in smallholder flocks. ILO-supported programs emphasize that poultry can empower female farmers. Nevertheless, gender pay gaps and limited access to credit or markets mean female poultry workers often earn less and have poorer conditions than men. Data on this are sparse, but general rural patterns suggest women bear a large share of the unpaid or low-paid labor in poultry farming.

Animal welfare

Living conditions: Health and safety metrics in Ethiopia's poultry sector is given in Table 4. The vast majority (~95%) of Ethiopia's chickens are indigenous village stock, kept extensively under free-range or simple coop conditions. Chickens usually scavenge the household vicinity with minimal housing or veterinary care. In the small commercial sector, birds may be kept indoors on litter floors or in cages, but welfare standards are low: there is no animal-welfare legislation specific to poultry in Ethiopia (Animal Protection, 2020). Basic "five freedoms" (adequate space, rest, enrichment) are not enforced. Overcrowding, poor ventilation, and temperature extremes are common (Jerlström, 2013). Culling is often by rough methods (neck-breaking or drowning) with little anesthesia.

Health and mortality: Disease is rampant. Recent surveys report annual flock mortality rates of **20–50%** in Ethiopia (Asfaw et al., 2021). Some outbreaks in northern Ethiopia have killed up to **68%** of birds (Asfaw et al., 2021). Young chicks are especially vulnerable (Mazengia et al., 2012) found ~45% died within the first weeks) (Asfaw et al., 2021). By contrast, well-managed research flocks had only ~7% mortality. In practice, most farmers lose 10–30% of flocks yearly to Newcastle disease, infectious bursal disease, parasites and predators. High mortality reflects poor nutrition, lack of vaccines, and inadequate biosecurity (Asfaw et al., 2021). Ethically, such losses indicate severe neglect of the "livelihoods" of animals.

Welfare compliance: Officially, only general anti-cruelty laws apply. The criminal code bans willful animal cruelty or deliberate disease spread, but there are *no* binding regulations on housing, transport, or slaughter of poultry (Animal Protection, 2020). In effect, poultry are outside any welfare oversight. NGOs note this regulatory vacuum: farmers are not required to provide even basic shelter or veterinary care beyond disease control requirements (Animal Protection, 2020). Industry associations have minimal welfare codes. Result: routine mistreatment (e.g., inhumane culling, denial of veterinary treatment) likely occurs unchecked.

Table 4. Health and safety metrics in Ethiopia's poultry sector

Metric	*Value / Impact*	*Source*
Farm-level *Salmonella* prevalence	36.2% of poultry farms tested positive	[Salmonella study, Addis Ababa] (Akalu et al., 2024).
Salmonella multi-drug resistance	40.6% of isolates resistant to ≥2 drugs	(Akalu et al., 2024)
E. coli multi-drug resistance (backyard)	78.1% of isolates are MDR, 100% resistant to amoxicillin, 46% to tetracycline	bmcvetres.biomedcentral.com (Sarba et al., 2019)
Foodborne illness (poultry origin)	Up to 1.8 million cases/year; ~850 deaths**	(Leslie et al., n.d.) (2017 data)
Child stunting (decreases with eggs)	42% lower odds (*Agriculture, Food Industry, Ethiopia Salaries - Paylab.com,* n.d.)*pia Salaries - Paylab.Com, n.d.)*	
Agricultural worker's monthly wage	3,696–9,320 ETB (≈$60–150) (gross)	(Agriculture, Food Industry, Ethiopia Salaries - Paylab.Com, n.d.).Accessed on 07 July 2025.
Farm injury rate (state farm example)	783 injuries per 1000 workers/year	(Kumie et al., 2016)

Notes: "MDR" = multi-drug resistant. **The foodborne figures are estimated total illnesses/deaths attributable to chicken-borne bacteria in 2017 (Campylobacter + Salmonella) frontiersin.org. The child nutrition metric comes from a controlled trial where rural Ethiopian children fed 1 egg/day (via a poultry-ownership program) had significantly reduced undernutrition pmc.ncbi.nlm.nih.gov.

Result and discussion

Characterization of poultry producers and sample distribution

The investigation is carried out using samples from four cities in and around the Addis Ababa area, including Adama, which is located no more than 100 kilometers east of Addis Ababa, as detailed in the methods section of this article. Addis Ababa accounts for the majority (about 50%) of the sample farms, with Bishoftu and Adama accounting for 27% and 18% of the sample, respectively (Table 4; Figure 5).

Table 5. Study area poultry farm sample distribution

City (sample study area)	*Number of sample poultry farms*	*Percentage*	*Cumulative percentage*
Adama	48	17.71	17.71
Addis Ababa	134	49.45	67.16
Bishoftu	72	26.57	93.73
Dukem	17	6.27	100.00
Total samples	271	100	

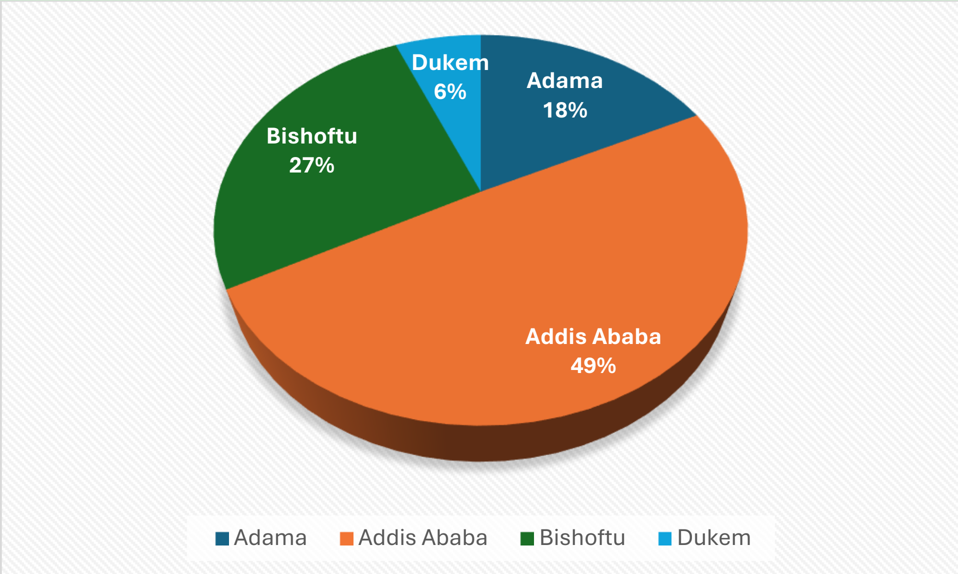

Figure 5. Number of sample poultry farms

Broiler production system

Figure 6 presents the distribution of broiler flock sizes across the surveyed farms and shows that most farms keep relatively small numbers of birds. Of the 78 broiler farms, only about 9% (7 farms) are classified as large-scale operations, each rearing more than 10,000 broilers. The majority are medium-scale producers, keeping 1,000–10,000 broilers, followed by small-scale farms with fewer than 1,000 broilers, which account for 33% (26 farms) (Table 3). Most producers (75 out of 78; 96%) use a half-slatted, half-floor (deep-litter) housing system, whereas only 4% of farms employ a battery-cage housing system.

Table 3. Broiler production system in Ethiopia

Variable description	*Number of farms*	*Mean number of broilers*
Small-scale production (<1000 broilers)	26 (33%)	569 (67)
Medium-scale production (>1000 and <=10,000 broilers)	45 (58%)	4392 (401)
Large-scale production (>10,000 broilers)	7 (9%)	15536 (2511)
Battery-cage system house type users	3 (3.85)	-
Floor system/Deep litter system house type users	75 (96.15%)	-

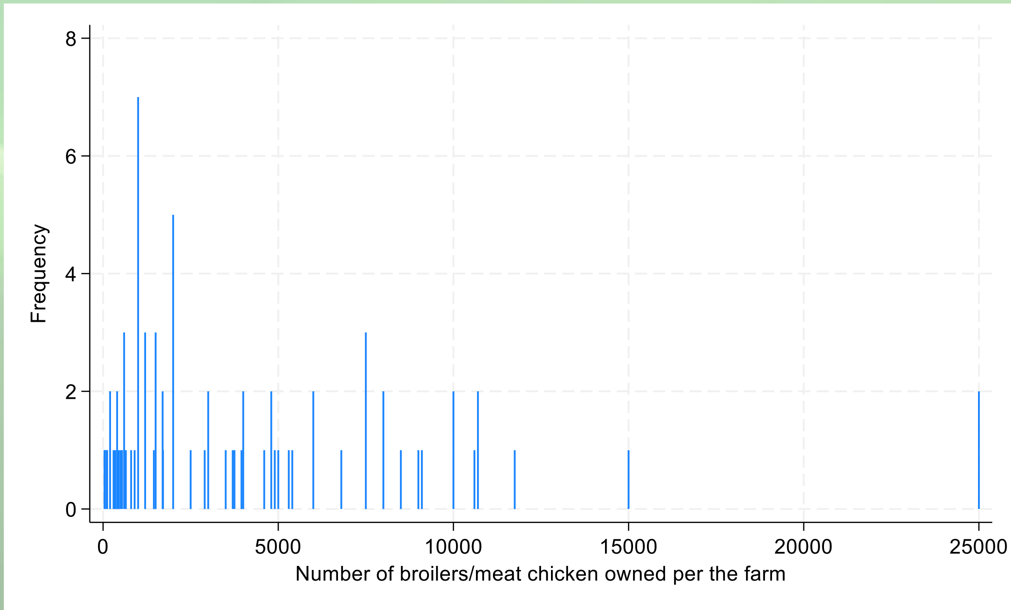

Figure 6. Number of broilers/meat chickens owned by each farm

Layer chicken production system in Ethiopia

The majority of layer producer farms are categorized as small-scale farms. Around 67% (135 farms out of 201 egg-producing farms) of the farms are operating with 1000 or fewer layer chickens, while the rest 32% (65 farms) are operating with a bird size of between 1001 and 10,000 chickens, while there is only one farm under a large-scale production system. With a total share of 95%, the housing system used in egg-layers production system is mainly a floor system or deep litter system, while only 4.5% of the farms are using the cage and battery system. Even though the battery cage system is widely used throughout the globe, it is being abandoned by the European Union, promoting non-cage eggs mainly due to animal welfare issues (Appleby, 2003). Hence, the intensive layers (eggs) production system in Ethiopia is a more animal welfare-friendly system, at least in terms of the housing system. The mean number of poultry birds (layers) for small-scale and medium-scale farms was 524 and 2421 birds, respectively.

Table 6. Layers chicken production system in Ethiopia

Variable description	*Number of farms*	*Mean number of layers*	*Std. Deviations*
Small-scale production (<1000 layers)	135 (67%)	524	27
Medium-scale production (>1000 and <=10,000 layers)	65 (32%)	2421	196
Large-scale production (>10,000 layers)	1 (0.50%)	11000	.
Battery-cage system	9 (4.50%)		
Floor system/Deep litter system	192 (95.50%)		

*Numbers in parentheses are standard deviations

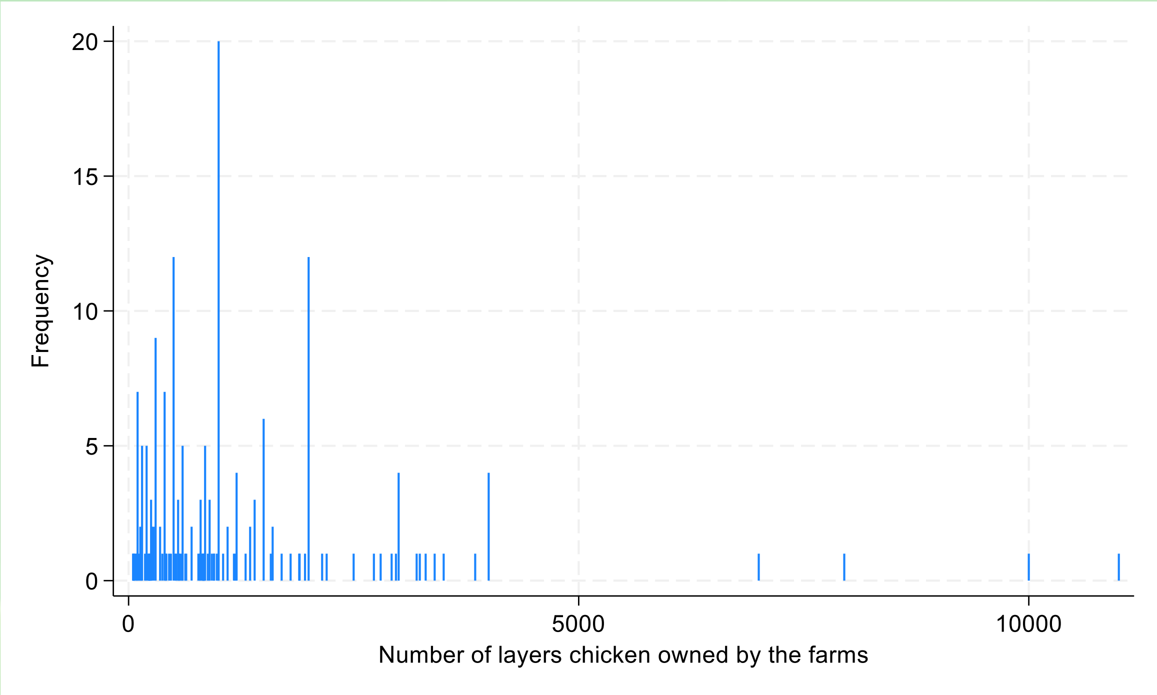

Figure 7. Number of layers of chickens per farm

Economic performance of layers and broiler farms in Ethiopia

The economic performance of broiler farms in Ethiopia indicates that the farms are operating profitably, as presented in Table 7. The results reveal that the average net farm profit amounts to USD 440. As expected, feed and water expenses constitute the largest share of operational (variable) costs, accounting for approximately 78%, while fixed costs remain minimal in broiler production. The cost of day-old chicks represents the second-largest component of variable costs, contributing about 17%. The relatively low level of fixed costs may be attributed to the small scale of operation and the continued use of traditional production methods.

Table 8 presents the economic performance of table-egg production in Ethiopia. On average, layer farms earn an annual profit of USD 12,500, which is substantially higher than that of broiler farms. As expected, feed and water expenses constitute the largest share of production costs, accounting for approximately 74% of the total cost and 95% of the variable cost. Fixed costs represent only about 22% of the total. Overall, the findings suggest that layer farms are financially sustainable and possess substantial potential for future growth and expansion.

Table 7. Economic analysis of broilers (chicken meat) in Ethiopia

Description	*Value (USD)*	*Values (ETB)*
Total Revenue from Broilers	39,307	4,127,222
Feed and water cost	27,249	2,861,101
Day-old chicken costs	6,074	637,816
Health costs	619	65,047
Transport costs	200	21,034
Marketing costs	33	3,414
Total labor cost	876	91,938
Total variable cost	35,051	3,680,350
Fixed cost	66	6,958
Total production cost for broiler	35,117	3,687,308
Net profit of the Broiler farm	4,190	439,914

Table 8. Economic analysis of layer-hens (table egg) in Ethiopia

Description	*Value (ETB)*	*USD*
Total Layers Revenue	3,387,217	32,259
Feed and water cost	1,549,212	14,754
Labor cost	19,746	188
Energy cost	6,827	65
Health cost	34,964	333
Marketing cost	1,080	10
Transport cost	20,279	193
Total variable cost	1,632,108	15,544
Fixed cost	447,416	4,261
Total cost	2,079,524	19,805
Profit before tax	1,307,693	12,454
Income tax	2,993	29
Net profit after income tax	1,304,700	12,426

The environmental footprint and true costs of poultry production in Ethiopia

The environmental footprints considered in this study are greenhouse gas (GHG) emissions, air pollution, land transformation, land occupation, and scarce water use. In egg production, environmental footprint cost accounts for a total of about 0.075 US$/egg. The GHG emissions considered are comprised of Carbon dioxide (CO_2), Methane (CH_4), and Ammonia (NH_3). The result of the analysis shows that GHG emissions contribute to a major share of externality costs in egg production by exerting 0.05US$/egg, which accounts for about 71% of the total environmental footprint costs, followed by air pollution that contributes 0.02 US$/egg, which is approximately 26% of the total environmental footprint costs. The scarce water use, land occupation, and land transformation each contribute very small amounts of environmental costs with values of 0.001 US$, 0.001 US$, and 0.0001US$ respectively.

Similarly, the environmental cost per kg of chicken meat is around 0.80US$, out of which around 0.55US$ (70%) is contributed by GHG emission, followed by air pollution, which accounts for 0.18US$ (22%) of the total environmental costs. The rest of the environmental costs in chicken meat production are contributed by land occupation, scarce water use, and land transformation, each contributing 0.05US$, 0.014US$, and 0.005US$ or 6%, 1.74% and 0.62% of the total environmental costs, respectively (Table 6).

Table 9. Summary of Environmental footprint costs (GHG emission costs)

Environmental cost categories	*Cost per egg (US$)*	*Percentage of total cost*	*Cost per kg of chicken meat (US$)*	*Percentage of total cost*
Land transformation	0.0001	0.13	0.0049	0.62
Land occupation	0.0008	1.07	0.047	5.92
Scarce water use	0.0008	1.07	0.0138	1.74
Air pollution	0.0198	26.44	0.1753	22.06
Greenhouse Gas Emissions	0.0535	71.43	0.5535	69.67
Total	0.0749	100.00	0.7945	100.00

Sources of greenhouse gas emissions in broilers and egg poultry production

Greenhouse gas (GHG) emissions in poultry production come from several sources throughout the production cycle. The largest contributor to GHG emissions in poultry production is feed production. Fertilizer (especially nitrogen-based) that releases nitrous oxide (N_2O), land use change related to deforestation, and transportation and processing of feed ingredients are the main sources of GHG emissions. Feed production and related activities, such as feed transportation by producers, contributed a cost of 0.04US$ while pullet transportation, which is mainly done by vehicles, contributes 0.01US$. The direct GHG emission from layers is only from manure management, which contributes around 0.01US$, while the enteric emission in poultry production, whether it is in broiler or layer, is neglected and equivalent to zero (Dunkley & Dunkley, 2013). Results in Table 7 show that the majority of GHG emissions are from feed production and related activities like transportation using animal-drawn carts, the two cost components accounting for around 69% of the total GHG emissions in egg production (Dunkley & Dunkley, 2013; Leinonen & Kyriazakis, 2016; Mottet & Tempio, 2017; Sousa et al., 2017). Emissions from fuel that is mainly used for transportation of pullets are the most important source of GHG, followed by manure management in egg production, each contributing 17 and 14% of total GHG emissions in egg production. This result is consistent with other previous authors' findings. The higher transportation cost in egg production can also be attributed to the frequent transportation of eggs to the market centers.

As shown in Table 7, greenhouse gas (GHG) emissions from broiler meat production contribute approximately $0.55 in externality costs per kg of chicken meat produced. Among the main sources, manure management, on-farm energy use, poultry feed production, and slaughterhouse operations are the most significant contributors, accounting for roughly $0.33, $0.11, and $0.11, respectively. These correspond to approximately 59%, 20%, and 19% of the total GHG emission costs in broiler production. As explained earlier, broilers—and poultry in general—do not produce enteric methane emissions like cattle. Being monogastric rather than ruminant animals, their digestive systems involve minimal fermentation. They consume low-fiber, easily digestible diets and lack the microbial environment found in ruminants that facilitates methane production. The finding of this case study, that manure management is the largest contributor to GHG emission costs, is consistent with previous research conducted in Malaysia (Suffian et al., 2018).

As indicated in Table 8, the social cost of egg production, comprising factors such as employee health and safety, underpayment, gender discrimination, child labor, and under-earning by both employees and poultry-farming households, amounts to approximately 0.014 USD per egg. Among these, health and safety risks and underpayment contribute the largest shares, accounting for about 0.007 USD (48%) and 0.006 USD (44%) per egg, respectively. The contribution of child labor is minimal, suggesting that poultry farms in this study primarily rely on hired labor, with limited involvement of family labor. Social costs related to gender discrimination and under-earning are also relatively minor. The substantial share of health and safety issues and underpayment in the total social cost highlights the need for government intervention, such as setting a minimum wage and implementing effective insurance policies within private enterprises.

The social externality costs per kilogram of chicken meat are presented in Table 8. The total social cost is substantial, amounting to approximately 0.19 USD per kilogram. The largest contributors to this cost are underemployment and health and safety concerns, which account for about 0.12 USD (64%) and 0.034 USD (18%), respectively. Gender discrimination and under-earning also make notable contributions, each adding approximately 0.014 USD (8%) and 0.011 USD (6%) to the total social cost.

Equation 2 is employed to calculate True Price of the two products (broiler meat per kg and egg). According to the result from Table 8, the True Price of egg is the sum of market price and external cost which is equals to 0.1991US$ per egg. On the other hand, the per kg True Price of chicken meat is 4.9926US$.

The result (Figure 7) also depicts that environmental cost is contributing more to external cost than social cost in both egg and broiler meat production. In both egg and chicken meat products of True Price, the market price has the largest share, with a larger share in meat production. In egg production, the market price only covers more than 52% of the True Price per egg, while in broiler meat production, it contributes more than 80% of the True Price per kg of chicken meat.

Table 10. Greenhouse gas emission costs from different sources in broiler and egg production

GHG emission sources	*Cost per egg (US$)*	*Cost per kg of meat (US$)*
Slaughterhouse	-	0.1068 (19.28%)
Transportation by animal-drawn cart	0.0187 (34.96%)	0.0028 (0.51%)
Manure management, emission, and energy use, such as heating	0.0076 (14.22%)	0.3275 (59.16%)
Feed production and processing	0.0180 (33.67%)	0.1080 (19.51%)
Fuel for transportation of chicks and/or inputs	0.0092 (34.96%)	0.0085 (1.53%)
Total	0.0535 (100%)	0.5535 (100%)

Table 11. Social externality costs of broiler and egg production in Ethiopia

Social cost categories	*Cost per egg (US$)*	*Percentage of total social cost*	*Cost per kg of chicken meat (US$)*	*Percentage of total social cost*
Underearning	2.21E-05	0.16	0.0114	6.15
Child labor	0.0004	2.43	0.0070	3.78
Discrimination (gender)	0.0007	4.62	0.0142	7.68
Underpayment	0.0063	44.07	0.1187	64.13
Health & Safety	0.0069	48.74	0.0338	18.27
Total (social) cost	0.0142	100%	0.1851	100%
Mean financial cost	0.10	-	2.73	
Market price	0.11	-	4.013	
Total externality costs (environmental plus social costs)	0.0891	-	0.9796	-
True Price (externality cost plus market price)	0.1991	-	4.9926	

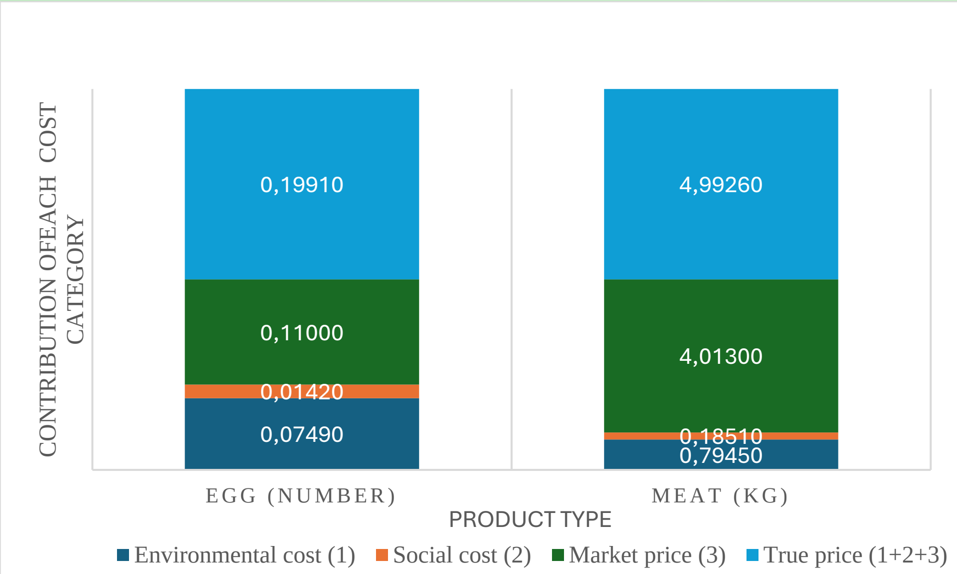

Figure 8. Comparison of sources of the True Price of poultry products in Ethiopia

Conclusion and recommendation

Conclusion

This study highlights the structure, production systems, and external costs of poultry farming in Ethiopia, focusing on broiler and layer production in four urban and peri-urban centers around Addis Ababa. The sample distribution shows that poultry production is concentrated in Addis Ababa, Bishoftu, and Adama, with Addis Ababa alone accounting for nearly half of the farms.

Broiler production is dominated by medium-scale farms (58%), followed by small-scale farms (33%), with only a small proportion operating on a large scale. The deep litter system is almost universally adopted (96%), with battery-cage housing being rare. Layer production, on the other hand, is largely small-scale (67%), with most farms keeping fewer than 1,000 birds and similarly favoring the deep litter system over cages. The preference for non-cage systems makes Ethiopian egg production relatively more animal welfare–friendly compared to intensive caging systems common in other countries.

From an environmental perspective, greenhouse gas (GHG) emissions are the largest contributor to the externality cost in both egg and chicken meat production, mainly arising from feed production and manure management. For eggs, GHG emissions represent 71% of environmental costs, while in broiler production, manure management alone accounts for 59% of these costs. Air pollution is the second largest environmental cost factor. Water use, land occupation, and land transformation contribute minimally. Social externality costs, though smaller than environmental ones, are still significant. In both systems, underpayment and health and safety risks make up the bulk of social costs, reflecting labor market challenges in the sector. Child labor and gender discrimination have relatively low contributions.

When incorporating both market and external costs into the True Price, it is evident that current market prices substantially understate the real societal cost of poultry products. For eggs, the True Price is $0.199 per unit, with environmental costs being more than six times higher than social costs. For chicken meat, the True Price is $4.99 per kg, with market price making up over 80% of that value, but still excluding considerable environmental and social externalities.

Overall, the findings suggest that while poultry production in Ethiopia is dominated by small- and medium-scale farms using welfare-friendly housing, it carries substantial hidden environmental costs, primarily from feed production and manure management, and social costs from labor-related issues. Addressing these through improved feed efficiency, manure management practices, and labor protections could reduce the true societal cost of poultry production and improve its sustainability.

Recommendations

True Cost assessment is essentially an exercise aimed at accounting for externalities and incorporating them into the current market price, which ultimately increases the burden on consumers. The goal is to understand the environmental and social costs, prioritizing the upstream activities of the value chain that contribute to these externalities. By doing so, actions can be taken to reduce the negative externality costs through the effective dissemination of information. To enhance the sustainability, efficiency, and social responsibility of poultry production in Ethiopia, the following recommendations are proposed:

1. Enhance feed production and efficiency: This can be accomplished by promoting the use of locally sourced feed ingredients to minimize transport-related GHG emissions. Additionally, research on feed formulation can facilitate the development of well-balanced diets and feed additives that enhance feed conversion rates, decrease nitrogen excretion, and minimize emissions from manure. Furthermore, offering incentives for the establishment of modern, energy-efficient feed mills in close proximity to poultry production sites can help reduce transportation emissions and expenses.

2. Improve manure management practices: To drastically reduce methane and ammonia emissions, poultry producers should be urged to implement manure treatment methods such as composting, biogas production, or other low-emission manure management systems. This can be achieved by offering extension and training services, as well as by creating regulatory incentives like tax exemptions or subsidies for commercial farmers who use low-emission manure technology.

3. Encourage energy efficiency in poultry production: Because Ethiopia does not experience severe weather, on-farm energy consumption in poultry production is negligible. Fossil fuel use can be reduced in poultry houses by implementing renewable energy sources, including solar-powered heating, ventilation, and lighting systems. In order to encourage better practices, energy auditing and the voluntary energy efficiency certification for chicken farms can help advance this.

4. Establishment of labor standards and social protections: Another step that needs to be performed is the implementation of social protections and labour regulations. The problem can be resolved by establishing and enforcing minimum wage regulations tailored to the poultry sector to combat underpayment. It is essential to enforce health and safety regulations by mandating safety training, the supply of protective equipment, and recurring physical examinations for poultry workers. Additionally, the hidden social cost of chicken production can be reduced by promoting gender equality initiatives, including offering gender-sensitive training and guaranteeing equal compensation for equal labour in order to lessen discrimination.

5. Market transparency and true cost awareness: By stating the True Price on chicken products, consumers can become more conscious of the social and environmental costs associated with production. Pilot projects that label poultry meat and eggs with the corresponding environmental and social cost components can help reach this goal by educating customers about these hidden effects. Furthermore, producers can be encouraged to actively cut social and environmental costs by providing incentives for low-impact production, such as preferential procurement or market rewards to farms with smaller environmental footprints than average.

6. Assistance for producers on a small and medium scale: Access to financing is necessary to allow Ethiopia's young, modern chicken farms to implement improved housing systems, renewable energy sources, and manure management equipment. Promoting producer cooperatives might help in combining resources for product marketing, bulk feed procurement, and transportation in order to cut expenses and emissions.

7. Encourage animal welfare–friendly systems: To benefit from the system, the advantages of the current deep litter system must be well-maintained. Research on methods to enhance deep litter productivity and hygiene is beneficial, given its advantages for animal welfare and a supplement to other enterprises like crop production. Furthermore, Ethiopian eggs can be marketed as welfare-friendly in both local and foreign markets by obtaining national certification of cage-free production. This would help Ethiopia break into markets like the EU, where battery cage systems are being phased out to safeguard animal welfare.

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