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**Internalizing the External Costs of Animal Derived Food in Hungary:
Evaluating ETS and VAT Based Fiscal Measures**

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ABSTRACT

This thesis investigates the environmental externalities of animal-derived food, with a particular focus on how fiscal measures, specifically VAT adjustments and Emissions Trading Scheme (ETS) options, could help internalize these costs in Hungary. The study is motivated by the lack of attention to external costs and the persistent pricing gap in the animal agriculture sector, an issue with significant implications for food security and the sustainability of food systems.

To address this problem, the research estimates external costs using the environmental pricing methodology and evaluates a range of fiscal policy instruments. The methodology includes regionalizing environmental impact data based on information provided by national authorities; assessing a VAT adjustment scenario using current market prices and price elasticities for beef, milk, chicken, pork, and eggs; evaluating emissions coverage under two ETS designs (downstream ETS and on-farm livestock ETS); and examining a revenue redistribution mechanism in the form of a lump-sum transfer.

The findings reveal that the real prices of animal-derived foods, once environmental damages are accounted for, are nearly double their current market prices. The analysis further demonstrates that both VAT adjustments and ETS options can reduce environmental externalities by lowering demand, decreasing the profitability of the sector, and creating incentives to mitigate environmental harm. Additionally, the results underscore that fiscal policies must be assessed carefully and designed with regional specificity to be effective in practice and ensure social equity. Overall, these outcomes provide strong evidence that fiscal policy intervention is needed in the animal agriculture sector in Hungary.

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List of Abbreviations

List of Abbreviations	Full Description
CAP	Common Agricultural Policy
CIS	Coupled Income Support
ETS	Emission Trading System
EU	European Union
FAO	Food and Agricultural Organization
GHG	Greenhouse Gas
HWEN	He Waka Eke Noa
LSU	Livestock Unit
MRV	Monitoring, Reporting, and Verification
MS	Member States
VAT	Value Added Tax

Chapter 1: Introduction and Aim of the Thesis

Section 1.1 Animal Agriculture and Associated Externalities

Animal agriculture plays an essential part in the current food production systems and is often a matter of discussion in terms of sustainability and food security due to its controversial aspects, including ethical, environmental, and social. It is a source of income and employment for many people around the world, and a big part of culture and nutrition for many countries. According to the Food and Agriculture Organization (FAO), the contribution of livestock to the agricultural output is approximately 40% for developed, and 20% for developing countries (FAO, n.d.), and in 2021, the sector represented 36% of the European Union's agricultural industry sector's output (Adams et al., 2025). Although livestock farming is a major portion of the livelihoods especially in middle and low-income countries, the sector is also facing the risk of excluding small scale stakeholders from the market and making market entry difficult due to market failures, partially as a result of economies of scale, and partially of established standards that are harder to reach for small scale stakeholders (The World Bank, 2009). Currently, animal agriculture is responsible for 18% of all anthropogenic greenhouse gas (GHG) emissions, and 80% of the emissions from the agriculture industry (Adams et al., 2025). The cattle raised for human consumption also stand out as the main reason for anthropogenic methane and nitrous oxide emissions, and account for more than 60% of livestock-related emissions (FAO, 2023a). GHG emissions from animal agriculture are expected to increase further, as the global consumption of poultry, sheep meat, beef, and pig meat is projected to rise approximately 21%, 16%, 13% and 5% respectively, by 2034 (OECD & Food and Agriculture Organization of the United Nations, 2025).

In the European Union (EU), 84% of embodied GHG emissions from the agriculture sector are associated with animal-derived products, whereas only 35% of calorie and 65% of protein intake is supplied by them (Kortleve et al., 2024), further indicating an inefficiency in the system in terms of resource use.

In addition to GHG emissions, the livestock sector is the main user of land on Earth, due to pasture and feed crop production, making animal agriculture a major contributor to biodiversity loss and soil erosion (FAO, 2020). Waste resulting from animal farming practices

also registers the highest biochemical oxygen demand¹ levels, making it the primary source of agricultural water pollution (FAO & IWMI, 2018).

The EU recognizes the significant environmental impact of animal agriculture; however, the primary focus of the actions taken/planned by the EU is on increasing the productivity and lowering the emission intensity of the animal agriculture sector, and continues to frame dietary change as a consumer choice rather than a structural priority (European Commission, 2023c).

The main instrument that covers agriculture in the EU is the Common Agricultural Policy² (CAP), and providing income support has been the policy's focus since the 1980s (Sotte & Brunori, 2025). Between 2018 and 2022, 33% of the average agricultural income was supplied by the CAP (European Commission, 2025d), highlighting the importance of the policy in sustaining the sector. In contrast to the environmental issues associated with it, animal agriculture is heavily subsidized under the CAP. The sector received 82% of the EU's agricultural subsidies (38% directly and 44% for animal feed) in 2013 (Kortleve et al., 2024). The most recent reform of the policy, which sets the framework for the period 2023–2027, was agreed on in 2021. The reform aimed to align with the European Green Deal, after failing to address environmental issues in the agriculture sector through previous reforms. However, the current reform is criticized for failing to move on from former CAP policies that support the intensification of the sector through production-oriented mechanisms such as payments per hectare and the number of livestock heads, and continues to favor the large-scale companies that operate in intensive animal farming (Cuadros-Casanova et al., 2023) (Giuliani & Baron, 2025; Heyl et al., 2021).

In addition to being subsidized heavily, animal-derived products and animals intended for food production are excluded from high value-added tax (VAT) rates in most of the EU countries, further encouraging their consumption (European Commission, 2021c).

Another food system focused strategy of the EU, Farm to Fork³, acknowledges that the current food system is unsustainable. The strategy encourages a move toward more sustainable diets, to reduce GHG emissions, land degradation, and water use (European

¹ Biochemical oxygen demand is the oxygen required by organisms for the full oxidation of organic matter in the water sample, and it is an indicator of water quality (Byrne, 2011).

² Adopted on 2 December 2021, CAP aims to modernize agricultural policy in EU, and support farmers with a total of €386.6 billion from the EU budget (2021-2027) (European Commission, 2025e). CAP includes two different funds ("two pillars" of the CAP): Pillar 1 provides direct financial support to farmers and Pillar 2 provides funding for socio-economic and environmental interventions (European Commission, 2025f).

³ Farm to Fork is a strategy published in 2020 by the EU Commission as a part of the Green Deal and holds the importance of being the first food focused comprehensive strategy of the EU. It includes 27 measures to achieve a sustainable transition in food systems (European Parliament, 2025)

Commission, n.d.-c). However, it also fails to address the systemic role of industrial animal agriculture.

All the environmental impacts associated with animal agriculture result in externalities that reflect as a cost to society, which are not included in the consumer prices of food (European Environment Agency., 2017; The World Bank, 2009). When one person's decisions about production or consumption affect another without the decision maker's knowledge, this is known as an externality, and is considered negative when it reduces the affected person's utility or well-being (OECD, 2015). The environmental damage associated with animal agriculture is an example of a negative externality, indicating that the market price is lower than the true price, leading to overproduction and a social loss. These externalities are an example of deviations from perfectly functioning markets, indicating the presence of a market failure (Gillingham & Sweeney, 2010). Unpriced externalities lead to overconsumption of products that are harmful to the environment, and underconsumption of more sustainable products such as plant-based alternatives (Hendriks et al., 2021). Due to the lack of internalization, emitters are also not encouraged to invest in greener methods or reduce the external costs associated (Gillingham & Sweeney, 2010).

In recent years, there has been a growing effort to quantify the external costs associated with food systems. According to a study conducted by the Impact Institute, in 2022, the cost of production and consumption of animal-derived food in the EU is estimated as 765 B€, while the primary drivers of these costs are land use and air pollution (Rusman et al., 2023). The associated environmental cost of land use is estimated to reduce to €19B, from €111B, with a dietary shift towards plant-based. Another study carried out by the Food Economics Commission estimates the total environmental cost of today's food system at 3 trillion USD per year (Laderchi et al., 2024). In the transformation pathway, the study envisions a decrease in worldwide demand for livestock products that require extensive land, with plant-based proteins serving as substitutes, alongside other improvements such as waste reduction. The results of the evaluation show that the possible global revenue from this pathway could reach up to \$ 10 trillion per year.

The hidden cost of food is also acknowledged by the international institutions. In their report "The State of Food and Agriculture" published in 2024 (FAO, 2024), FAO estimates the hidden cost of the agrifood system at 11.6 trillion at 2020 purchasing power parity dollars for 156 countries, using the True Cost Accounting approach (FAO, 2023b). A scientific paper submitted in the 2021 UN Food Systems Summit highlights that the consumer prices are approximately a third lower than their true cost, which reflects the externalities associated,

and that sustainable and healthy options are generally more expensive to consumers while being less attractive for businesses to invest in, due to a lack of internalization (Hendriks et al., 2021). The paper calls for true pricing to prevent further social injustice, misleading information on the value of food, and the encouragement of unsustainable diets that result from externalities in the food systems. The paper also presents a graph illustrating the costs and benefits of potential dietary shifts-pescatarian, vegetarian, and vegan diets-as shown in Figure 1.

REF= Healthy Reference diet, PSC = pescatarian, VEG = vegetarian and VGN = vegan diets.

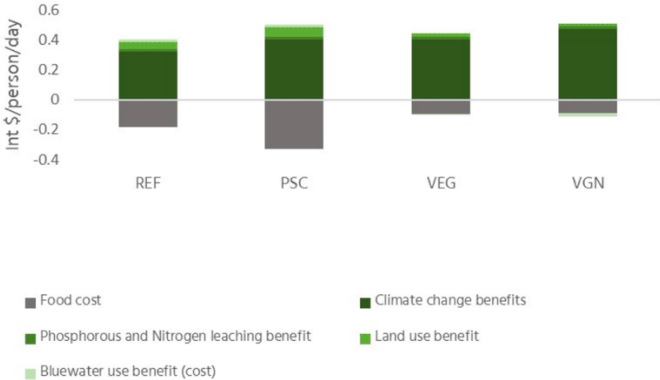


Figure 1. Costs and benefits of diet choices (Hendriks et al., 2021)

True Animal Protein Price Coalition is another leading institution that advocates for true pricing of animal-derived products, fiscal incentives to internalize these costs, and reduction of taxes and prices on vegetables, fruits, plant-based meat, and dairy. They proposed that EU 27 countries charge a tax of 10.15-2.24 €/kg for beef, 1.91 €/kg for pork and 1.44 €/kg for chicken in a report they published in 2023, to account for their environmental cost (Korteland et al., 2023).

In addition to theoretical efforts, there have also been practical attempts by the supermarket chains in Europe to raise awareness among customers, using the true prices of animal-derived products. For instance, Penny introduced the “True Cost” campaign to display the environmental cost of products in Germany (Rewe Group, 2023). Similarly, Albert Hein tried a true pricing trial in its three to-go markets in the Netherlands to raise awareness about the hidden cost of food products and steer consumers to sustainable choices (True Price, 2023).

Section 1.2 Fiscal Measures as Internalization Mechanisms

It takes well-designed policy measures that drive consumers and the market to make more sustainable choices and ensure an effective incentive to reduce environmental damage, in other words, to transition from true cost accounting to internalization of the quantified

external costs. Market-based environmental policy instruments such as taxes and the emission trading system (ETS) aim to make environmentally unsustainable choices more expensive and are considered effective tools for internalizing the negative externalities arising from consumption and production choices (EEA, 2005).

1.2.1 Fiscal Instruments: Environmental Taxes and Cap and Trade Systems

The market-based environmental policies investigated in this thesis can be classified into two categories: price-based and quantity-based (cap-and-trade). The main difference between these two instruments is that while tax instruments set a price for emissions, quantity-based instruments set a target emission level. Therefore, the achieved emission level is uncertain in the case of taxing.

The origins of environmental taxation can be traced back to the early 20th century, when A.C. Pigou developed the externality theory. However, it began to be applied in practice and discussed in environmental policy debates in the 1960s, following the rise of the environmental movement (Baumol & Oates, 1988). The British economist proposed taxing polluters to compensate for the damage they do to other individuals, which is also indicated by the “Polluter Pays Principle⁴”. The economics-named Pigouvian tax is a levy imposed on externalities at a rate equal to the marginal damage costs, and its role in correcting the market failures arising from external costs is discussed extensively (Dolbear, 1967; Sandmo, 1975). According to Pigou, in the presence of externalities, achieving a Pareto optimum⁵ is not possible (Pigou, 1932). It is argued that even when Pigouvian taxes are imposed, the outcome will likely fall short of the Pareto optimum, since governments must rely on distortionary taxes and often face incomplete information about preferences, marginal benefits, and costs (Baumol, 1972; Greenwood & McAfee, 1991). Still, Pigouvian taxes are considered valid instruments to address externalities when they are modified for compatibility with the objectives and framework of the tax system (Baumol, 1972; Sandmo, 1975). The impact of an environmental tax on bringing the market to an optimum point is illustrated in Figure 2.

⁴ Polluter-Pays Principle indicates that the party responsible for environmental damage should pay the cost of pollution prevention, control measures, remedy, and cost to the society (OECD, 1975).

⁵ Pareto optimum is defined as the point where no one can be better off, without leaving some one worse off, based on welfare economics theory. It serves as a reference point to distinguish the deviations (Brownstein, 1980).

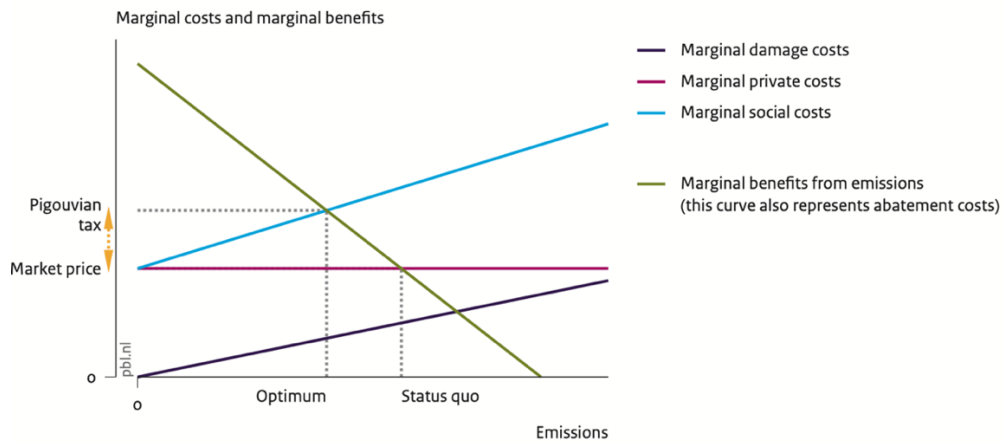


Figure 2. Status quo and optimum under the presence of externalities (Vollebergh, 2012)

At the status quo illustrated in Figure 2, producers operate at an output level that best serves their own interests, since they maximize profits without considering the environmental harm they cause. After implementing a Pigouvian tax that accounts for marginal social costs, emissions are reduced to the socially optimal level. This reduction in emissions also increases social welfare. Following the tax implementation, market operators would reduce their associated pollution to minimize the tax they pay. The optimum point is the status where the marginal benefit of additional pollution reduction no longer covers the additional loss of private benefits. In Figure 3, the revenue obtained from the implemented tax is illustrated as the orange area, which shrinks to its minimum in the optimal situation following operators' actions.

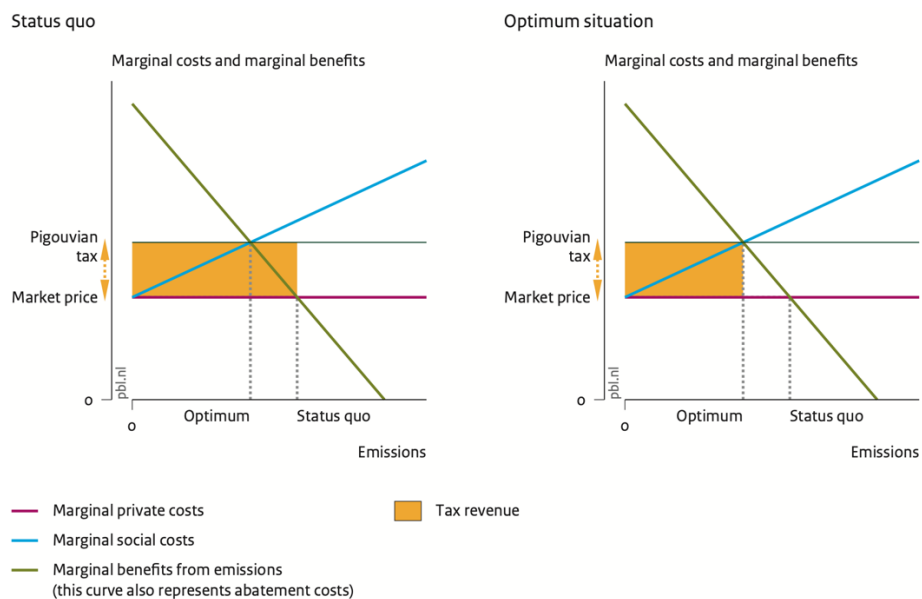


Figure 3. Tax revenue under operating at the status quo and optimum situation (Vollebergh, 2012)

It is important to consider that the efficiency and success of the price-based instruments depend on price elasticities of taxed /charged products or services. Price elasticity needs to be inelastic⁶ to achieve a revenue generation (Sandmo, 1974).

Environmental taxes are generally imposed at the point of production, increasing the production cost, therefore resulting in higher consumer prices. Unlike the production side taxes, Value Added Tax (VAT) is a consumption tax that is not considered an environmental tax; however, it is an effective method to drive consumers into sustainable choices, and is worth exploring for environmental objectives. It is also an important instrument to consider, in the sense that it already has an established operational framework and has a broad tax base, as consumption tax revenues accounted for 26.9% of the EU-27 tax mix (European Commission, n.d.-b). Following the 2022 reform on the VAT Directive in line with the Green Deal, Member States (MS) are allowed to apply lower VAT rates on sustainable products/services (European Parliament, n.d.). Previous studies have also explored the potential impact of consumption taxes that account for the environmental externalities of animal-derived foods, finding it to be an effective policy tool for influencing consumer prices. (Funke et al., 2022; Joint Research Centre et al., 2024; Springmann et al., 2025).

The cap-and-trade system, also mentioned as ETS, is another fiscal instrument investigated throughout this thesis, and represents an example of quantity-based instruments. The ETS includes a determination of a cap, which is the maximum amount of emissions allowed by the operators in the scope of the system. This allowance is reduced every year with the aim of reducing emissions. The allowance, which entitles companies to emit 1 ton of CO₂ eq, is initially given to companies free of charge and can be traded in the market, as illustrated in Figure 4.

⁶ Inelastic demand occurs when the quantity demanded of a product or service changes little in response to price variations. It is crucial for tax efficiency as taxing products with elastic demand may significantly cut consumption and overall tax collection, while taxing goods with inelastic demand guarantees steady revenue.

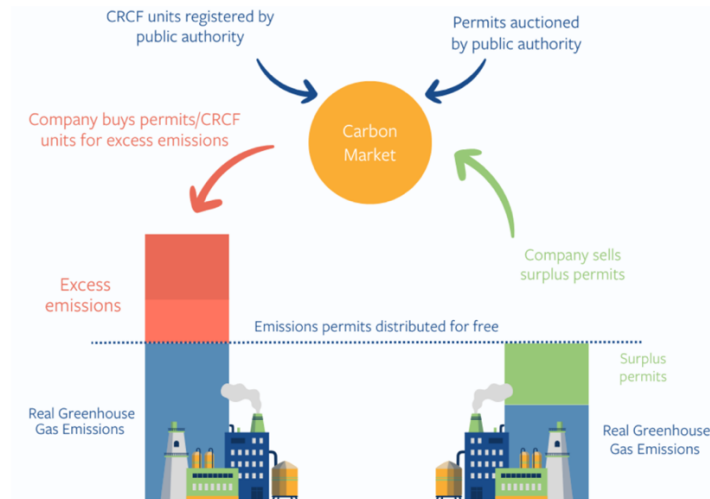


Figure 4. Trading of allowances in the carbon market under ETS (Scherger, n.d.)

Such as in Pigouvian tax, an optimum point is achieved in the mechanism with tradable emission permits. In this case, the marginal cost of pollution is set by the market. It would be feasible for operators to reduce their emissions until the profit from selling their unused permits is higher than the marginal cost of reducing emissions, or the marginal cost of reducing emissions exceeds the cost of emission permits. As the market price of allowances (the carbon price) rises, the incentive to reduce emissions becomes stronger. The determined emission reduction would be accomplished by implementing the least expensive option. Therefore, the cap and trade mechanism is a cost-effective instrument in terms of cutting emissions, where it is cheapest (Scherger, n.d.).

Both policy instruments aimed at addressing market externalities have advantages and disadvantages that require careful consideration during implementation. The choice of instrument depends on various factors, such as the policy's goal, the nation's structure, and its capacity. As argued in “Carbon pricing versus environmental tax incentives: is it “or” or “and”?”, a successful policy design can also combine carbon pricing and environmental tax incentives to take advantage of their complementary strengths (Valenduc, 2020).

1.2.2 Fiscal Instruments in Effect

The first carbon tax was introduced by Finland in 1990. Over the following decade, several other European countries adopted similar measures, bringing the total number of implemented instruments to eight by 2000. (Blok et al., 2015). In 2005, the EU established the first comprehensive ETS, covering emissions from power plants and other energy-intensive industries. Currently, the EU ETS applies to all MS, the European Free Trade Association

countries, and Northern Ireland for electricity generation. The EU ETS also expanded its scope to cover CO₂, N₂O, HFCs, and PFCs emissions from the industrial manufacturing, aviation, maritime transport, electricity, and heat generation sectors, accounting for approximately 40% of the GHG emissions of the EU (European Commission, n.d.-d, n.d.-a). In the EU, environmental taxes can be divided into four categories: energy taxes, transport taxes, pollution taxes, and resource taxes. Among these, energy taxes accounted for the largest share in 2023, generating €261.1 billion in revenue, which accounted for more than 76.4% of the EU’s environmental tax revenue. Approximately half of the environmental tax revenue gain was obtained from households, while the other half was received from corporations (Eurostat, n.d.-a).

Globally, total revenue from the carbon pricing mechanism amounted to 102 billion USD in 2024, with the majority from the EU ETS. Approximately 56% of revenues were utilized for environmental purposes, infrastructure, and development projects (World Bank, 2025) . ETS and tax mechanisms are also under development or planned for implementation in many other countries besides the EU, such as Türkiye, Brazil, and India. At the same time, the focus is more on ETS than on taxing (World Bank, 2025).

According to the World Bank, a total of 80 instruments (carbon taxes⁷ or ETS) are implemented, and 28% of global GHG emissions are covered by these instruments, while the majority -23%- of this coverage is through ETS in 2025 (World Bank, 2025). Still, a considerable percentage of emissions worldwide don’t face a carbon price. The coverage of emissions over the years by carbon taxes and ETS can be seen in Figure 5.

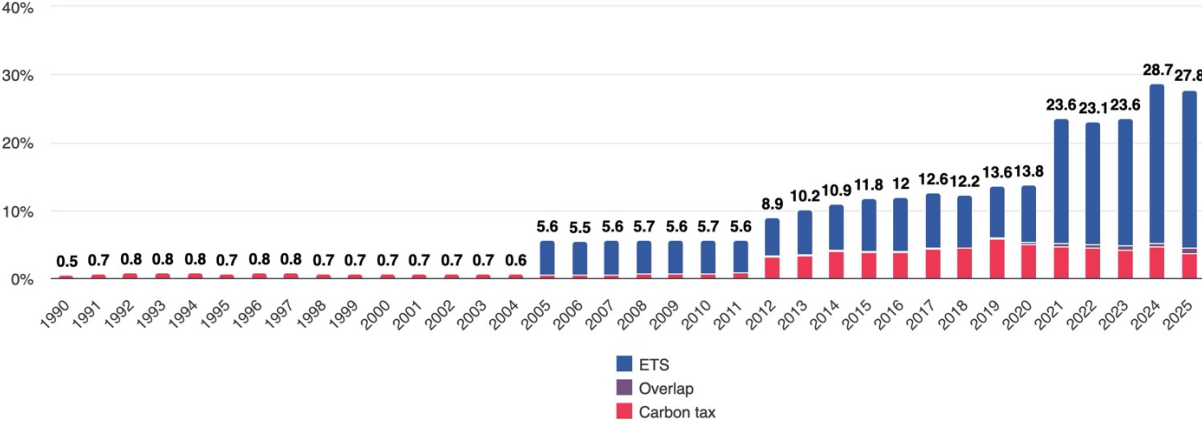


Figure 5. Coverage of emissions by ETS and Carbon Taxes over the years (World Bank Group, 2023a)

⁷ Under a carbon tax, the price of carbon is set by the government that operators must pay for each ton of GHG emissions they emit. The market determines the level of emission reductions incentivized by the price.

As the number of fiscal instruments increases over the years, the carbon prices are often criticized for not being high enough to effectively incorporate social costs, in both ETS and environmental tax systems. In 2022, just 4% of global carbon prices corresponded to emissions pathways that meet the targets of the Paris Agreement (World Bank, 2022), and only 3.2% of GHG emissions are priced at/above the recommended level (World Bank Group, 2023b). In addition to this price gap, real-life emission reductions and the effectiveness of the fiscal policies also remain challenging to estimate, as many other factors and policies have an impact on the emissions (World Bank, 2025). Still, it is possible to observe a reduction in emissions between 4% and 15% due to carbon pricing schemes, despite the low carbon prices (Döbbling-Hildebrandt et al., 2024).

Currently, a direct carbon price is available for over half of global emissions from the power sector and almost half of the industry sector. However, the coverage in other sectors still falls significantly short. In particular, non-energy agricultural emissions (methane from livestock and fertilizer application) are still not priced despite their contribution to global GHG emissions. The GHG emission coverage of carbon taxes and ETS across sectors is shown in Figure 6.

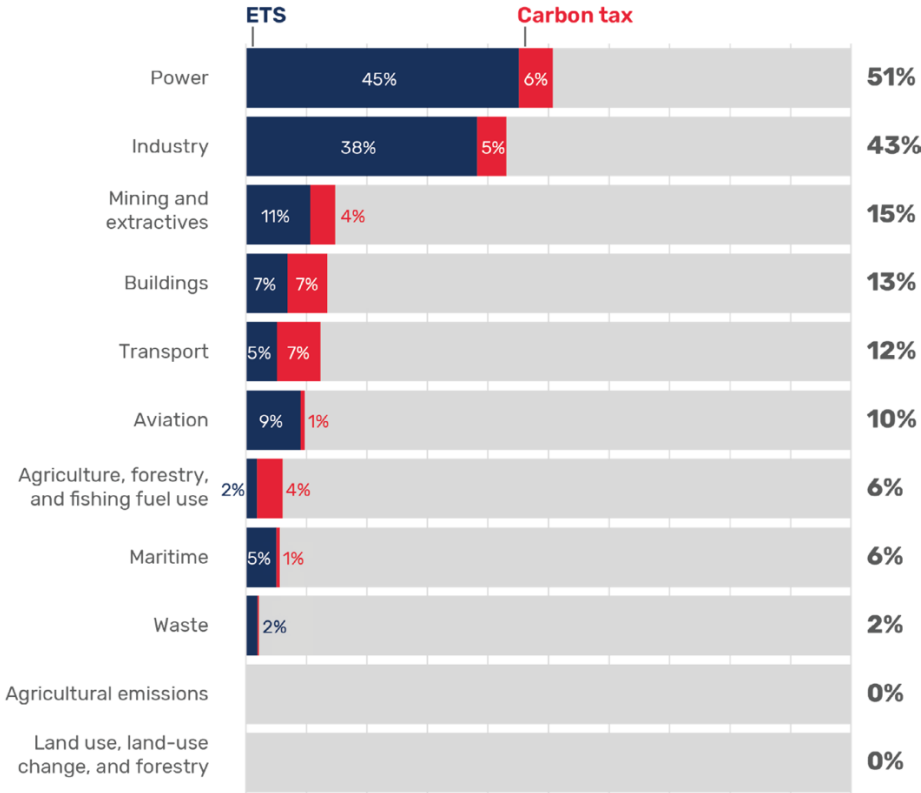


Figure 6. Emission coverage by pricing instruments in various sectors (World Bank, 2025)

Section 1.3 International Cases of Fiscal Instruments in the Agricultural Sector

This section presents previous attempts and plans to implement various fiscal instruments in other EU and non-EU countries, aiming to reduce emissions associated with animal agriculture. Investigation and understanding of these cases are crucial to design more effective policies by learning from the lessons.

1.3.1 Denmark's Carbon Tax: Green Tripartite Agreement

Denmark is a big producer and exporter of animal-derived products, especially dairy and pork. Accordingly, Denmark's agricultural sector accounts for approximately a quarter of the GHG emissions in the country (European Commission, 2023b). To address the issue, in 2021, Denmark reached an agreement, the Green Transition of Danish Agriculture, which put a special focus on agricultural emissions and stated that the Agriculture, Forestry and Other Land Use sector is required to reduce associated emissions by 55% to 65% by 2030 (compared to 1990 levels) (Ministry of Food, Agriculture and Fisheries of Denmark, 2021). In line with its ambitious goal, the government, key stakeholders from the agricultural sector, and environmental actors agreed on the Green Tripartite Agreement in June 2024, an important policy addressing the environmental damage caused by the intensive agricultural sector in Denmark (Blandford, 2024). The agreement has three main points: a livestock emissions tax, subsidies to reduce nitrogen pollution, and a Green Area Fund to restore habitat and biodiversity severely affected by livestock practices. It is estimated to result in 1.8 million tons of CO₂eq in Denmark in 2030.

The agreement is a crucial step because it is the first carbon tax applied to the agricultural sector/livestock emissions. Under the agreement, a levy would be charged on livestock emissions that exceed reduction targets, and farms will have to pay an additional \$40 per ton of emissions (carbon dioxide equivalent) in 2030, rising to around \$100 in 2035. However, with the 60% base deduction for farms with low emissions, the effective tax rate is much lower, at €16 per ton in 2030 and €40 in 2035.

The use of collected revenues is also disclaimed in the agreement. The government of Denmark is planning to return the revenue to the agriculture sector to support greening initiatives. In addition, 134 million € is intended for promoting plant-based products and organic farming.

The emissions resulting from the farms' activities will be calculated using the number of livestock (pigs and bovines) and emissions per animal, taking into account variables such as

climate-friendly practices, effluent management, feeding composition, and efficiency. Other animals besides pigs and bovine animals, fertilizer use, and small farms are currently excluded from the agreement.

As Denmark has comparatively efficient dairy production in terms of CO₂ emissions (Wirsenius et al., 2020), the agreement also highlights that the production should not shift to other countries, since it would result in increased emissions. The lack of pricing agricultural emissions in other EU countries, therefore, poses a risk of carbon leakage.

The success of the policy, despite the harsh environment in Europe, considering farmers' protests (Finger et al., 2024), is likely to arise from inclusive communication that enables farmers, industry, and environmental groups to collaborate on the issue.

1.3.2 New Zealand: He Waka Eke Noa Partnership

Methane emissions from ruminant animals, and nitrous oxide emissions from fertilizers and animal waste, are responsible for more than half of New Zealand's GHG emissions (OECD, 2017). However, agriculture remains the only industry not included in the NZ ETS, despite its significant contribution to climate change.

In 2019, the government of New Zealand agreed to price agricultural emissions, and parliament passed a law requiring that if the agricultural sector did not develop an alternative emissions pricing system by 2025, agriculture would automatically enter the NZ ETS, which would be applied at the processor (meat/dairy/fertilizer processors) level (New Zealand Ministry for the Environment, n.d.). This would make New Zealand the first country to price agricultural emissions.

Initially, the government sought the Interim Climate Change Committee's suggestions on how agriculture could be included in the NZ ETS. However, deciding that it is not the best option, the government launched a collaboration "He Waka Eke Noa (HWEN)" aiming to design an alternative to price agricultural emissions. After 3 years of discussion, HWEN came up with a proposal and submitted the final recommendation to the government (He Waka Eke Noa Primary Sector Climate Action Partnership, 2022). The proposal was to establish a farm-level split-gas levy for the agricultural sector in New Zealand, which would be implemented gradually. Split-gas levy indicated a different pricing system for levy rates to short- and long-lived emissions, such as methane and nitrous oxide. Under the proposed emission pricing system, registered farm business owners who exceed an emission threshold of 200 tons of CO₂ eq/year would be charged for their biogenic methane and nitrous oxide emissions. Pricing would be based on a farm basis rather than national averages, and the gradual

implementation indicated an introductory price for the first 5 years. Sequestration attempts on the farm were also included in the proposal's scope, and successful sequestration would reduce the levy on emissions. The collected revenues would be recycled to invest in R&D for climate-mitigation practices and incentives, to cover the operational costs of the proposed pricing system (monitoring, reporting, etc.), and to provide a dedicated fund for landowners. In 2022, the government published “Pricing Agricultural Emissions: Consultation Document”, seeking recommendations and feedback from stakeholders on several options to price agricultural emissions (Ministry for the Environment and Ministry for Primary Industries, 2022). Options included inclusion of fertilizer emissions into NZ ETS, farm-level split-gas levy (with or without including fertilizer), and a processor-level ETS option. The document received detailed responses, including DairyNZ’s, which is an organization representing New Zealand’s dairy farmers. Following this, the government conducted modelling and impact assessment to estimate the emission reductions, cost of mechanisms, revenue recycling, and equity of different options, and came up with a modified version of the HWEN’s proposal that included different prices. However, this modification faced backlash from industry stakeholders arguing that it would replace the partnership model with a punitive tax policy that would damage farmers economically, and would not recognize the effectiveness-equity balance of the former HWEN proposal (DairyNZ, 2022). In June 2024, the government backed down on implementing farm-level pricing, announced the removal of agriculture from the NZ ETS, and abolished the HWEN partnership.

1.3.4 Sweden and Germany: Meat Tax Proposal (FAIRR, 2017)

Sweden and Germany are European countries where a meat tax is being discussed in parliament, but has not yet yielded concrete results or led to legislation. In 2016, the Swedish Green Party called for a climate tax on food, which included a tax on beef as a first step. The proposal also recommended a complementary climate label for food to inform consumers about environmental impacts and encourage low-carbon choices, as well as revenue redistribution to reduce the risk of regression. The proposed tax would target consumers rather than producers to tackle the risk of carbon leakage and the import of beef. The suggestion suggested a price of roughly \$2.30 per kilogram.

In 2017, the German federal environmental agency also proposed increasing taxes on animal-derived products, raising the VAT rate from 7% to 19%, due to environmental damage caused by their consumption. The Environment Agency highlighted that reduced VAT acts as an environmentally harmful subsidy and should be abolished.

Section 1.4 Motivation for Hungary

Studying fiscal measures to address emissions from animal agriculture in Hungary is valuable from many aspects, including social, economic, and environmental.

Due to the availability of its natural landscape, the 5.3 million hectares of Hungary’s territory are used by the agricultural sector. This accounts for 55% of the land in Hungary, which is a share significantly higher compared to other EU countries (Hungarian Central Statistical Office, n.d.-h).

Hungary is also among the EU-27 countries where agricultural emissions are expected to increase, despite planned measures. Agricultural emissions in Hungary increased by 3.81% in 2022, compared to 2005 levels. This increase is expected to reach 19.14% by 2030, making Hungary the third EU-27 country with the highest growth in agricultural emissions, after Estonia and Bulgaria (Figure 7).



Figure 7. Current and projected % change in agricultural emissions in EU-27 countries (EEA, 2024)

It can also be argued that environmental issues are currently not considered a priority in Hungary. A very small share of official development assistance is allocated for the

environment. This allocation fell by 70% from 2020-2021 to 2022-2023, as climate change and biodiversity-related funding allocation nearly vanished (OECD, 2025). In contrast, animal agriculture receives a great amount of support from the government, both funded from the CAP and the national budget. These subsidies are further elaborated in Chapter 2.

The economic environment in Hungary also poses a challenging context for implementing fiscal measures. The country faced the highest inflation in the EU in 2023. Food prices were 42.6% higher than the previous year on average, while certain products, such as bread (67%), eggs (74%), and dairy products (72.8%), saw even higher increases. This high inflation in Hungary was a result of increased raw material prices globally, in addition to the weakening of the Hungarian forint (RICHTER, 2023), and had crucial impacts, especially on the lower income decile.

Accordingly, in 2023, Hungary was reported as one of the countries with the highest share of people at risk of poverty unable to afford a proper meal (37.3%), following Slovakia and Bulgaria (Figure 8) To tackle the high inflation rates, the government also decided to put a cap on retail margin prices of various food products, including cow milk, pork, chicken, and eggs (Maró et al., 2025).

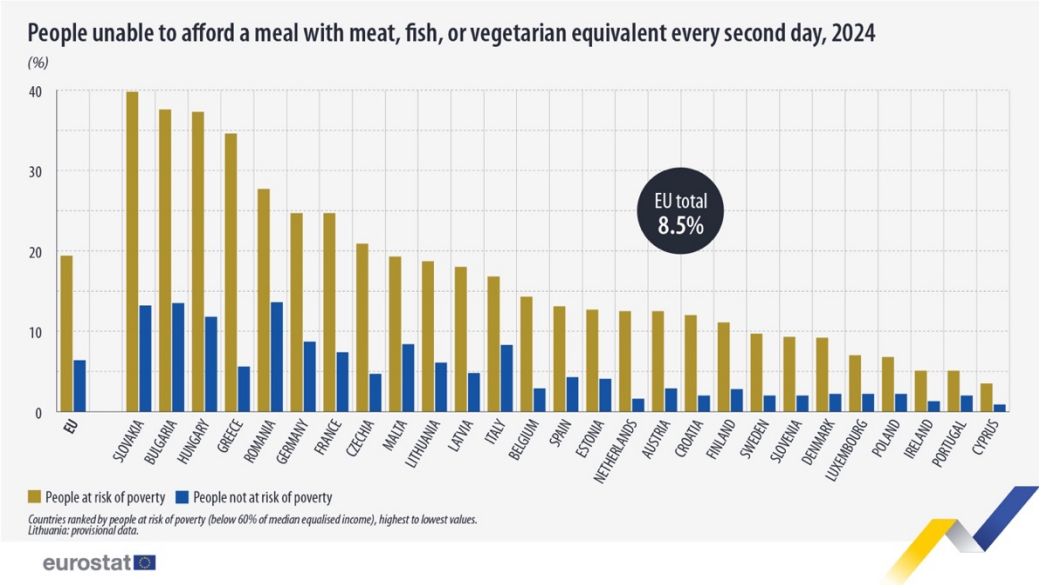


Figure 8. Share of population at risk of poverty in EU countries (Eurostat, 2025)

Hungary is also the country with the highest VAT rate (27% standard rate) among OECD countries in 2024, as shown in Figure 9. In the same year, the consumption taxes accounted for more than 40% of the taxes in Hungary .

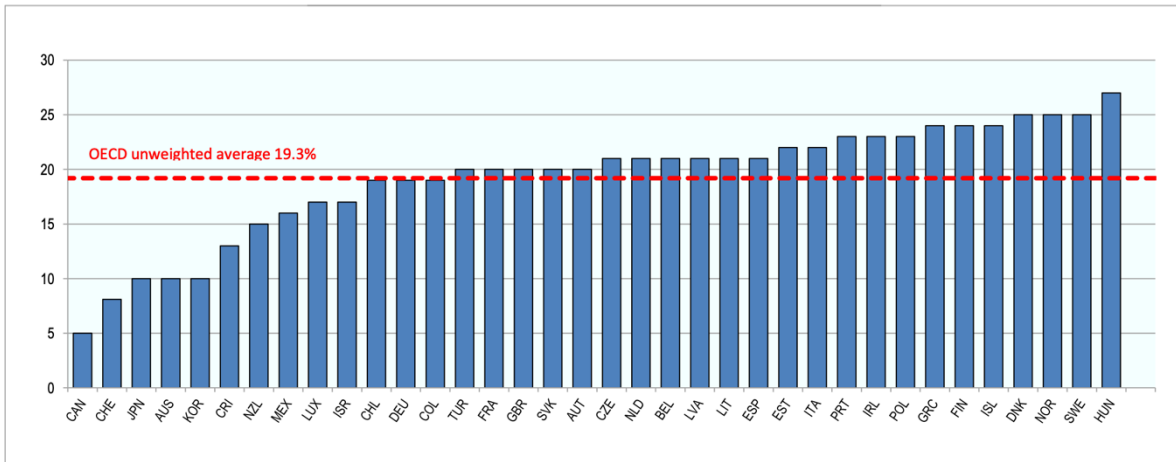


Figure 9. Standard VAT Rates in OECD Countries (OECD, 2024).

All these points create a challenging context for implementing fiscal measures for animal agriculture in Hungary, where food affordability is already a topic of discussion. Still, they also highlight the need to address the environmental and social losses resulting from the sector. In addition, Hungary has never discussed a pricing system for animal agriculture, and a significant research gap on this issue remains.

The following chapter provides greater detail on Hungary's agricultural structure and policy environment to contextualize the fiscal analysis.

Section 1.5 Research Aim, Question, and Objectives

This thesis's main goals are to emphasize the necessity of internalization mechanisms for the animal agriculture industry and investigate potential fiscal measures that Hungary could implement to internalize the environmental externalities associated with the consumption of animal-derived food. The study aims to incorporate different aspects, such as economic, environmental, and social, of the implementation of various fiscal policies: ETS, VAT reform, and a revenue recycling mechanism in the Hungarian setting.

The thesis follows the research question:

“What are the external costs of animal-derived product consumption in Hungary, and how could policy instruments such as ETS and VAT adjustments, combined with revenue redistribution, reduce these costs while maintaining public support?”

The thesis aims to answer this question by exploring the following objectives:

- Highlighting the importance of environmental externalities associated with animal agriculture and the need to address them through fiscal instruments.
- Quantifying the environmental externalities resulting from animal-derived food consumption in Hungary for beef, milk, pork, chicken, and eggs.
- Evaluating the impact of VAT adjustment in terms of reduction in consumption and reduced external costs and estimating the VAT revenue received.
- Evaluating the potential emission coverage of downstream and on-farm livestock ETS mechanisms implemented in the Hungarian setting.
- Investigating the social fairness of VAT collection and the revenue redistribution mechanism.
- Evaluating the instruments' social equality, administrative feasibility, impact on the food system, and public acceptance within the Hungarian context.

Section 1.6 Structure of the Thesis

This thesis is structured into five main chapters:

- **Chapter 1: Introduction**
Introduces the background of animal agriculture and its environmental externalities, outlines the need for intervention through fiscal measures such as environmental taxation and ETS, and explains the motivation to study Hungary. It presents the research question, objectives, and the study's structure.
- **Chapter 2: Context – Animal Agriculture in Hungary**
Provides an overview of Hungary's livestock production and consumption patterns, environmental performance of the sector, the role of subsidies and CAP strategic plans, and policies regarding the sector and animal-derived food.
- **Chapter 3: Methodology**
Describes the methodological framework adopted to estimate the external costs of animal-derived products and evaluate fiscal interventions. It details the environmental pricing methodology, regionalization for Hungary, and VAT and ETS modeling.
- **Chapter 4: Results and Discussion**
Presents and interprets the results of external cost estimation, evaluates the effectiveness and implications of VAT and ETS policy scenarios, and analyzes revenue redistribution mechanisms. The chapter concludes with an integrated discussion on feasibility, fairness, and policy relevance.

- **Chapter 5: Conclusion**

Summarizes key findings, discusses policy implications, identifies study limitations, and proposes directions for future research.

Chapter 2: Animal Agriculture in Hungary

Section 2.1 Introduction

Understanding the characteristics of the region in which a fiscal instrument would be employed is crucial to developing efficient, context-specific policies. Since conditions such as economic structure, cultural norms, geographic location, and climatic circumstances can all vary significantly, a policy's effectiveness in one country does not necessarily translate to another. Policies must be tailored to the specific requirements and conditions of each country to ensure their success and long-term viability.

This section aims to examine Hungary's status in animal agriculture and place the discussion in a regional context. It provides an overview of farm structures, trends in the animal population intended for human consumption, sectoral emissions, and policies regarding animal agriculture that include significant government support.

Section 2.2 Farm Structure and Animal Population Trends

Hungary has a comparatively small share of agricultural outputs in the EU (2.1 % in 2020 for all agricultural products, 1.9% for animal-derived products (European Commission, 2021a), whereas the share of agriculture in the national economic structure is larger (representing 3.4% of the GDP in Hungary in 2024 (Hungarian Central Statistical Office, n.d.-d)). For countries such as France and Germany, this is the opposite case, as they together account for one-third of the EU's agricultural output, but agriculture makes only a small contribution to their national GDP (Biró & Toldi, 2022). The average share of various products in terms of economic output between 2018 and 2020 is shown in Figure 10.

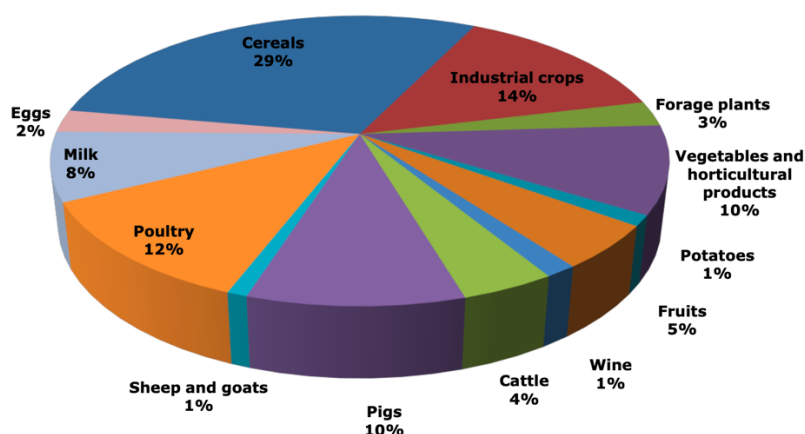


Figure 10. Share of products in economic output (European Commission, 2021a)

The animal agriculture sector underwent significant changes over the past few decades in Hungary. Following the political and economic changes in the 1990s, the sector saw a sharp decline. Livestock production had dropped to two-thirds and remained consistently low from 1993 to 2004. Animal agriculture continued to decline when Hungary joined the EU in 2004. One of the most impacted industries in Hungary's post-transition agricultural landscape is still animal agriculture, which has not recovered. Due to government incentives to revive livestock production, the number of cattle has been steadily increasing in recent years (between 2010 and 2020, the cattle population increased by 32%), but the number of pigs has further declined (KIS-KOVÁCS et al., 2022). The change in livestock population is also evident in the livestock density index⁸, as shown in Figure 11.

⁸ The livestock density index indicates the number of animals in livestock units (LSU) per hectare of utilized agricultural area (UAA) (Eurostat, n.d.-b). It is also considered as an agri-environmental indicator, as it shows the pressure livestock farming places on the environment (Eurostat, 2023).

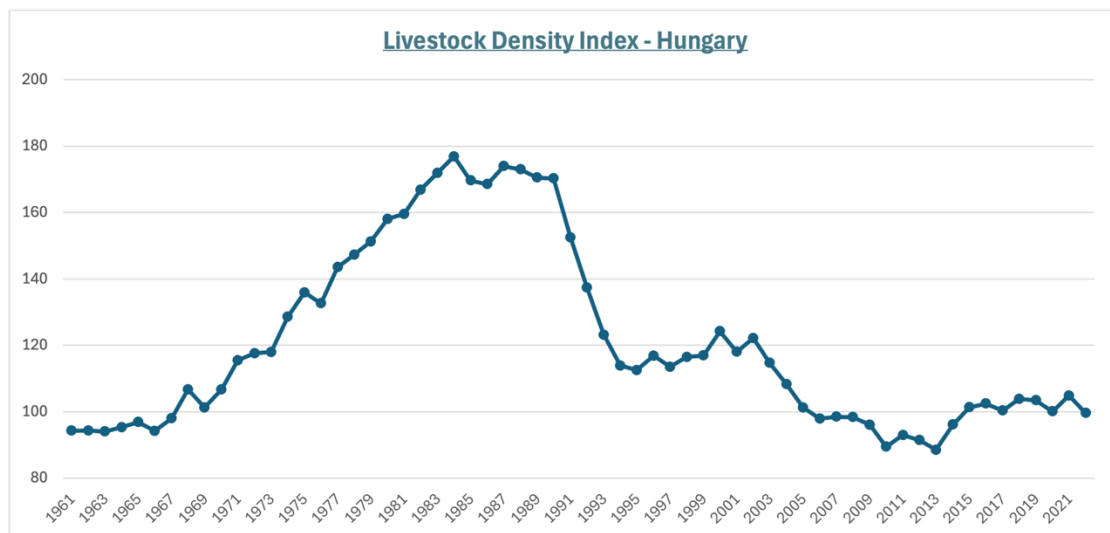


Figure 11. Livestock Density Index in Hungary between 1961 and 2022 (author's calculation based on World Bank Data (World Bank Group, n.d.))

Intense farm concentration has also occurred in Hungary's livestock industry, with large-scale operations expanding while smaller farms and domestic animal husbandry have decreased (KIS-KOVÁCS et al., 2022) (Farkas et al., 2023).

Currently, approximately 60% of the farms operating in Hungary are operating as livestock farms, mainly poultry, pig, sheep, and cattle (European Commission, 2025i). The size of farms is significantly below the EU average, with an average of 8.1 ha, while 87% of the farms have less than even 5 ha (European Commission, 2025b). Therefore, a polarized structure is present in Hungary, as a lot of small farms and a few very large farms are operating in the sector. The large enterprises have control over 50% of the utilized agricultural area (fi-compass, 2020).

Section 2.3 Environmental Impact of the Animal Agriculture Sector

Hungary's GHG emissions are dominated by the energy sector, including transport, energy industries, and the building sector, which accounts for 73% of GHG emissions. The energy sector is followed by industrial and agricultural emissions (both having a share of around 10%) (KIS-KOVÁCS et al., 2022). Due to lower priority, policies and measures addressing the agricultural sector are also far fewer than those in the energy and transportation sectors, and the EU average (European Commission, 2023a).

Livestock was responsible for 54% of GHG emissions in agriculture in 2023, while cattle are the biggest contributor to livestock emissions, accounting for a 31% share of total agricultural emissions. Two main GHG emissions resulting from animal agriculture, methane - mostly

generated at waste disposal sites and in animal farms- and nitrous oxide – mainly originating from agricultural soils, and manure management -contribute 15% and 6% to the total GHG emissions, respectively (KIS-KOVÁCS et al., 2022).

It is also possible to detect the impact of animal agriculture by examining emission trends over the years, as shown in Figure 12. The sharp decline – especially in enteric fermentation and manure management - in 1990 is mainly due to the drop in the animal population after the political change. Before the population decrease in 2022, increased numbers of cattle, milk production, and fertilizer use resulted in higher emissions for 10 years, starting in 2012 (Biró & Toldi, 2022). CH4 emissions also peaked in line with the animal population in 2021, at 3071 Gg CO₂-eq, which was at its lowest point in 2011(KIS-KOVÁCS et al., 2022).

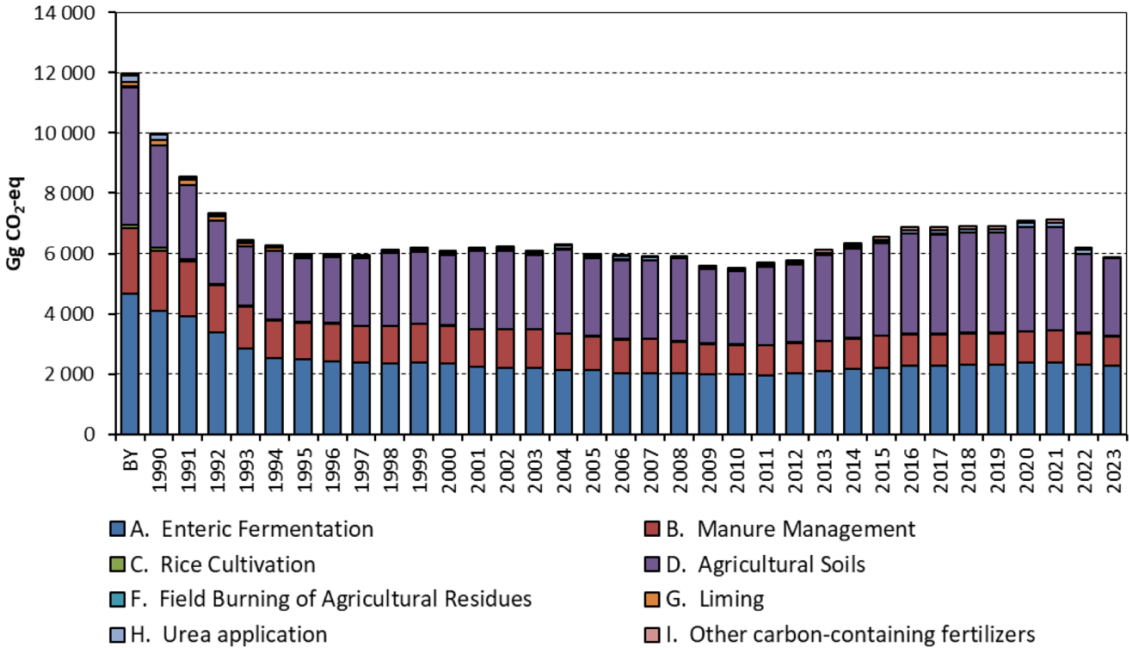


Figure 12. Trend of emissions resulting from the agriculture sector (KIS-KOVÁCS et al., 2022)

Section 2.4 Governmental Support

The agricultural sector receives major support in Hungary. Farmers from 13 sectors, including dairy and meat, are even prevented from operating at a loss through subsidies (European Commission, 2025a). Since 2021, the Rural Development Program, under the European Agricultural Fund for Rural Development, has provided 1.2 billion € for livestock farm investments, which indicates the largest support scheme since 1990. The increase in the number of animals over the past years, discussed in earlier sections, is also associated with

higher purchase prices, accompanied by lower financing and feed costs due to government support schemes (Magyarország Kormánya, n.d.).

In 2024, a total of 3.2 billion € was paid under agricultural and rural development subsidies, according to the Institute of Agricultural Economics. 62% of this payment was supplied from EU funds, while the rest of it came from the national budget. Livestock farmers received 17.3% of these subsidies, and one-third of the subsidies allocated for livestock breeders were received by cattle breeders, which was mainly dominated by dairy farmers (Vörös-Illés et al., 2025).

Like other MS, Hungary proposed and got approval for its CAP Strategic Plan that focuses primarily on supporting farmers, after several drafts and revisions. In the scope of CAP, Hungary would receive 8.4 billion € from the EU budget, while 2 billion € of this is allocated to environmental and climate objectives and eco-schemes (European Commission, 2025h). Hungary also supports the animal agriculture sector through coupled income support (CIS)⁹, which allocated 126M€ to animal-derived food production in total from their annual national ceiling for direct payments in 2022 (European Commission, 2022b). CIS poses a significant environmental risk, as it encourages intensified production due to triggering overstocking, overproduction, and especially resulting in emission-intensive practices in the livestock sector (Bas-Defosse & Meredith, n.d.). The majority of the CIS are allocated to livestock in MS, as in the case of Hungary (European Commission, 2022b), (Bas-Defosse & Meredith, n.d.). These payments are also criticized for benefiting larger industrial farms when income support is allocated based on land area or livestock numbers, further moving away from supporting low-income farmers or environmental outcomes (Baldock et al., 2025). This risk is also highlighted in the observation letter of the European Commission on the CAP Strategic Plan of Hungary, where the European Commission requested Hungary to clarify the interventions planned to overcome the possible intensification of environmental pressure (due to intensification of animal agriculture, water use in water-scarce regions, etc.) resulting from CIS (European Commission, 2022a).

It is also feasible to estimate that the indirect support for the animal agriculture sector is higher when indirect supports are considered. This indirect support mechanism includes subsidized crop production that benefits animal agriculture by making feed purchases more affordable for farmers, as well as support for young farmers through CAP payments.

⁹ Unlike other support mechanism, CIS is voluntary for the MS. The support is paid per animal or hectare of the sector in question. MS cannot use more than 13% of their direct payment budget to grant CIS, and have to justify the need for CIS. (European Commission, 2025g)

Alongside the income support supplied to livestock farmers (directly and indirectly through feed prices) , the animal agriculture sector is also favored with a reduced VAT rate of 5%, for both live animals and processed animal-derived products (European Commission, 2021b). This further encourages the overconsumption and increases the gap between private and social costs.

Although animal agriculture is not the primary contributor to GHG emissions in Hungary, the sector is intensifying each day uncontrollably due to government policies, likely resulting in increased emissions. When this environmental aspect is coupled with the low purchasing power in Hungary and the fact that high income deciles are usually the ones benefiting from low prices of animal-derived products (Hungarian Central Statistical Office, n.d.-b) , the social equity worries also enter the picture. Considering all these points, the need to implement fiscal measures that take the environmental costs of animal-derived food becomes clearer.

Chapter 3: Methodology

3.1 Purpose of the Methodology

This chapter describes the methodological framework employed to estimate the external costs of animal-derived product consumption in Hungary and to investigate the possible impact of different policy options: ETS and VAT adjustments, combined with a revenue distribution approach to gain political support.

The approaches described in the report "Pay as You Eat: Internalizing External Costs of Animal Food Products in France, Germany, and the EU27" (Korteland et al., 2023) and "Pricing agricultural emissions and rewarding climate action in the agri-food value chain" (Bognar et al., 2023) serves as a foundation for the methodology used in this thesis.

The first report outlines a model for quantifying the external costs of animal-derived products and for assessing policy instruments to internalize them. This study uses national policies on animal agriculture and regionalized data to adapt the frameworks provided in the reports to the Hungarian setting.

There are three main parts to the methodology. First, external costs associated with the environmental impact of animal-derived product consumption in Hungary are estimated using the environmental price methodology in SimaPro. The estimation is carried out for selected animal-derived products: beef (obtained from both beef and dairy cattle), milk, pork, chicken,

and eggs. Second, the potential efficacy of two economic policy tools in internalizing these costs is evaluated: an ETS and VAT adjustments. For ETS, two different approaches are investigated: on-farm livestock ETS and downstream ETS. Third, a possible revenue redistribution mechanism is investigated to improve social acceptance and social equity. For beef obtained from dairy cattle, only the external cost estimation has been carried out. The rest of the analysis excludes beef from dairy cattle and considers beef from beef cattle in the following estimations.

3.2 External Cost Estimation

3.2.1 *Life Cycle Assessment*

The initial stage in assessing environmental externalities is conducting a Life Cycle Assessment (LCA) using the SimaPro software and the available Agri-footprint database. For the life cycle assessment of animal-derived products, the system boundaries are set to cradle-to-gate: the entire production chain up to the point at which the meat is sold to retail. The final product is the fresh product that leaves the farm/slaughterhouse; the steps, such as transport to retail and to consumers, packaging, and disposal, are not included. Both direct emissions at the farm level and indirect emissions throughout the production chain, including animal feed, the energy mix, and transportation, are covered by the analysis.

The Recipe Midpoint method is used to calculate environmental impacts, including 17 impact categories that the economic activity contributes to. The impacts are calculated for 1 kg of each animal-derived product. For meat, this is 1 kg of boneless meat; for eggs and milk, it represents 1 kg of the product. The final packaging is not included in the product weight. The allocation method is economic allocation, which attributes environmental impact to products and by-products proportional to their market share, using the market prices in the database for the allocation.

3.2.2 *Environmental Prices*

To monetize environmental impacts, this study uses environmental prices developed by CE Delft¹⁰. Environmental prices enable combining midpoint and/or endpoint indicators into a

¹⁰ A Dutch independent environmental research organization that focuses on sustainability evaluations, policy suggestions, and environmental economics.

single monetary value, including assigning different weights to different environmental impacts. This single monetary value offers a valuable quantitative foundation for decision-making for policymakers and companies.

Environmental prices included in the LCA package in SimaPro are expressed in euros per unit of emission at 2015 price levels, which represent the monetary valuation of environmental damage and include an average VAT rate. This indicates the marginal welfare loss to society from the emission of one additional kilogram of the pollutant. To put it another way, environmental prices reflect society's willingness to pay to prevent the negative impacts associated with these emissions.

The first step in estimating these prices is to conduct a damage assessment, which uses scientific models to quantify the impacts of emissions or resource use, such as premature mortality from air pollution and biodiversity loss from land use. The next step is economic valuation, which monetizes these damages using willingness-to-pay studies or economic methods that assess the social cost of prevention, mitigation, or restoration associated with one additional unit of negative environmental impact. The environmental prices determined for the environmental themes included in this assessment are shown in Table 1. The valuation system that connects interventions, environmental impacts, and endpoints to their monetary values is further illustrated in Figure 13.

Table 1. Environmental Prices of ReciPe Impact Categories

Theme	Unit	Environmental Price
Climate change	€/kg CO ₂ -eq.	€ 0.0566
Ozone depletion	€/kg CFC-eq.	€ 30.4
Human toxicity	€/kg 1,4 DB-eq.	€ 0.0991
Photochemical oxidant formation	€/kg NMVOC-eq.	€ 1.15
Particulate matter formation	€/kg PM10-eq.	€ 39.2
Ionizing radiation	€/kg kBq U235-eq.	€ 0.0461
Acidification	€/kg SO ₂ -eq.	€ 4.97
Freshwater eutrophication	€/kg P-eq.	€ 1.86
Marine eutrophication	€/kg N	€ 3.11
Terrestrial ecotoxicity	€/kg 1,4 DB-eq.	€ 8.69
Freshwater ecotoxicity	€/kg 1,4 DB-eq.	€ 0.0361
Marine ecotoxicity	€/kg 1,4 DB-eq.	€ 0.00739
Land use	€/m ² ·year	€ 0.0845

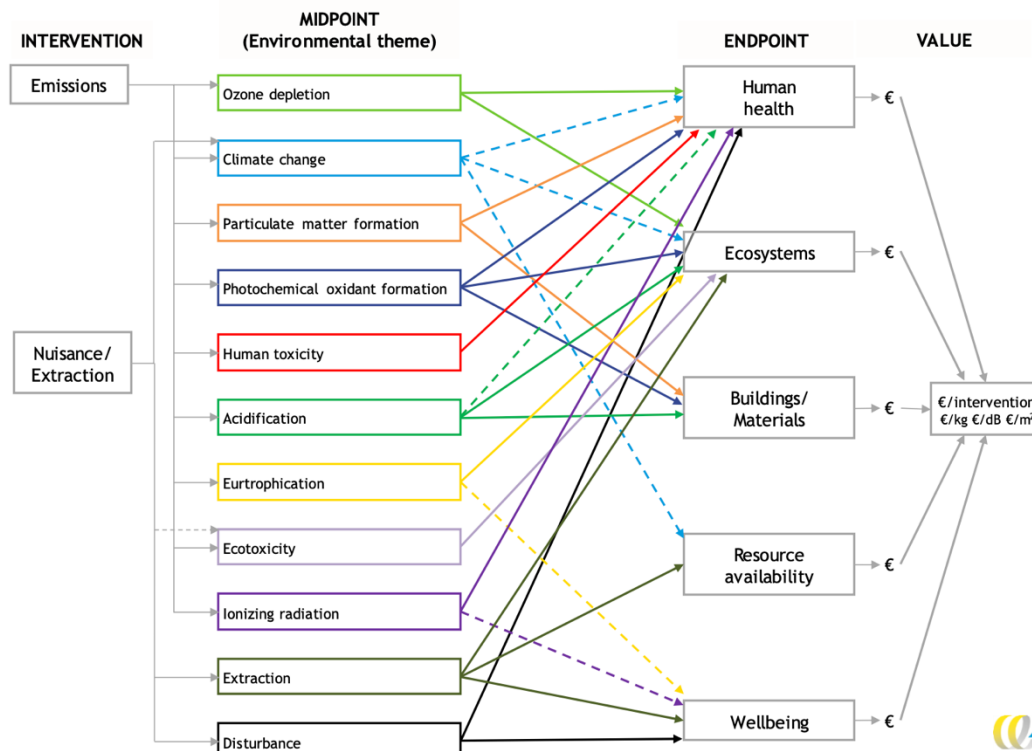


Figure 13. Relationship between interventions, midpoints, endpoints, and valuation in the CE Delft Environmental Price Handbook (Mohammadzadeh Valencia et al., 2024)

3.2.3 External Cost Calculation Using Environmental Prices

Following the determination of environmental impacts, the external costs of selected animal-derived products are calculated using the formula:

$$EC_i = \sum_{j=1}^{14} EP_j * I_{i,j} \quad \text{Equation 1}$$

where j represent the 14 different environmental themes included in the assessment, EC_i represents the external cost for a kilogram of product i , $I_{i,j}$ is the environmental impact -such as kg of CO₂- associated with the production of product i , and environmental theme j and EP_j is the environmental price determined by the CE Delft for that environmental theme, which can be seen in Table 1. This calculation is carried out automatically by the software as part of the environmental price methodology.

External costs are calculated for a kilogram of beef from beef cattle, beef from dairy cattle, milk, pork, chicken, and eggs.

3.2.4 Regionalization of Data for Hungary

The default Agri-footprint data in SimaPro, which mainly represent production systems in the Netherlands and Ireland, are partially replaced in this analysis with data unique to Hungary to ensure that the environmental cost estimation appropriately reflects Hungarian agricultural conditions, wherever possible. Methane and nitrous oxide emissions for beef and dairy cattle resulting from enteric fermentation and manure management, feed composition for cattle, poultry, and pigs, fertilizer and manure application, and, where available, water and electricity mix are regionalized. With this modification, national variations in production methods, input usage, and emission intensities can be taken into consideration in the analysis.

a. Emissions from Livestock

One of the main regionalized datasets is the methane and nitrous oxide emissions from cattle farming in Hungary. Data from the National Inventory Document published by the Institute of Agricultural Economics are used to update annual methane and nitrous oxide emissions for dairy and non-dairy cattle in the Agri-footprint dataset, as shown in Table 1 (KIS-KOVÁCS et al., 2022). The most recent available data, from the year 2022, is used in the calculations. As methane emissions from other livestock (pigs and poultry) are negligible compared to those associated with cattle farming, the default data for the Netherlands Economic Region are used for these products.

Table 1. Methane and nitrous dioxide emissions per animal for dairy and non-dairy cattle

	Emission Source		Emission Source	
	Enteric Fermentation		Manure Management	
	CH₄		CH₄	N₂O
Dairy Cattle	134 kg per animal		8.00 kg per animal	0.27 kg per animal
Non-Dairy Cattle	73 kg per animal		7.20 kg per animal	0.34 kg per animal

The emissions related to milk production are calculated using annual milk production per animal and the emissions from dairy cattle. According to the Hungarian data, on average, 8405 liters of milk are obtained from each dairy cattle annually, compared to the original Netherlands data in the Agri-footprint dataset, which is based on 8652 kg of raw milk produced by every cow in a year, indicating a lower efficiency for the Hungarian milk production.

b. Feed Composition & Fertilizer Application

The environmental impact of different livestock varies depending on the type of feed they are fed, among other factors related to enteric fermentation. Different feed sources, such as soybean, oilseeds, and maize, result in various environmental impacts (Bidoglio et al., 2024). Therefore, the composition of the feed has a significant impact on the environmental performance. Hungarian feed composition data for the year 2019, obtained from the report published by the Ministry of Agriculture, is incorporated into the model to better reflect the local use of cereals, protein crops, and by-products (Fekete et al., 2020)(Table 2).

Table 2. Feed composition used for cattle, poultry, and pigs

Feed Composition (%)	Cattle	Poultry	Pig
Cereals	39,4	62	68,6
Protein Crops	14,2	18,3	10,6
Oil Seeds	20,5	-	5,3
Feed Supplements	5	1,8	3,1
Processing By-products	15,9	5,6	-
Fats and Oils	-	-	1

To implement this feed composition in the analysis, the total feed conversion ratio, therefore the total amount of feed, is assumed to be the same as the Agri-footprint data. While keeping the total amount the same, the amounts of the ingredients are arranged according to the composition reported by the Ministry of Agriculture.

Fertilizer application rates for cropland are updated using data obtained from the Hungarian Central Statistical Office for the year 2022 (Hungarian Central Statistical Office, n.d.-e) (Hungarian Central Statistical Office, n.d.-f) (Table 3). Both synthetic fertilizers and manure applications are considered, as these are important sources of N₂O emissions (Hassan et al., 2022).

Table 3. Fertilizer application rates and emissions in Hungary

	Application Rate (kg/hectare)	Total Application (hectares)	Total N₂O Emissions Resulting (Gg)
Synthetic fertilizer	324	3236346	5,12

Animal manure	15900	233,5	1,61
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To incorporate the N₂O emissions into the analysis, the emissions per hectare of soil is estimated based on the total N₂O emissions resulting from synthetic fertilizer and animal manure application and application rate. The calculation is as follows:

$$E_{hectare} = \frac{E_{N_2O,total}}{A_{total}} \quad \text{Equation 2}$$

where $E_{hectare}$ represents emission resulting from application of synthetic fertilizer or animal manure per hectare of soil, E_{N_2O} is the total N₂O emissions resulting from the application of synthetic fertilizer or animal manure, and A_{total} is the total hectare of soil that fertilizer or manure application has been done in 2022.

To guarantee that resource usage and energy-related emissions associated with Hungarian agricultural practices are more accurately reflected, data on water use and electricity mix are updated as Hungary-specific whenever available.

The calculated external costs at 2015 prices are adjusted to the 2025 price level using the harmonized index of consumer prices, as suggested by the CE Delft Handbook (de Bruyn et al., 2018). The most recent consumer price index (CPI), taking the year 2015 as a base, is used for the calculations, which is estimated as 1,743. This estimation is carried out using the 2015 and 2024 harmonized index of consumer prices published by Eurostat (Eurostat, 2022b), and the percentage change of consumer prices between 2025 and 2024 announced by the Hungarian Central Statistical Office (Hungarian Central Statistical Office, n.d.-i). The external costs of products in the 2025 price level are calculated as:

$$P_{2025} = P_{2015} * 1,743 \quad \text{Equation 3}$$

where P_{2025} is the external cost in 2025 prices, and P_{2015} is the external cost of products calculated using environmental prices established for the year 2015.

3.2.5 External Cost Calculation for Consumption

To calculate the cost of consumption of selected animal-derived products, the obtained environmental prices are multiplied by the annual consumption per capita data for 2025, retrieved from the Hungarian Central Statistical Office.

$$EC_{total,i} = EC_i * Q_i \quad \text{Equation 4}$$

where $EC_{total,i}$ reflects the environmental cost of consumption of the product per capita, expressed in €/capita/year, EC_i indicates the external cost of that product, and Q_i the quantity consumed annually per capita.

3.3 Policy Instrument Design: VAT Adjustments

For the VAT adjustment scenario, a policy change increasing the VAT to the standard rate of 27% from the current reduced rate of 5% is analyzed. This represents a 21% increase in the consumer prices of the selected animal-derived products. The highest possible VAT rate level in Hungary is selected to carry out the analysis to address the externalities at a maximum level. This VAT adjustment can be implemented in steps, starting from the reduced level at 18% in the first place, to reduce the risk of public opposition. This is further discussed in Chapter 4.

The average market prices for May 2025, for beef, pork, chicken, milk, and eggs are obtained from the Hungarian Central Statistical Office (Hungarian Central Statistical Office, n.d.-a), and converted from Hungarian forints (HUF) to euros (€) using the 2025 official average exchange rate between 18/06/2025 and 18/09/2025, 397,23 HUF/€ (Eurostat, 2022a) (Table 4) The following products, specified with different codes from the Hungarian Central Statistical Office, are used:

- Milk: 11101 Pasteurized ESL milk, 2.8% fat content, liter
- Egg: 11001 Eggs, 10 pieces
- Pork: 10003 Pork thigh, without bone, kg
- Beef: 10103 Beef, without bone, kg
- Chicken: 10401 Chicken, cut into pieces, kg

Table 4. Market prices of animal-derived products in Hungary (2025)

Product	Market Price (HUF/kg)	Market Price (€/kg)
Beef	3940	12,44
Pork	1930	4,86
Chicken	1270	3,20

Milk	413	1,04
Eggs	1455	3,66

For milk and eggs, the obtained prices are reported per liter for milk and per 10 pieces for eggs. To ensure comparability, these prices were converted to per-kilogram prices. The density of milk is assumed to be 1.03 kg/l, and the average weight of one egg is considered to be 61.5 g/piece for conversion (Korteland et al., 2023).

3.3.1 Price Elasticity and Reduction in Consumption

The estimation of the reduction in consumption resulting from the increased VAT is calculated through applying own-price elasticities of demand, obtained from a study that analyzes a database collected that includes more than 50,000 demand elasticities from 87 countries (Bouyssou et al., 2024) (Table 5).

These elasticities represent the percentage change in quantity demanded of a product due to a 1% increase in its price, while holding all other factors constant.

In this analysis, the unconditional own-price elasticities reported for the EU are used for the calculations. Own-price elasticity measures how responsive demand is to changes in the price of the same product, enabling changes in the overall amount spent on the group. Price adjustments can therefore affect how much consumers spend on animal-derived products in general as well as how they switch between products.

Table 5. Own-price elasticity of demand for selected animal-derived products

Product	Price Elasticity
Beef	-0,75
Milk	-0,87
Pork	-0,79
Chicken	-0,84
Egg	-0,97

Elasticity values for beef, pork, chicken, milk, and eggs are used to estimate the percentage reduction in consumption of these products in the VAT increase scenario, which assumes a consumer price increase of 21%. The expected percentage reduction in consumption is calculated as:

$$\% \Delta Q_i = e_i * \% \Delta P_i \quad \text{Equation 5}$$

$$\% \Delta P_i = \frac{P_{27\% \text{ VAT},i} - P_{5\% \text{ VAT},i}}{P_{5\% \text{ VAT},i}} \quad \text{Equation 6}$$

where ΔQ_i , e_i , and ΔP_i represent percentage change in consumption of the product, own-price elasticity of the product, and percentage change in consumer price, respectively.

$P_{27\% \text{ VAT},i}$ and $P_{5\% \text{ VAT},i}$ are the consumer prices with 27% VAT and 5% VAT for the product i . The consumption data for the year 2020 is obtained from the Hungarian Central Statistical Office and represents only the volume consumed exclusively in the household (Hungarian Central Statistical Office, n.d.-c).

3.4 Policy Instrument Design: Emission Trading System

To design and analyze the ETS scenario, the suggestions and approaches presented in the report “Pricing agricultural emissions and rewarding climate action in the agri-food value chain” are considered as a foundation. The report aims to analyze the potential applications of the polluter pays principle for the GHG emissions at the EU level resulting from agriculture (Bognar et al., 2023). The outline that is used to analyze the ETS options for the EU level is adapted to the Hungarian setting in this assessment.

This analysis follows the approach for two of the ETS options discussed in the report:

- On-farm livestock ETS establishes a limit on emissions resulting from livestock. The point of obligation for on-farm livestock ETS is livestock and mixed farms, and it covers CH₄ emissions from enteric fermentation, N₂O, and CH₄ from manure management.
- Downstream ETS covers animal-derived products that result in on-farm emissions during production and applies to processors of meat and dairy products. The downstream ETS covers CH₄ emissions from enteric fermentation and N₂O emissions from manure management.

These two ETS options are selected among five options presented in the report: An on-farm ETS for all GHG emissions, an on-farm ETS for livestock emissions only, an on-farm ETS for peatlands only, an upstream ETS, and a downstream ETS. The primary reason for this selection is the availability of data, and the advantages and disadvantages of the selected ETS options are further discussed in Chapter 4.

For the assessment of ETS scenarios, the coverage of emissions or enterprises is estimated, rather than the revenue generated and the possible decrease in consumption. Therefore, these two different policy options are mainly compared in terms of coverage of emissions associated, ease of implementation, public acceptance, and possible impacts in the food chain in Section 4.6.

For ETS scenarios, coverage indicates the range of processes/farms and causes of on-farm emissions that are estimated to be addressed by the application of the polluter pays principle.

3.4.1 On-farm Livestock ETS

As suggested in the report, the de minimis threshold is the number of livestock on-farm using livestock units (LSUs) for the on-farm livestock ETS option, and the LSU threshold for the on-farm livestock ETS is determined as 150 LSU, based on the Commission's proposal on the update of the Industrial Emissions Directive¹¹ (IED) to cover all industrial farms that own more than 150 LSUs. Accordingly, 150 LSU equals 150 adult cows, 10,000 laying hens, or 500 pigs.

The data for the number of private enterprises in Hungary, and the number of livestock owned by them, are retrieved from the Hungarian Central Statistical Office. Enterprise and livestock coverage are estimated considering the threshold of 150 LSU for cattle, poultry, and pig farms. The most recent published data, which is for the year 2016, is used for the coverage estimations.

The number of farms that surpass the 150 LSU threshold for cattle, pig, and poultry farms is calculated and expressed as a percentage of all actively operating farms in each livestock category in Hungary. As an increased number of livestock clearly links to higher emissions of CH₄ and N₂O, and more fertilizer requirements, to account for their contribution to overall emissions, the percentage of farms with total livestock numbers above the threshold is also calculated.

3.4.2 Downstream ETS

¹¹The Industrial Emissions Directive (IED) is a significant element of EU environmental law, aimed to reduce harmful industrial pollutants, including that brought on by extensive animal raising in pig and poultry farms. It regulates emissions to the air, water, and soil across the EU from particular industrial and agricultural processes (European Commission, 2025c).

For downstream ETS, a de minimis threshold is established for businesses with more than 50 employees, in line with the approach used in the report. Data on enterprises working in the processing and preservation of meat and the production of meat products, and in the manufacture of dairy products in Hungary, including the number of employees and annual turnover, are obtained from Eurostat. The most recent data, for 2020, is used for the estimations.

As also stated in the report, turnover coverage is assumed to be in line with and an indicator of emissions coverage. This assumption is consistent with the Environmentally Extended Input-Output (EEIO) model, which links sectoral economic output to emissions (Kitzes, 2013).

In the case of downstream ETS, coverage is estimated by calculating the total number of enterprises with more than 50 businesses and expressing it as a percentage of all enterprises operating in the meat and dairy processing sectors. To account for their contribution to overall emissions, the rate of enterprises' annual revenue above the threshold is estimated.

3.5 Redistribution Mechanism

3.5.1 Estimation of VAT Revenues

To improve the political acceptance of the policy changes regarding VAT adjustments or the ETS mechanism, a revenue redistribution mechanism is incorporated into the analysis. For the total revenue estimation, reduced consumption for each product is calculated using price elasticities, and the Hungarian population is considered. It is assumed that the whole 27% VAT revenue is redistributed to the population. The calculation for total revenue is as follows:

$$Q_{,27\% \text{ VAT},i} = Q_{5\% \text{ VAT},i} * (1 + \% \Delta Q_i) \quad \text{Equation 7}$$

$$Rev_i = P_{27\% \text{ VAT},i} - \left(\frac{P_{5\% \text{ VAT},i}}{1,05} \right) \quad \text{Equation 8}$$

$$R_t = \sum_i^5 P * Q_{,27\% \text{ VAT},i} * Rev_i \quad \text{Equation 9}$$

where R_t is total revenue for all taxed products (beef, chicken, pork, milk, and eggs), P is population of Hungary, $Q_{5\% \text{ VAT},i}$ and $Q_{,27\% \text{ VAT},i}$ are the consumption before and after the

VAT adjustment based on $\% \Delta Q_i$, which is the percentage change in consumption that is estimated based on own-price elasticities in Section 3.3.1. Rev_i is the revenue gained for every purchase of VAT adjusted price of product i , $P_{5\% VAT,i}$ is the 2025 market price of the product which includes 5% VAT (This price is then divided by 1,05 to obtain the price without the VAT), $P_{27\% VAT,i}$ is the estimated market price with 27% VAT.

The total VAT revenue from the consumption of animal-derived products is then distributed using a lump-sum method. Instead of being paid in regular installments, a lump-sum payout is a single payment. Therefore, VAT revenues are assumed to be distributed to the public annually. The lump-sum transfer per capita -assuming all population is eligible- is calculated as:

$$V = R_t / P \quad \text{Equation 10}$$

Where V represents the amount of money individuals receive (€/capita/year), R_t is the total VAT revenue collected annually, and P is the population of Hungary.

In all calculations, the population of Hungary is considered to be 9,539,502 for the year 2025 (Eurostat, 2022c).

3.5.2 VAT Revenues for Different Income Deciles

To observe the impact of adjusted VAT on animal-derived products across 10 income deciles in Hungary, the data on annual average consumption per capita for 2020 are obtained from the Hungarian Central Statistical Office (Hungarian Central Statistical Office, n.d.-b) (Table 6).

Table 6. Consumption of animal-derived products by different income deciles

Product (kg/capita/year)	1	2	3	4	5	6	7	8	9	10
Beef	0,9	1,2	0,8	0,4	1,3	1,3	1,3	0,8	1	2
Milk	52,9	49,5	53,0	61,0	62,3	60,9	61,2	58,3	60,7	63,7
Pork	18,5	19,2	17,9	20,3	21,2	23,7	27,4	23,9	24,1	27
Chicken	24,8	25,4	23,2	26,7	62,3	60,9	61,2	58,3	60,7	63,7
Egg	9,8	9,5	9,1	9,7	9,7	9,9	10,8	10,6	11,0	10,9

These consumption rates of 5 products are then multiplied by the VAT revenue received from every purchase to obtain the VAT burden resulting from their consumption of VAT-adjusted products for each income decile. The calculation is as follows:

$$R_{VAT,j} = \sum_i^5 C_{i,j} * Rev_i \quad \text{Equation 11}$$

where $C_{i,j}$ is the average consumption of product i by the income decile j , expressed in kg/capita/year, Rev_i represents the VAT revenue received from each a kg purchase of that product, expressed in €/kg, and $R_{VAT,j}$ is the VAT burden on income decile j , where j changes from 1 to 10, as shown in Table 6.

The VAT revenues obtained from each income decile are further compared with Hungary's average per capita consumption values, and the impact of the lump-sum transfer across income deciles is investigated.

Chapter 4: Results & Discussion

4.1 Introduction

The findings of the analysis conducted in this study are presented in this chapter, along with their implications for the study's goals. The aim is to quantify the environmental external costs of animal-derived products in Hungary and to investigate how fiscal incentives, such as VAT adjustments and ETS policies, can help address these costs, while a revenue redistribution system can improve public acceptance.

The structure of the chapter is as follows:

- Section 4.2 presents the estimated external cost for beef from beef cattle, beef from dairy cattle, chicken, pork, eggs, and milk, followed by a comparison among the products and an interpretation of these results in terms of main cost drivers.
- Section 4.3 investigates how VAT adjustment policy can help reduce environmental costs by estimating reduced consumption based on product price elasticities after the VAT increase, and presents the amount of VAT revenue expected from the purchase of animal-derived products.
- Section 4.4 examines the coverage estimation for two different ETS options: on-farm livestock ETS and downstream ETS and discusses possible advantages and

disadvantages of both options in terms of effectiveness in policy implementation and addressing the emissions associated with the sector.

- Section 4.5 examines the use of policy revenues to increase public support for VAT and ETS policies. It presents several solutions, including vouchers, lump-sum payments, targeted green subsidies, and lower VAT rates on fruits, vegetables, and legumes. An estimate of the possible lump-sum transfer amount for recycling VAT revenues is also provided in this section, accounting for the potential impact across Hungary's income deciles.
- Section 4.6 introduces an integrated discussion, presenting the strengths and weaknesses of different policy scenarios, supported by outcomes from various countries, including Hungary. The aspects discussed in the section include public acceptance, ease of implementation, estimated impact on the food system, and potential risks.

4.2 External Cost of Animal-Derived Products

This section presents the estimated external cost per kilogram of beef from beef cattle, beef from dairy cattle, milk, chicken, pork, and eggs, and discusses the main drivers of externalities associated with these products. In addition, the total consumption cost for these products is presented, estimated based on consumption data in Hungary.

Using the environmental price methodology described in Chapter 3, external costs are calculated for each product at 2015 prices, then converted to 2025 prices using the CPI, as explained in Chapter 3. The results reflect the partial regionalization of the data for Hungary, which better reflects national agricultural practices rather than relying solely on the EU average.

4.2.1 External Costs Per Product

The external costs per kilogram of a product are summarized in Table 7. These external costs represent the welfare loss to society that is currently not reflected in market prices.

Table 7. Estimated external cost for animal-derived products

Product	External Cost (€/kg)
----------------	-----------------------------

Beef from beef cattle	19,47
Beef from dairy cattle	4,01
Milk	0,54
Pork	5,71
Chicken	3,28
Eggs	3,04

Beef from beef cattle has a significantly higher cost than other products, reflecting its high emission intensity and feed requirements. The beef from dairy cattle has a lower cost, as the environmental impact is allocated between beef and milk, and the fact that a higher amount of milk is obtained from a cow over its lifetime, compared to beef. This is also the reason the external cost of milk is significantly lower when compared with other products.

The external costs and contributing environmental themes are further illustrated in Figure 14.

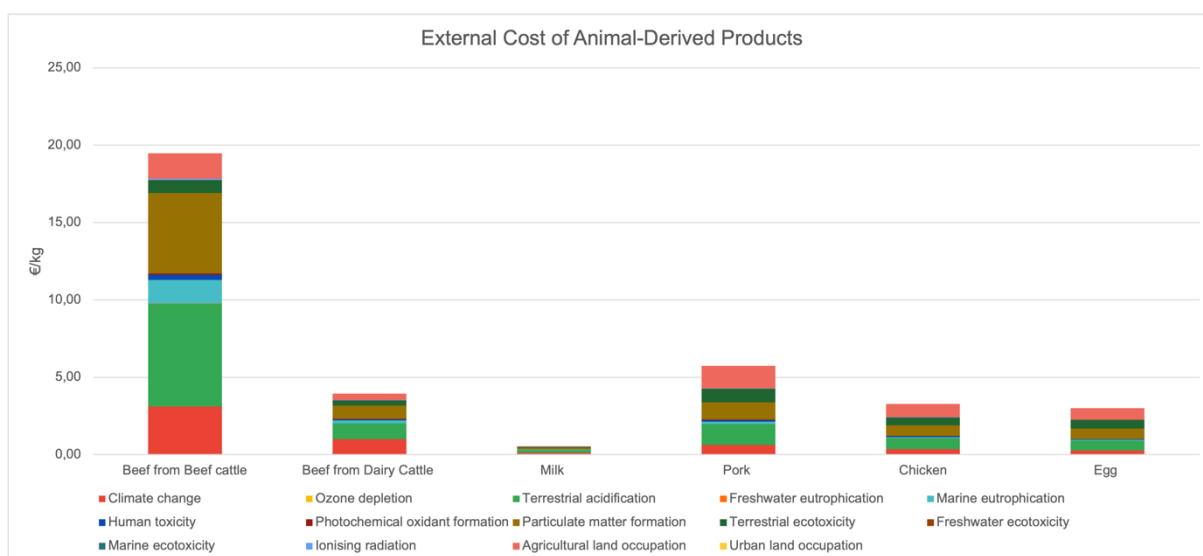


Figure 14. Contribution of environmental themes to the external costs of animal-derived products

The main factors influencing the price difference between beef from beef cattle and other animal-derived products are three environmental themes: terrestrial acidification, particulate matter formation, and climate change.

Cattle production systems are closely linked to terrestrial acidification and particulate matter formation due to high ammonia emissions. Cattle are responsible for most livestock-related ammonia emissions due to a higher amount of nitrogen release compared to pigs or poultry, as it is associated with a higher ratio of N lost as NH_3 (Groenestein et al., 2019). NH_3 plays an

essential role in atmospheric particulate matter generation and contributes to the acidification of terrestrial ecosystems by altering nutrient balances and soil pH (Behera et al., 2013). Lastly, enteric fermentation in ruminant livestock, such as cattle, is a major source of methane emissions compared to non-ruminant livestock (pigs, poultry, horses, etc.), mainly because of differences in digestive systems (Dong et al., n.d.). Therefore, beef production results in higher methane emissions, thereby contributing more to climate change than other animal-derived products.

4.2.2 External Costs of Annual Consumption in Hungary

The total cost of consumption for beef, milk, pork, chicken, and eggs, calculated using 2020 annual consumption data, and the estimated external costs of the products are shown in Table 8.

Table 8. Annual per capita consumption of animal-derived products, and the associated cost of consumption

Product	Annual Consumption (kg per capita)	Cost of Annual Consumption (€ per capita)
Beef	1,1	21,42
Milk	58,4	31,54
Pork	19,2	109,63
Chicken	25,2	82,66
Eggs	10,3	31,31

The calculations show that although the beef has the highest external cost among products, the consumption of pork has the highest total external cost of annual consumption, which is 109,53 € per capita, due to the dual effect of its moderate external cost and high consumption per capita. Among the products analyzed, milk has the highest annual consumption per capita. Still, the relatively low external cost of milk compensates for its high annual consumption. External cost of consumption for pork is followed by chicken, with the cost of 82,66 €, and milk, which has an annual cost of 31,54 € per capita.

The high consumption cost of pork is especially important to consider when discussing pricing policies to internalize external costs, as some policies carry the risk of shifting consumption,

thereby increasing the environmental burden on pork and chicken rather than beef. This aspect is further discussed in Section 4.6.

4.2.3 Economic Significance of Results

These findings highlight the economic significance of environmental externalities in Hungary's livestock sector. When external costs are quantified in monetary terms, the unpaid environmental damages associated with the consumption of animal-derived products become evident; these unpaid damages are not included in the existing market prices.

For example, the external cost for a kilogram of beef even exceeds beef's market price by approximately 7€. This high external cost indicates that the true societal cost of the product is significantly higher than its market price, leading to a large gap between social and private costs and requiring strong corrective measures to internalize these externalities and bring the market to a Pareto-optimal level.

In case all the estimated externalities are internalized, in other words, when equilibrium prices accurately represent the economic value of environmental damages, the market price of beef would almost triple to €31,91 per kg. In the same scenario, milk would cost €1,58 per kg, pork €10,57 per kg, chicken €6,48 per kg, and eggs €6,7 per kg. However, there would likely be a backlash from the public due to this sudden, high price increase. Therefore, it is essential to design policies that would partially internalize the external costs to maintain public acceptance.

In Figure 15, the true prices that consider full internalization of the environmental costs of animal-derived products are presented.

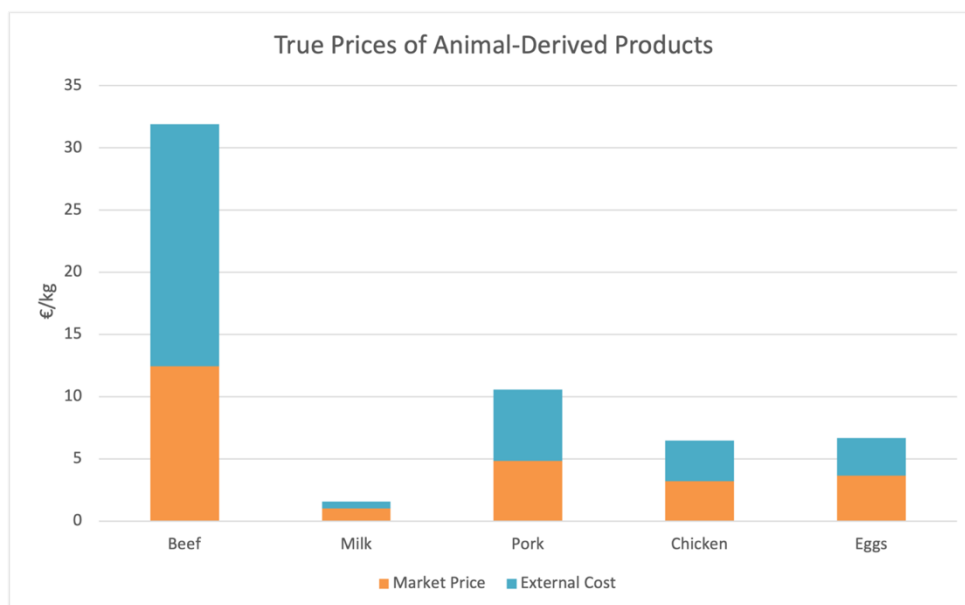


Figure 15. True prices of animal-derived products considering a full internalization of estimated externalities

These findings further underscore the artificially low prices of the animal-derived products in the market and serve as the starting point for the policy scenarios that follow (Sections 4.3–4.5), in which the possibility of internalizing these costs through VAT or ETS adjustments will be investigated.

4.3 VAT Adjustment Scenario Results

This section presents the results of the VAT adjustment scenario, where the Value Added Tax on animal-derived products, which are currently treated as basic food, is increased from the current reduced rate of 5% to the standard rate of 27%, leading to a 21% increase in consumer prices. The aim is to investigate how this price increase would affect consumption patterns and the external costs associated with animal-derived products in Hungary.

The VAT adjustment is a demand-side approach, which directly affects consumption through the pricing. Therefore, it is important to consider possible regressive effects on households. This aspect is further discussed in Section 4.5, which discusses a possible revenue recycling mechanism to ensure fairness and public acceptance.

4.3.1 Market Prices After VAT Adjustment

The market prices after the adjustment, which increases VAT from the current reduced rate of 5% to the standard rate of 27%, are shown in Table 9.

Table 9. Market prices of animal-derived products before and after the VAT adjustment

Product	Market Price Before VAT Adjustment (€)	Market Price After VAT Adjustment (€)
Beef	12,44	15,10
Milk	1,04	1,30
Pork	4,86	5,90
Chicken	3,20	3,90
Egg	3,66	4,40

Even when the products are taxed at the highest VAT rate, the externalities are not fully internalized. The greatest internalization is observed in milk prices, which nearly reach 80%. For other products, the internalization rates are 47%, 56%, 60%, 60% for beef, pork, chicken, and eggs, respectively.

4.3.2 Consumption Reductions

The estimated consumption reduction for beef, milk, pork, chicken, and egg, calculated following the methodology explained in Section 3.3, is shown in Table 10.

Table 10. Reduction in consumption of animal-derived products

Product	Annual consumption per capita before VAT adjustment (kg/capita/year)	Annual consumption per capita after VAT adjustment (kg/capita/year)	Percentage decrease in consumption (%)
Beef	1,1	0,93	15,8
Milk	58,4	47,73	18,3
Pork	19,2	16,01	16,6
Chicken	25,2	20,75	17,6
Egg	10,3	8,20	20,4

As expected, the reduction in demand is higher for products with higher price elasticities and lower for those with more inelastic demand (pork, beef). The largest percentage decrease in consumption is observed for eggs, driven by the product's high price elasticity in absolute terms. As the price increase is the same for all products - 21% -, price elasticities of the animal-derived products are the determinant in consumption reductions. Milk still has the highest annual per capita consumption in Hungary after the VAT adjustment, followed by chicken and pork.

4.3.3 External Cost Saving

The estimated reduction in the cost of annual consumption of animal-derived products before and after the VAT adjustment is shown in Figure 16. This analysis aims to link consumption reductions to the environmental damage avoided by the VAT policy.

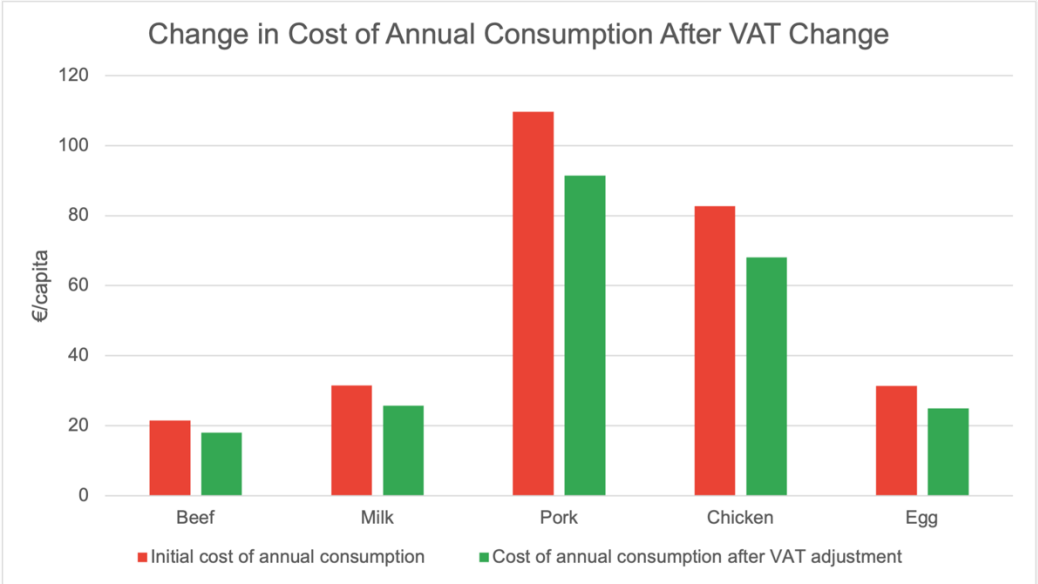


Figure 16. Change in external cost resulting from the consumption of animal-derived products after VAT adjustment

Before the VAT adjustment, the total cost of annual consumption for the selected animal-derived products is estimated as 276,55 € per capita, corresponding to 26,38 B€ annual cost for the whole population. Following the VAT adjustment, this external cost of consumption decreases to 228,27 € per capita annually, and 21,94 B€ for the entire population in total. The partial internalization of external costs through VAT adjustment leads to a 4,44 B€ reduction in the cost of consumption due to a decrease in consumption of beef, milk, pork, chicken, and eggs.

The biggest contribution to cost savings is the decrease in pork consumption, which is 18,19 € per capita, followed by a decrease in chicken consumption, which enables savings of 14,58 € per capita annually. Although the external cost of pork is much lower than that of beef, the high consumption, which is nearly 20 times that of beef, is the reason behind this significant cost saving. Milk and eggs contribute to cost savings to a moderate extent. For milk, this result reflects the compensating effect of low external cost and high consumption; for eggs, it reflects the impact of comparatively low consumption and moderate external cost, despite the largest decrease in consumption resulting from the high price elasticity.

4.3.4 VAT Revenues

The estimated VAT revenue collected by the Hungarian government from the purchase of beef, milk, pork, chicken, and eggs is shown in Table 11.

Table 11. VAT revenue collected from the purchase of animal-derived products

Product	VAT revenue per purchase (€)	Consumption per capita after VAT adjustment (kg)	Total VAT revenue per year (M €)
Beef	2,3	0,9	28.33 M
Milk	1,0	15,7	121.99 M
Pork	0,7	21,0	191.28 M
Chicken	0,3	48,1	163.22 M
Egg	0,7	8,2	73.77 M

In total, 579 M€ in revenue is estimated to be collected from the purchase of beef, milk, pork, chicken, and eggs annually, with pork accounting for the largest share. This contribution is expected, when the high consumption compared to beef, milk, and eggs is considered, in addition to moderate VAT revenue per purchase.

The revenue collected from these selected animal-derived products with the adjusted VAT is estimated to be 449 M€ higher than the current estimated VAT revenue of 130 M€, representing an approximately 345% increase in governmental revenues.

4.4 ETS Scenario Results

4.4.1 Coverage of Livestock ETS Scenario

The estimated coverage of enterprises and animals in Hungary under the livestock ETS scenario, assuming a threshold of 150 LSU, is shown in Table 12.

Table 12. Coverage of enterprises and the number of animals in the livestock ETS scenario

Farm Type	Number of Private Enterprises	Coverage	Number of Animals	Coverage
Cattle	739	60%	487100	94%
Pigs	289	38%	2218800	98,6%
Poultry	225	44%	23367300	98,9%

The total farms that would be regulated within the ETS for the on-farm livestock ETS is estimated as 1253. Cattle farms account for the largest share of the coverage ratio by number of enterprises, with 60% of farms surpassing the 150 LSU threshold. The coverage of animals on cattle farms, however, is the lowest at 94%, even with this comparatively high enterprise coverage. This disparity results from the fact that many smaller cattle farms in Hungary contribute fewer animals per enterprise and operate below the 150 LSU threshold.

The disparity between enterprise and animal coverage is even more noticeable for pig and poultry farms: only 38% of pig and 44% of poultry farms surpass the threshold, even though they together account for nearly 99% of the animals in each category.

Despite the relatively small percentage of businesses included, setting the threshold at 150 LSU would guarantee coverage of more than 90% of total emissions from cattle, pig, and poultry farms in Hungary, assuming that emissions are proportionate to the number of animals.

4.4.2 Coverage of Downstream ETS Scenario

The number of private enterprises above the determined threshold and their annual turnover for processors/manufacturers of meat and dairy products are shown in Table 13. As explained in Section 3.4, the threshold is established as a business with more than 50 employees.

Table 13. Coverage of enterprises and annual turnover in the downstream ETS scenario

Type of Enterprise	Processing and preserving of meat and production of meat	Manufacturing of dairy products

	products	
Number of enterprises	75	18
Coverage of enterprises	13,71 %	12,59 %
Annual turnover (M €)	3063,6	792,9
Coverage of annual turnover	87,18 %	91,30 %

The total number of enterprises that would participate in the downstream ETS is estimated at 93. For meat and meat product processors, the number of enterprises above the threshold is 75, corresponding to only 13,1% of the total number of enterprises. However, although the enterprise coverage is low, the coverage of annual turnover is 87,3 %. This is like the case for the manufacturing of dairy products, which has 18 enterprises above the threshold that corresponds to 12,59 % of the total number of enterprises. Still, the determined threshold ensures that 91,3 % of the annual turnover is addressed. This is resulting from the fact that bigger enterprises with more employees account for a bigger portion of the total annual turnover.

If the annual turnover is assumed to be in line with the emissions caused, the downstream ETS option is estimated to address 87,3% and 91,3% of emissions resulting from the manufacturing and processing of the meat and dairy products industry, respectively.

4.5 Redistribution of Policy Revenues

4.5.1 Introduction: *Why Revenue Recycling Matters*

The political viability of environmental taxes depends not just on their environmental impact but also on their perceived equity and social acceptability. Pricing tools discussed in Section 4.3 and Section 4.4 would result in higher consumer prices -21% higher in the case of VAT adjustment- and governmental revenues when implemented. However, this implementation might hold the risk for loss of purchasing power for certain income groups in society, creating further food security concerns for the public. This concern can hold back the implementation of these policies. Still, the policy revenues can also be utilized to compensate for this price increase and loss in purchasing power for the public. An appropriate compensation would lessen social inequality in addition to averting social backlash (Klenert et al., 2023).

On the other hand, the establishment of ETS would result in higher costs and a reduction in the profit for the farms and enterprises operating in the sector. This may result from not

reflecting the costs directly to the consumer prices. In the case where costs are directly reflected in consumer prices, the decrease in demand for animal-derived products can also lead to a reduction in profit, which can create backlash, especially in the case of small-scale producers and farmers.

Knowing that revenues divided equitably or invested in public goods, such as subsidies for renewable energy, increase the likelihood of political acceptability (Mohammadzadeh Valencia et al., 2024), incorporating redistribution mechanisms into policy design is crucial for long-term policy stability and successful implementation, in addition to equity.

4.5.2 Potential Uses of Revenues

There are several possible uses of the policy revenues.

- Reduced VAT on fruits, vegetables, and legumes: This option would offset the higher consumer prices of animal-derived products by lowering the prices of fruits, vegetables, and legumes. This would indicate the same amount of reduction in prices for every income decile in Hungary. In Hungary, currently, the fresh fruits and vegetables are classified as basic food, and taxed at a reduced rate of 5%, which is the same taxation rate as beef, pork, chicken, milk, and eggs. VAT on fruits and vegetables can thus be lowered to 0%.
- A lump-sum transfer to the public that can be distributed to the population as a single payment. This option enables households to use this amount of money freely and gives the option to adjust the eligible income deciles to ensure social equity.
- Targeted green subsidies for farmers, which can be used to encourage farmers to embrace more environmentally friendly agricultural practices or switch from livestock to plant-based production.
- Vouchers distributed that can be used to purchase fruits, vegetables, and legumes in supermarkets. Different from the lump-sum transfer, vouchers give consumers a range of products that they can use the voucher for, obligating them to make a more sustainable choice.

Redistribution of VAT revenues as a lump-sum transfer in Hungary is further analyzed in Section 4.5.4.

4.5.3 Recycling of VAT Revenues with Lump-Sum Transfer

The total annual revenue obtained from the VAT-adjusted prices of beef, milk, pork, chicken, and eggs is 583 M€. As mentioned in Section 3.5, this revenue is distributed to the entire population using the lump-sum approach. This total revenue amounts to 61€ per capita annually and can be distributed to the public.

In July 2025, the average gross earning in Hungary is reported as HUF 693,700 by the Hungarian Central Statistical Office (Hungarian Central Statistical Office, n.d.-g). This corresponds to an average monthly income of 1746 €. A lump-sum transfer of 61 € would indicate a monthly addition of 5,1 € to the income.

In 2020, while the lowest income decile consumed 64.1 kg of meat and meat products per capita/year, this amount was 76.7 kg per capita/year for the highest income decile, indicating an approximately 20% higher consumption of meat products per capita compared to lower income households. The highest income decile also consumed approximately 17% more milk and 10% more eggs than the lowest income decile in 2020 (Hungarian Central Statistical Office, n.d.-b). Considering that lower-income households consume less animal-derived products on average, they would receive the same amount of transfer despite paying a smaller share of VAT revenues.

Additionally, lower-income households will likely respond more strongly to higher meat prices (Klenert et al., 2023), leading to a correspondingly greater decline in consumption. If price

elasticities across different income deciles are considered, VAT revenue from the lowest-income decile might decline. Therefore, the recycling of revenues as a lump-sum transfer or vouchers helps offset the possible regressive effects of the policy implementation on the lower-income households, while improving public acceptance.

The position of lower-income households in the context of a VAT adjustment in Hungary can also be further investigated by examining data on consumption by income deciles.

In Figure 17, the estimated VAT revenue received by the different income deciles in Hungary from total purchases of beef, milk, pork, chicken, and eggs is shown, with the red flat line representing the average VAT revenue collected per capita.

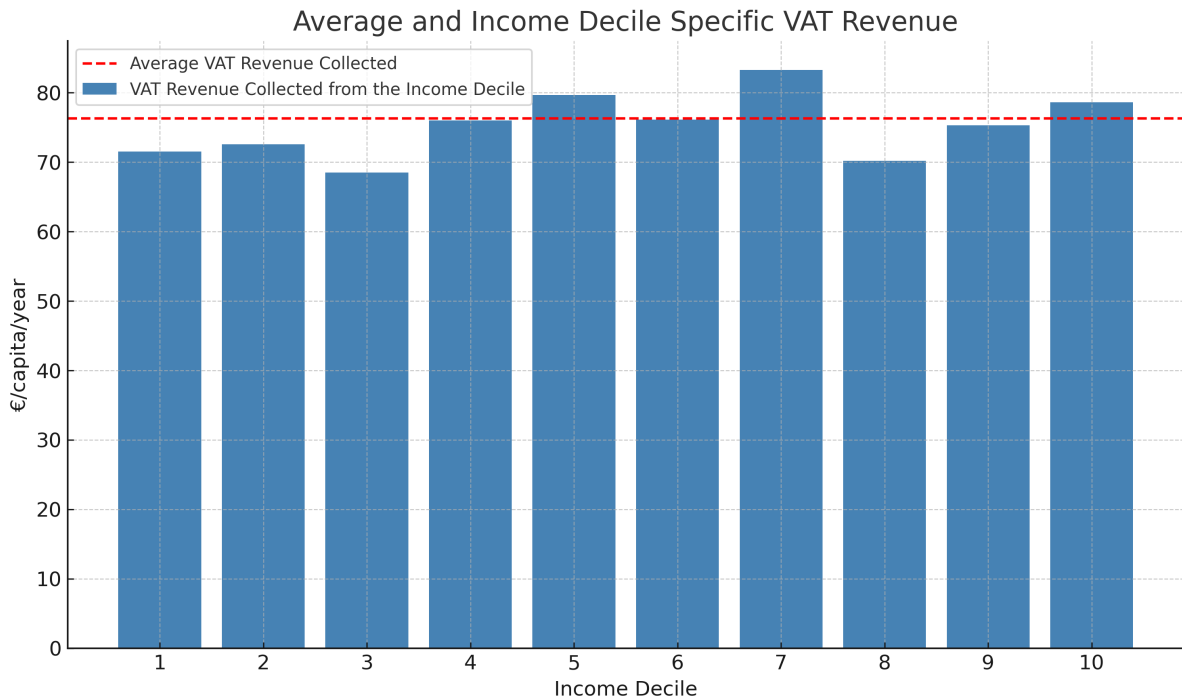


Figure 17. VAT revenues received by different income deciles compared to the average

In Hungary, the sale of beef, milk, pig, chicken, and eggs generates an average of 76.3 € in VAT revenue per capita annually. With a per capita contribution of 71.5€, the first income decile is the third-lowest source of VAT revenue among income groups, whereas revenue collected is lower for the third and eighth deciles. The seventh decile has the heaviest VAT burden, whereas the highest-income decile contributes 2.3 € per capita more than the average. These results show that, from a distributional perspective, households with higher incomes generally have higher absolute tax burdens because they consume more animal-derived products.

Approximately 85% of the 71.5€ annual VAT burden borne by the lowest income decile would be offset by the lump-sum payment of 61€ per capita, as previously mentioned in this section. Figure 18 presents the uncompensated amount per capita for each income decile.

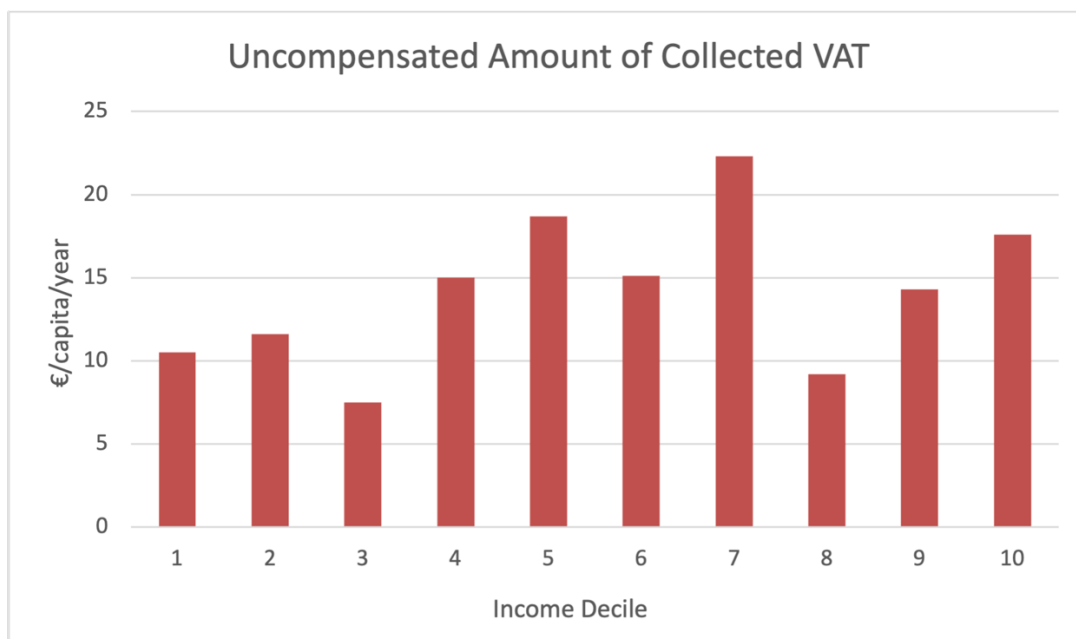


Figure 18. Amount of VAT revenue collected that is uncompensated through the lump-sum transfer, by the income decile

Further compensation for the lower income deciles can also be ensured with the policies considering distributing the revenues to only a portion of the income deciles -excluding the highest income deciles- rather than the whole population. Targeted lump-sum transfers to the lower-income households are found to be more effective in terms of reversing the regressive impact of the meat tax, compared to a uniform lump-sum redistribution (Klenert et al., 2023).

4.6 Integrated Discussion: Economic, Environmental, and Social Perspectives

This section aims to present an integrated discussion based on the findings of the former sections, policy recommendation papers, and international cases. It includes a discussion of the strengths and weaknesses of VAT adjustment and ETS scenarios (for both livestock and downstream ETS), considering public acceptance, ease of implementation, impacts on the food production system, and associated risks.

4.6.1 Summary of Policy Interventions in Hungary

Table 14 presents a summary of information based on the estimations carried out in the former sections.

Table 14. Summarized impact of policy options: VAT adjustment, livestock, and downstream ETS

Policy Options	Impact of the Policy
<p>VAT Adjustment (The increase of VAT on animal-derived products from reduced rate of 5% to 27%)</p>	<p>The expected reduction in the annual consumption cost per capita of beef, milk, pork, chicken and eggs are 3,37 €, 5,76 €, 18,19 €, 14,58 €, 6,38 €, This represents a 48,28 € reduction in external cost per capita in total for these five products in total, which indicates a 4,44 B € reduction for the whole population in Hungary. The annual VAT revenues collected from the purchase of VAT adjusted products are estimated as 583 M €.</p>
<p>Livestock ETS (Considering the cattle, pig, and poultry farms in Hungary with a threshold of 150 LSU)</p>	<p>The livestock ETS implementation which the point of obligation is the livestock farms. The estimated farm coverage for cattle, pig, and poultry farms are 60%, 38%, and 44%, while the estimated coverage for number of animals (assumed to be in line with the emissions associated) is 94%, 98,6%, and 98,9%.</p>
<p>Downstream ETS (Considering meat and dairy product producers/manufacturers, with a threshold of 50 employees)</p>	<p>The estimated coverage of private enterprises for meat and meat products processors are 13,71%, and 12,59% for manufacturer of dairy products. The estimated coverage for turnover (assumed to be in line with the emissions associated with the sector) is 87,18% for the meat and meat products processors, and 91,93% for the manufacturers of dairy products.</p>
<p>Revenue Distribution (Through lump-sum transfer of VAT revenues to the whole population)</p>	<p>The estimated annual VAT revenues (583 M €) is assumed to distributed to whole population in a lump sum transfer, in the amount of 61€. In average, a VAT of 76,3 € per capita is collected from the population annually. While this revenue received is 71.5€ for the lowest income decile, the burden this income decile bears is compensated at a percentage of 85% through the lump-sum transfer of 61€.</p>

4.6.2 Public Acceptance

A key factor in determining whether fiscal measures are successful is public opinion, which is heavily influenced by how quickly and strongly households feel the intervention. One of the differences between the ETS and the VAT adjustment scenarios is that while the ETS is implemented at the production side, the VAT adjustment directly impacts the demand side through the consumer prices. The apparent costs to consumers, which set green tax policies apart from other instruments like subsidies or restrictions, are the main reason why the public opposes their implementation (Bürgisser et al., 2024). The visible, instant increase in consumer prices implemented by the government carries the risk of sparking a backlash and raising food security concerns in the case of a VAT adjustment. Affordability of food is already a sensitive and challenging topic in Hungary, as discussed in Chapter 2. Especially considering Hungary has a standard rate of 27%, which is above the European average, and the fact that VAT revenues accounted for 24% of the total government revenues in 2018, which is higher than the OECD average, this current state in Hungary also puts pressure on the VAT adjustment policy in terms of public acceptance, as it might be perceived as unnecessary contribution to governmental VAT revenues (O'Donoghue et al., 2017). Additionally, as a VAT rise from 5% to 27% would be perceived as abrupt and likely to meet greater public resistance, a phased implementation, first increasing the rate to 18%, then to 27% , could be considered.

Consumption of meat is a sensitive matter on both emotional and cultural levels, and demographic characteristics such as age, gender, and financial status have a significant impact on dietary habits (Jayasinghe et al., 2025). In Hungary, where animal-derived products are one of the main ingredients in traditional foods, there will likely be significant social debates following the VAT increase. Therefore, it is crucial to make the benefits of increased VAT visible to the public and show the use of increased governmental revenues transparently. For example, according to a study, by drastically reducing CO₂ emissions from agriculture, a VAT increase on meat would lessen the likelihood that Germany will eventually have to buy more emission allowances to reach its climate goals (Oebel et al., 2025). A similar case is likely in Hungary, and communicating the long-run benefits of a VAT increase to society can reduce the impact of a sudden price increase.

The redistribution mechanism presented in Section 4.5.4 would also help improve the public acceptance of the lump sum transfer in the amount of 61€, compared to the average of 71.5€ VAT revenue received annually per capita. Perceived fairness and effectiveness were the most significant factors among all the variables, according to a study that examines 15 distinct factors that influence public opinion regarding climate change taxes and laws (Bergquist et

al., 2022). The estimated VAT revenues can be reinvested to ensure a socially just implementation of the VAT by adjusting eligible income deciles for the lump-sum transfer, as explained in Section 4.5.4, thereby improving the 85% compensation ratio for the lowest-income decile. This way, the perceived socioeconomic inequalities resulting from the implementation of VAT can be reduced, leading governments to see these fiscal incentives as risky.

In addition, an accompanying reduction in VAT on healthy foods like fruits and vegetables would improve public opinion (Scheffler & Wiegmann, 2022). This VAT relief on fruits and vegetables can also reduce the debates on nutrition while also encouraging the public to shift to a healthier diet.

On the other hand, the VAT increase can also be beneficial for raising public awareness of the impact of animal-derived products, as the true price of food becomes more visible to consumers in supermarkets. These high prices should be complemented by educational campaigns explaining the reasons for their high prices and the environmental impact of animal-derived products. This can be achieved through labelling in supermarkets that provides information on the product's environmental performance.

Like VAT, the downstream ETS has cost pass-through, as higher compliance costs for processors and retailers result in higher retail prices that impact customers at the point of purchase. However, because expenses are incurred upstream at the production stage, consumer prices rise more slowly and often more gradually in an on-farm livestock ETS. However, this places a burden on farmers, particularly in regions where farming plays a significant role in local economies and cultures. Evidence from EU agricultural policy discussions indicates that farmer acceptance is significantly impacted by administrative convenience, regulation clarity, and the provision of financial and technical support (Verschuuren et al., 2024).

When on-farm livestock ETS is discussed, the concern often focuses on small farmers due to their limited administrative capacity. This raises opposition from them as they believe the schemes are too complicated or costly. Small farms are somewhat protected by the 150 LSU threshold of the Hungarian livestock ETS design, which guarantees that compliance requirements concentrate on larger, more industrial operations where emissions are concentrated. Considering the polarized structure of farms in Hungary, the threshold would ensure targeting industrial-scale operators in the sector. By protecting smallholders from disproportionate burdens, this design decision may increase political viability while also being consistent with equity considerations and the polluter-pays principle.

The “Nitrogen Crisis” in Netherlands¹² serves as a valuable lesson in terms of communication of green policies in agriculture, considering the farmers effected by them. Although there are also other reasons arising from the political environment in the Netherlands, the poorly managed communication of the nitrogen tax on farmers led to a conflict between the government and the farmers, and nationwide protests in 2019. The farmers argue that the government did not propose any guarantee of financial return in global markets, and the suggested compensation, which is around 1 million € per farm, was too little and too late. Especially dairy farmers stated that they felt they were being targeted too much (Siegmann, 2024).

For this reason, in the case of on-farm ETS, specific communication and support measures, like training, advisory services, or designated subsidies/investments for sustainable practices, become crucial. It is important to place the farmers as valuable stakeholders rather than targets of the policy interventions and collaborate with them on the transition to sustainable food production. In a study that surveyed stakeholders and experts, the proposal that farmers should receive the funds raised through the EU ETS to aid in their transition to more sustainable farms received widespread approval (Verschuuren et al., 2024).

To conclude the discussion on public opinion, both cases -ETS and VAT adjustment- require a clear communication and effective framing of policies, which stands out as a crucial step to make the fiscal interventions possible and acceptable. To improve public acceptance, complementary steps such as behavioral interventions and educational campaigns promoting plant-based foods are important for shaping public opinion towards the fiscal incentives.

4.6.3 Ease of Implementation

The phrase "ease of implementation" in this section refers to the administrative expenses, technical capacity, and regulatory readiness of nations to carry out the policy alternatives discussed in previous sections. It is crucial that policies work both theoretically and practically since implementation difficulties or hidden costs might hinder the success of policy changes.

¹² Series of events and protests that started off with the Dutch administrative court declaration that the existing regulatory system is invalid under EU law, forcing abrupt policy change without preparation in 2019. Nitrogen pollution resulting from extensive livestock industry in Netherlands has been clear for years (Hill & Weulen Kranenbarg, 2025).

One of the biggest differences between the VAT adjustment and the ETS option is the ease of implementation. VAT changes can be done relatively quickly, requiring little administrative costs and effort, as the VAT changes depend on the established tax collection and administrative processes. The Hungarian law allows for different VAT rates to be applied at different reduced rates, such as 5% and 18%, ensuring the regulatory categories are already established in the nation. In addition, after 2004, Hungary changed VAT rates many times. For example, Hungary has changed its standard rate from 25% to 27% and at the same time experienced a move of goods between the VAT rates (O'Donoghue et al., 2017). Therefore, businesses, the public, and tax authorities in Hungary are already familiar with different VAT rates and the reclassification of goods.

On the other hand, for ETS, a reliable monitoring, reporting, and verification (MRV) system is crucial for the functioning of the policy. Agriculture's lack of preparedness for strong MRV systems has made the sector's integration into the EU ETS extremely difficult. Compliance schemes such as the EU ETS, in contrast to voluntary carbon markets, require high-certainty MRV frameworks that many agricultural producers are currently unable to support, especially in livestock and soil-based emissions (Verschuuren et al., 2024).

When both options are considered, the MRV costs are likely to be higher for the on-farm livestock ETS due to the large number of enterprises operating above the threshold. The regulated number of farms is 1253, while the downstream ETS has 93 operators. Still, the on-farm livestock options would result in less administrative costs compared to a possible on-farm ETS option that covers all GHG emissions. In addition, the exclusion of small farms through the threshold of 150 LSU further reduces the complexity of the process, as administrative costs and the effort for monitoring and reporting for the small farms would be higher, as they have lower capacity. This also increases the policy's political acceptability by protecting small stakeholders from administrative costs.

For on-farm livestock ETS, estimations based on the number of livestock can be used to measure emissions from livestock on farms. The Hungarian inventory report on GHG emissions estimate the methane and nitrous oxide emissions resulting from on farm activities based on livestock numbers, as other MS. Annual methane and nitrous oxide emission factors for dairy and non-dairy cattle, pigs, and poultry are already available for Hungary in the National Inventory Report -which are presented and used in the Chapter 3 of this study as well-. In addition, data on livestock populations are already collected annually by the Hungarian Central Statistical Office and the Ministry of Agriculture. This existing centralized

database can be integrated into an MRV system for an on-farm livestock ETS system to prevent the need for the establishment of a system from scratch.

However, these estimations may hold the risk of performing poorly when the actions carried out by the specific farm are considered, and give a generalized estimation. For the downstream ETS, emissions can be precisely approximated based on the quantity of output, data on the animal from which the product is produced, feed composition, manure management practices, and the deployment of any mitigation technologies for emission capture. Therefore, for more precise measurement, improved methods would be necessary in the long term.

When these two options are compared, the VAT adjustment scenario has a relatively easier implementation process, requiring lower administrative costs and less capacity enhancement.

4.6.4 Impact on Food Production System & Possible Risks Associated

When well implemented, the fiscal incentives discussed hold substantial potential to reduce the externalities associated with the production of animal-derived products. The VAT scenario addresses approximately 17,5% of the externalities associated with the production of beef, milk, pork, chicken, and eggs. While on farm livestock ETS systems cover more than 90% of the emissions resulting from cattle, pig, and poultry farms, the downstream ETS mechanisms ensure more than 85% of the emissions that processors of dairy and meat products are responsible for are addressed.

The relatively low coverage of externalities in the VAT scenarios is largely due to the high external costs associated with consumption of animal-derived products. However, it is important to consider that the emissions considered for the ETS systems are limited by the methane and nitrous oxide emissions, whereas the coverage of VAT adjustment considers various environmental externalities that are in the scope of midpoint environmental themes presented in Chapter 3 of this study.

As outlined earlier, the VAT adjustment is an intervention operating on the demand side, primarily by altering consumer prices. The likely outcome of this intervention is the reduced demand for animal-derived products and an accompanying reduction in the environmental cost, as estimated in Section 4.3. The overconsumption driven by the artificially low prices is therefore estimated to decrease in line with the price elasticity of demand. A similar decrease in demand is expected in the downstream and on-farm livestock ETS scenario, as the higher costs for the producers are likely to pass on to consumer prices. However, the impacts may

differ across actors, as the profit margin would decline more for the emission-intensive producers and small stakeholders.

As demand for animal-derived products decreases, the sector's profitability would diminish, making it less feasible for actors to operate in. In response to this change in demand, the producers or retail sector might follow different strategies, including exiting the market or changing their portfolio into more sustainable products such as plant-based food.

It is possible to observe similar cases in the energy sector, where carbon pricing mechanisms such as carbon taxing and ETS are widely applied, as mentioned in Chapter 1. For example, energy economics uses the concept of the "optimal tax frontier" to identify the tipping thresholds at which companies find it more lucrative to invest in renewable energy sources rather than staying in the fossil fuel markets (Mengesha & Roy, 2025). A similar approach may help policymakers develop tailored taxes to phase out high-emission activities gradually. Differentiating from other options, downstream ETS can also trigger product reformulation to mitigate increased production costs. This product reformulation can alter the milk or dairy ingredients in products, such as switching from cow milk to a plant-based milk in the pastry products or replacing meat products with legumes in ready-to-eat meals offered in retail stores. This product innovation can be further supported by government funding to help firms during the transition to plant-based ingredients, as the transition can entail high fixed costs initially.

While in the case of on-farm livestock ETS, intensifying the production might be seen as a viable solution by the farm operators. However, this practice to increase the efficiency - obtaining more milk/meat from one animal- in the sake of animal welfare usually leads to an emission-intensive production process (Clay et al., 2020).

An important consideration when discussing the ETS is the carbon leakage risk it entails. Carbon leakage happens when reductions in emissions in one nation or industry (resulting from climate policies such as carbon pricing or ETS) lead to higher emissions in other countries, usually because of production shifting to areas with less stringent regulations. If the ETS system is established only by the singular nations, it is likely that increased imports from nations with less stringent environmental laws will cause carbon leakage. This can occur through import of products, and land use shifts, in the lack of harmonization of policies. To prevent carbon leakage, as in energy policy, border carbon adjustments (BCAs) may be applied to agri-food imports.

Another concern raised by the introduction of fiscal incentives, such as VAT and ETS, is the potential for impact shifting across product categories. Because beef from cattle farming has

higher external costs and is consequently subject to higher taxes and higher consumer prices, both producers and consumers may switch to lower-emission alternatives, such as pork or poultry. This may seem beneficial from the perspective of GHG emissions, but the overall impact is more nuanced. As presented in Section 4.2, pork has a total external cost of consumption in Hungary that is approximately five times higher than that of beef, due to its significantly higher per capita consumption. Therefore, Hungary is a prime example of where “burden shifting” must be anticipated and neutralized. This is an important consideration also realizing that the consumption of pork and chicken are already expected to increase (OECD & Food and Agriculture Organization of the United Nations, 2025). Product-specific thresholds, or minimum excise levels on high-volume animal-derived products, are examples of complementary policy measures that can be considered to reduce the burden shift. Additionally, consumer education and labeling initiatives could increase demand-side knowledge by encouraging shifts to low-impact diets in general, including plant-based choices, instead of shifting meat options with lower prices.

Chapter 5: Conclusion

This thesis aims to investigate fiscal instruments to internalize the external costs associated with animal-derived food consumption in Hungary.

External costs associated with the animal agriculture sector are shown to be lacking from the national and international fiscal policies in most countries, despite its significant contribution to climate change.

In Hungary, the need to develop fiscal policies targeting animal agriculture is increasingly evident. Although emissions from the sector may currently appear less urgent than those from transport or industry, animal agriculture is on a concerning path. Significant government support, especially through coupled payments, risks further intensifying livestock production and the consumption of animal-derived products.

The analysis revealed that the external cost of a kg of animal-derived food consumption in Hungary is 19,47 € for beef obtained from beef cattle, 0,54 € for milk, 5,71 € for pork, 3,28 € for chicken, and 3,04 € for eggs. These estimated externalities highlight the gap between the true price and the market prices of the products, leading to overconsumption and no incentive to reduce emissions from the operator’s side. The possible impact of VAT adjustment would be the reduced demand for animal-derived products and a reduction in environmental costs. The VAT adjustment scenario revealed that a 21% increase in market prices of these animal-

derived products can lead to a 48,28 € reduction in external cost per capita in total. This corresponds to a 4,44 B€ reduction for the whole population in Hungary, which represents a 16.83% decrease in annual external costs associated with these products. The total annual VAT revenue collected from the purchase of these products is estimated as 583 M€, and in the case that the estimated VAT revenues are redistributed to the public, a lump sum transfer in an amount of 61€ per capita is estimated. As an average of 76,3 € per capita is collected per capita, this puts some income deciles in a net burden position. However, as revenue collected is 71,5€ for the lowest income decile due to their lower consumption of animal-derived products, the burden that VAT created is compensated at a percentage of 85% for them. The revenue redistribution is shown to have a crucial impact on public acceptance of the policy, especially in Hungary, where food affordability is an issue due to high inflation.

Another downside of VAT adjustment is the inability to reflect full external costs into consumer prices, as the prices would double -even triple for beef- for most of the products. This is also why a phased implementation, such as taxing these products at an 18% rate first, then taxing at a standard rate of 27% would be a feasible option to maintain public support and avoid backlash. However, the directly visible price change to consumers can also create awareness in public about the environmental impact of animal-derived food consumption, when coupled with awareness campaigns and education.

VAT adjustment offers another advantage compared to the ETS option: its implementation is comparatively easier than the establishment of an ETS, as the taxing mechanism is already in place, and the government, public, and institutions in Hungary are already experienced in changing rates and moving goods between rates. In contrast, the ETS option requires an MRV system, which is currently lacking for the agriculture sector.

Among two different ETS options, the on-farm livestock option is estimated to cover 60%, 38%, and 44% of emissions associated with cattle, pig, and poultry farms in Hungary, in the case the threshold is established as 150 LSU. The other ETS option, the downstream ETS that obligates meat and dairy processors to pay, enables a coverage of 13,71 % of meat and meat product processors, and 12,59% for manufacturers of dairy products, with a threshold of 50 employees. These coverages correspond to 87,18% for the meat and meat products processors, and 91,93% for the manufacturers of dairy products, based on their annual turnover. These established thresholds would ensure that the small-scale farmers and operators are somehow protected, and industrial operators are not being targeted by the ETS. This would further increase the public support for the policy.

Two ETS options might also have different implications for the food system in Hungary. On-farm livestock ETS might drive farm operators to intensify the production process while further disregarding animal welfare, when the calculations are done based on the number of animals. On the other hand, an ETS at a processor level could lead to a product reformulation, altering animal-derived ingredients with plant-based options. While both ETS options hold the risk of carbon leakage in the case the policy is established by only Hungary, the burden shifting risk between products due to the high external cost of beef compared to pork and chicken is a risk for all fiscal policies discussed.

These results highlight the need for fiscal instruments to address the externalities of animal agriculture. As discussed in previous chapters, the sector draws less attention compared to the energy and industry sectors, and there are currently no pricing instruments to address the emissions, besides Denmark's taxing plan. Alongside drawing attention to the subject, the analysis also highlights the challenges and various aspects of policy design, and the importance of tailor-made solutions. Every country has its own culture, norms, and habits. In general, a direct comparison between policies is not feasible, as numbers are not the outcome of the policy change. Every aspect -environmental, economic, and social- should be carefully considered while choosing the best fit and be backed up with other policies to achieve a successful, sustainable impact.

This research aims to contribute to the following sustainable development goals:

Primary SDGs:

- SDG 12 – Responsible Consumption and Production: By analyzing how internalizing external expenses might make goods sourced from animals reflect their true cost, this thesis encourages sustainable consumption behaviors. This encourages producers and consumers to adopt more sustainable production methods and diets.
- SDG 13 – Climate Action: The work directly supports SDG 13 by studying how to internalize the climate impact of the animal agriculture sector.
- SDG 2 – Zero Hunger: This thesis contributes to food security by aiming to transform the current unsustainable food production system, and promoting an efficient, low-impact food system that ensures food security without degrading the environment, while considering food affordability in the meantime.

Secondary SDGs:

- SDG 6 – Clean Water and Sanitation: One of the main causes of water overuse and pollution is animal agriculture. Freshwater resources can be safeguarded by policies that internalize these externalities.

- SDG 14 – Life Below Water & SDG 15 – Life on Land: Reducing animal agriculture’s negative environmental effects, such as nutrient runoff, deforestation, and biodiversity loss, the study contributes to the preservation of terrestrial and marine ecosystems.
- SDG 3 – Good Health and Well-being: By lowering the risk of chronic diseases (such as obesity and heart disease) through reducing excessive intake of animal-derived food.
- SDG 10 – Reduced Inequalities: Internalizing external costs, if done properly, can also advance equity by making sure that individuals who cause environmental harm pay the price rather than low-income populations.

This research was limited by data availability, as the calculations relied on data published by the Hungarian authorities. Although more recent data were available for market prices and consumption per capita, estimations for ETS options had to rely on older data, such as 2016. Full adjustment of Hungary's external costs was also not possible due to data restrictions. The shared data by the Hungarian authorities were limited, although the most important parameters -methane and nitrous oxide emissions due to enteric fermentation and manure management- were considered. Lastly, price elasticities for the EU are used to estimate demand changes following the VAT adjustment. The estimates would be more insightful if Hungary-specific price elasticities were available and used in the calculations.

Future research could examine how a revenue recycling system could be implemented in ETS options by estimating the revenue collected. This assessment would enable a better quantitative comparison between two policy options. In addition, a scenario in which subsidies are reduced can be examined, as the sector is heavily subsidized in Hungary. Studying this scenario would add valuable insight to the topic. Lastly, an income-based VAT adjustment scenario is crucial to investigate, as it would reduce social inequalities and further gain public support.

Bibliography

- Adams, N., Sans, A., Trier Kreutzfeldt, K.-E., Arias Escobar, M. A., Oudshoorn, F. W., Bolduc, N., Aubert, P.-M., & Smith, L. G. (2025). Assessing the impacts of EU agricultural policies on the sustainability of the livestock sector: A review of the recent literature. *Agriculture and Human Values*, 42(1), 193–212.
<https://doi.org/10.1007/s10460-024-10595-y>
- Baldock, D., Bradley, H., Godfroy, A, Muro, & M. (2025). *Realigning selected CAP payment schemes towards sustainable agriculture—Exploring options, benefits and risks.*

Institute for European Environmental Policy. <https://ieep.eu/wp-content/uploads/2025/06/Realigning-selected-CAP-payment-schemes-IEEP-2025.pdf>

- Bas-Defosse, F., & Meredith, S. (n.d.). *CAP 2021-27: A comparative analysis of the environmental performance of the COMENVI and COMAGRI reports on the Commission's proposals*. report for NABU by IEEP.
- Baumol, W. J. (1972). On Taxation and the Control of Externalities. *The American Economic Review*, 62(3), 307–322. <https://www.jstor.org/stable/1803378>
- Baumon, W. J., & Oates, W. E. (1988). *The Theory of Environmental Policy* (Second edition). Cambridge University Press. <https://books.google.com.tr/books?id=32-r0N819BgC>
- Behera, S. N., Sharma, M., Aneja, V. P., & Balasubramanian, R. (2013). Ammonia in the atmosphere: A review on emission sources, atmospheric chemistry and deposition on terrestrial bodies. *Environmental Science and Pollution Research*, 20(11), 8092–8131. <https://doi.org/10.1007/s11356-013-2051-9>
- Bergquist, M., Nilsson, A., Harring, N., & Jagers, S. C. (2022). Meta-analyses of fifteen determinants of public opinion about climate change taxes and laws. *Nature Climate Change*, 12(3), 235–240. <https://doi.org/10.1038/s41558-022-01297-6>
- Bidoglio, G. A., Schwarzmüller, F., & Kastner, T. (2024). A global multi-indicator assessment of the environmental impact of livestock products. *Global Environmental Change*, 87, 102853. <https://doi.org/10.1016/j.gloenvcha.2024.102853>
- Biró, K., & Toldi, O. (2022). Hungarian agricultural pathways revealing climate-related challenges. *Cognitive Sustainability*, 1(4). <https://doi.org/10.55343/cogsust.28>
- Blandford, D. (2024). The Vikings have landed – Denmark's decision to tax livestock emissions as a 'game changer.' *EuroChoices*, 23(3), 38–41. <https://doi.org/10.1111/1746-692X.12440>
- Blok, K., Borkent, B., Klein, N., Kossoy, A., Lam, L., Oppermann, K., Peszko, G., Prytz, N., & Wong, L. (2015). *State and Trends of Carbon Pricing 2015*. World Bank.
- Bognar, J., Springer, K., Nesbit, M., Nadeu, E., Hiller, N., van Dijk, R., Lam, L., Forestier, O., Finesso, A., Bolscher, H., Jakob, M., Tarpey, J., McDonald, H., Zakkor, P., Heller, C., Scheid, A., & Tremblay, L. (2023). *Pricing agricultural emissions and rewarding climate action in the agri-food value chain*. Trinomics B.V.
- Bouyssou, C. G., Jensen, J. D., & Yu, W. (2024). Food for thought: A meta-analysis of animal food demand elasticities across world regions. *Food Policy*, 122, 102581. <https://doi.org/10.1016/j.foodpol.2023.102581>
- Brownstein, B. P. (1980). Pareto Optimality, External Benefits and Public Goods: A Subjectivist Approach. *The Journal of Libertarian Studies*, 4(3), 93–106.
- Bürgisser, R., Stadelmann-Steffen, I., & Armingeon, K. (2024). Can information, compensation and party cues increase mass support for green taxes? *Journal of European Public Policy*, 1–28. <https://doi.org/10.1080/13501763.2024.2444332>

- Byrne, R. J. (2011). Utilities and Effluent Treatment | Design and Operation of Dairy Effluent Treatment Plants. In *Encyclopedia of Dairy Sciences* (pp. 619–630). Elsevier. <https://doi.org/10.1016/B978-0-12-374407-4.00477-5>
- Clay, N., Garnett, T., & Lorimer, J. (2020). Dairy intensification: Drivers, impacts and alternatives. *Ambio*, 49(1), 35–48. <https://doi.org/10.1007/s13280-019-01177-y>
- Cuadros-Casanova, I., Cristiano, A., Biancolini, D., Cimatti, M., Sessa, A. A., Mendez Angarita, V. Y., Dragonetti, C., Pacifici, M., Rondinini, C., & Di Marco, M. (2023). Opportunities and challenges for Common Agricultural Policy reform to support the European Green Deal. *Conservation Biology*, 37(3), e14052. <https://doi.org/10.1111/cobi.14052>
- DairyNZ. (2022). *Government's pricing agricultural emissions consultation—Te tātai utu o ngā tukunga ahurhenua*. DairyNZ.
- de Bruyn, S., Bijleveld, M., de Graaff, L., Schep, E., Schroten, A., Vergeer, R., & Ahdour, S. (2018). *Environmental Prices Handbook: EU28 version*. CE Delft.
- Döbbeling-Hildebrandt, N., Miersch, K., Khanna, T. M., Bachelet, M., Bruns, S. B., Callaghan, M., Edenhofer, O., Flachsland, C., Forster, P. M., Kalkuhl, M., Koch, N., Lamb, W. F., Ohlendorf, N., Steckel, J. C., & Minx, J. C. (2024). Systematic review and meta-analysis of ex-post evaluations on the effectiveness of carbon pricing. *Nature Communications*, 15(1), 4147. <https://doi.org/10.1038/s41467-024-48512-w>
- Dolbear, F. T. Jr. (1967). On the Theory of Optimum Externality. *American Economic Association*, 57(1), 90–103. <https://www.jstor.org/stable/1815607>
- Dong, H., Mangino, J., McAllister, T. A., Hatfield, J. L., Johnson, D. E., R. Lassey, K., de Lima, M. A., & Romanovskaya, A. (n.d.). Chapter 10: Emissions from Livestock and Manure Management. In *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, (Vol. 4). Intergovernmental Panel on Climate Change.
- EEA. (2005). *Market-based instruments for environmental policy in Europe*. European Environment Agency.
- EEA. (2024, October 31). *Greenhouse gas emissions from agriculture in Europe*. European Environment Agency. <https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emissions-from-agriculture>
- European Commission. (n.d.-a). *About the EU ETS*. European Commission - Climate Action. Retrieved October 17, 2025, from https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/about-eu-ets_en
- European Commission. (n.d.-b). *European Commission presents Annual Report on Taxation*. European Commission - Taxation and Customs Union. Retrieved October 17, 2025, from https://taxation-customs.ec.europa.eu/news/european-commission-presents-annual-report-taxation-2025-06-24_en
- European Commission. (n.d.-c). *Farm to Fork Strategy*. Food Safety - European Commission. Retrieved October 16, 2025, from https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

- European Commission. (n.d.-d). *Scope of the EU ETS*. Climate Action - European Commission. Retrieved October 17, 2025, from https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/scope-eu-ets_en
- European Commission. (2021a). *Agriculture and Rural Development Statistical Factsheet Hungary*. European Commission. https://agriculture.ec.europa.eu/document/download/652495c6-9099-451a-8eb5-ec35d2e874e9_en?filename=agri-statistical-factsheet-hu_en.pdf
- European Commission. (2021b). *VAT rates applied in the Member States of the European Union*. European Commission. https://taxation-customs.ec.europa.eu/system/files/2021-06/vat_rates_en.pdf
- European Commission. (2021c). *VAT rates applied in the Member States of the European Union Situation at 1st January 2021*. European Commission. https://taxation-customs.ec.europa.eu/system/files/2021-06/vat_rates_en.pdf
- European Commission. (2022a). *Observations on the proposal by Hungary for a CAP Strategic Plan 2023-2027—CCI: 2023HU06AFSP001*. European Commission. https://agriculture.ec.europa.eu/document/download/9b637707-1b0c-46ca-9afe-762cc5fb833f_en?filename=observation-letter-hungary_en.pdf
- European Commission. (2022b). *Voluntary coupled support—Member States' support decisions applicable for claim year 2022* [Informative note]. European Commission.
- European Commission. (2023a). *Climate Action Progress Report 2023 Country profile Hungary*. https://agriculture.ec.europa.eu/document/download/652495c6-9099-451a-8eb5-ec35d2e874e9_en
- European Commission. (2023b). *Climate Action Progress Report 2023 Country profile—Denmark*. European Commission. https://climate.ec.europa.eu/document/download/c61eb9cd-9bbb-4bb7-95cb-54a15ef46ac0_en?filename=dk_2023_factsheet_en.pdf
- European Commission. (2023c). *Tackling Climate Change through Livestock. A global assessment of emissions and mitigation opportunities*. European Commission - Knowledge for Policy. https://knowledge4policy.ec.europa.eu/publication/tackling-climate-change-through-livestock-global-assessment-emissions-mitigation_en
- European Commission. (2025a). *At a glance: HUNGARY'S CAP STRATEGIC PLAN* [Fact Sheet]. European Commission.
- European Commission. (2025b). *Factsheet on 2014-2020 Rural Development Programme for Hungary* [Fact Sheet]. European Commission. https://agriculture.ec.europa.eu/document/download/c07e2021-6b7e-40cc-9d79-e643ee7d4168_en?filename=rdp-factsheet-hungary_en.pdf
- European Commission. (2025c, September 16). *Industrial and Livestock Rearing Emissions Directive (IED 2.0)—Environment*. European Commission - Energy, Climate Change, Environment. https://environment.ec.europa.eu/topics/industrial-emissions-and-safety/industrial-and-livestock-rearing-emissions-directive-ied-20_en

- European Commission. (2025d, September 24). *CAP expenditure*. European Commission - Agriculture and Rural Development. https://agriculture.ec.europa.eu/data-and-analysis/financing/cap-expenditure_en
- European Commission. (2025e, October 21). *CAP at a glance—European Commission*. Agriculture and Rural Development - European Commission. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en
- European Commission. (2025f, October 21). *CAP funds—European Commission*. Agriculture and Rural Development - European Commission. https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en
- European Commission. (2025g, October 21). *Coupled income support*. Agriculture and Rural Development - European Commission. https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/additional-schemes/coupled-income-support_en
- European Commission. (2025h, October 21). *The Commission approves the CAP Strategic Plan for Hungary*. Agriculture and Rural Development - European Commission. https://agriculture.ec.europa.eu/media/news/commission-approves-cap-strategic-plan-hungary-2022-11-07_en
- European Commission. (2025i, November 20). *Hungary—Agriculture and rural development*. European Commission. https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans/hungary_en
- European Environment Agency. (2017). *Food in a green light: A systems approach to sustainable food*. Publications Office. <https://data.europa.eu/doi/10.2800/884986>
- European Parliament. (n.d.). *Texts adopted—Implementation of the Sixth VAT Directive—Wednesday, 16 February 2022*. European Parliament. Retrieved October 17, 2025, from https://www.europarl.europa.eu/doceo/document/TA-9-2022-0034_EN.html
- European Parliament. (2025, September 20). *Farm to Fork strategy on sustainable food system | Legislative Train Schedule*. European Parliament. <https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-farm-to-fork-strategy>
- Eurostat. (n.d.-a). *Environmental tax statistics*. Eurostat. Retrieved October 19, 2025, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Environmental_tax_statistics
- Eurostat. (n.d.-b). *Glossary: Livestock density index*. Eurostat - Statistics Explained. Retrieved October 22, 2025, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Livestock_density_index
- Eurostat. (2022a). *Euro/ECU exchange rates—Annual data [Dataset]*. Eurostat. https://doi.org/10.2908/ERT_BIL_EUR_A
- Eurostat. (2022b). *HICP - annual data (average index and rate of change) [Dataset]*. Eurostat. https://doi.org/10.2908/PRC_HICP_AIND

- Eurostat. (2022c). *Population on 1 January* [Dataset]. Eurostat. <https://doi.org/10.2908/TPS00001>
- Eurostat. (2023, January). *Agri-environmental indicator—Livestock patterns*. Eurostat - Statistics Explained. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_livestock_patterns
- Eurostat. (2025, August 28). *Almost 9% in the EU could not afford a proper meal*. Eurostat - News Articles. <https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250828-1>
- FAIRR. (2017). *THE LIVESTOCK LEVY: ARE REGULATORS CONSIDERING MEAT TAXES?* FAIRR.
- FAO. (n.d.). *Animal Production* [Food and Agricultural Organization of the United Nations]. Food and Agricultural Organization of the United Nations. Retrieved October 14, 2025, from <https://www.fao.org/animal-production/en>
- FAO. (2020). *Biodiversity and the livestock sector—Guidelines for quantitative assessment*. FAO. <https://doi.org/10.4060/ca9295en>
- FAO. (2023a). *Pathways towards lower emissions—A global assessment of the greenhouse gas emissions and mitigation options from livestock agrifood systems*. FAO. <https://doi.org/10.4060/cc9029en>
- FAO. (2023b). *The State of Food and Agriculture 2023—Revealing the true cost of food to transform agrifood systems*. FAO. <https://doi.org/10.4060/cc7724en>
- FAO. (2024). *The State of Food and Agriculture 2024—Value-driven transformation of agrifood systems*. FAO. <https://doi.org/10.4060/cd2616en>
- FAO & IWMI. (2018). *More people, more food, worse water? A global review of water pollution from agriculture*. FAO and IWMI.
- Farkas, J. Z., Kőszegi, I. R., Hoyk, E., & Szalai, Á. (2023). Challenges and Future Visions of the Hungarian Livestock Sector from a Rural Development Viewpoint. *Agriculture*, 13(6), 1206. <https://doi.org/10.3390/agriculture13061206>
- Fekete, G., Dankóné, S. Z., Tóth, V., & Varga, E. (2020). *Takarmánygyártás 2019*. NAIK Agrárgazdasági Kutatóintézet (Research Institute of Agricultural Economics).
- fi-compass. (2020). *Financial needs in the agriculture and agri-food sectors in Hungary* [Study Report]. European Commission, European Investment Bank. https://www.fi-compass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_Hungary.pdf
- Finger, R., Fabry, A., Kammer, M., Candel, J., Dalhaus, T., & Meemken, E. M. (2024). Farmer Protests in Europe 2023–2024. *EuroChoices*, 23(3), 59–63. <https://doi.org/10.1111/1746-692X.12452>
- Funke, F., Mattauch, L., Bijgaart, I. van den, Godfray, H. C. J., Hepburn, C., Klenert, D., Springmann, M., & Treich, N. (2022). Toward Optimal Meat Pricing: Is It Time to Tax

- Meat Consumption? *Review of Environmental Economics and Policy*, 16(2), 219–240.
<https://doi.org/10.1086/721078>
- Gillingham, K., & Sweeney, J. (2010). Market Failure and the Structure of Externalities. In *Harnessing Renewable Energy in Electric Power Systems: Theory, Practice, Policy*.
- Giuliani, A., & Baron, H. (2025). The CAP (Common Agricultural Policy): A Short History of Crises and Major Transformations of European Agriculture. *Forum for Social Economics*, 54(1), 68–94. <https://doi.org/10.1080/07360932.2023.2259618>
- Greenwood, J., & McAfee, R. P. (1991). Externalities and Asymmetric Information. *The Quarterly Journal of Economics*, 106(1), 103–121.
- Groenestein, C. M., Hutchings, N. J., Haenel, H. D., Amon, B., Menzi, H., Mikkelsen, M. H., Misselbrook, T. H., Van Bruggen, C., Kupper, T., & Webb, J. (2019). Comparison of ammonia emissions related to nitrogen use efficiency of livestock production in Europe. *Journal of Cleaner Production*, 211, 1162–1170.
<https://doi.org/10.1016/j.jclepro.2018.11.143>
- Hassan, M. U., Aamer, M., Mahmood, A., Awan, M. I., Barbanti, L., Seleiman, M. F., Bakhsh, G., Alkharabsheh, H. M., Babur, E., Shao, J., Rasheed, A., & Huang, G. (2022). Management Strategies to Mitigate N₂O Emissions in Agriculture. *Life*, 12(3), 439.
<https://doi.org/10.3390/life12030439>
- He Waka Eke Noa Primary Sector Climate Action Partnership. (2022). *Recommendations for pricing agricultural emissions—Report to Ministers*. He Waka Eke Noa Primary Sector Climate Action Partnership.
- Hendriks, S., de Groot Ruiz, A., Acosta, M. H., Baumers, H., Galgani, P., Mason-D’Croz, D., Godde, C., Waha, K., Kanidou, D., von Braun, J., Benitez, M., Blanke, J., Caron, P., Fanzo, J., Greb, F., Haddad, L., Herforth, A., Jordaan, D., Masters, W., ... Watkins, M. (2021). *The True Cost and True Price of Food*. Scientific Group for the UN Food Systems Summit. <https://sc-fss2021.org>
- Heyl, K., Döring, T., Garske, B., Stubenrauch, J., & Ekardt, F. (2021). The Common Agricultural Policy beyond 2020: A critical review in light of global environmental goals. *Review of European, Comparative & International Environmental Law*, 30(1), 95–106. <https://doi.org/10.1111/reel.12351>
- Hill, J. M., & Weulen Kranenbarg, M. (2025). Polluted Nature, Polluted Debate: A Longitudinal Analysis of Disinformation Around the Nitrogen Crisis in The Netherlands. *European Journal on Criminal Policy and Research*.
<https://doi.org/10.1007/s10610-025-09624-1>
- Hungarian Central Statistical Office. (n.d.-a). 1.2.1.8. *Average consumer price of selected products and services (raw data), monthly*. Hungarian Central Statistical Office. Retrieved September 26, 2025, from https://www.ksh.hu/stadat_files/ara/en/ara0044.html
- Hungarian Central Statistical Office. (n.d.-b). 14.1.1.27. *Annual food consumption volume per capita by income deciles*. Hungarian Central Statistical Office. Retrieved October 24, 2025, from https://www.ksh.hu/stadat_files/jov/en/jov0026.html

- Hungarian Central Statistical Office. (n.d.-c). *14.1.2.11. Annual per capita quantity of food consumption by regions and type of settlements*. Hungarian Central Statistical Office. Retrieved September 26, 2025, from https://www.ksh.hu/stadat_files/jov/en/jov0051.html
- Hungarian Central Statistical Office. (n.d.-d). *19.1.1.1. Summary data of Agriculture*. Hungarian Central Statistical Office. Retrieved October 21, 2025, from https://www.ksh.hu/stadat_files/mez/en/mez0001.html
- Hungarian Central Statistical Office. (n.d.-e). *19.1.1.39. Manure application*. Hungarian Central Statistical Office. Retrieved September 26, 2025, from https://www.ksh.hu/stadat_files/mez/en/mez0040.html
- Hungarian Central Statistical Office. (n.d.-f). *19.1.2.25. Fertilization by county and region*. Hungarian Central Statistical Office. Retrieved September 26, 2025, from https://www.ksh.hu/stadat_files/mez/en/mez0093.html
- Hungarian Central Statistical Office. (n.d.-g). *Average gross earning*. Hungarian Central Statistical Office. Retrieved September 26, 2025, from <https://www.ksh.hu/gyorstajekoztatok/#/en/list/ker>
- Hungarian Central Statistical Office. (n.d.-h). *Integrated Farm Statistics data collection – IFS 2023, preliminary data*. Hungarian Central Statistical Office. Retrieved October 16, 2025, from <https://www.ksh.hu/s/publications/agriculture-2023-preliminary-data/>
- Hungarian Central Statistical Office. (n.d.-i). *Prices*. Hungarian Central Statistical Office. Retrieved September 26, 2025, from <https://www.ksh.hu/prices>
- Jayasinghe, S., Byrne, N. M., & Hills, A. P. (2025). Cultural influences on dietary choices. *Progress in Cardiovascular Diseases*, *90*, 22–26. <https://doi.org/10.1016/j.pcad.2025.02.003>
- Joint Research Centre, European Commission, Ricci, M., Dominguez, P., I., Hristov, J., Vandyck, T., van Houtven, & S. (2024). *Pricing GHG emissions in agriculture: Accounting for trade and fairness for effective climate policy*. European Commission.
- KIS-KOVÁCS, G., LABAN CZ, K., LUDÁNYI, E. L., TÓTH, V., ZUBOR-NEMES, A., KÁLMÁN, K., SOMOGYI, Dr. Z., TOBISCH, Dr. T., KIRÁLY, É., & HORVÁTH, K. (2022). *National Inventory Document 1985-2022*. HungaroMet. <https://unfccc.int/documents/461959>
- Kitzes, J. (2013). An Introduction to Environmentally-Extended Input-Output Analysis. *Resources*, *2*(4), 489–503. <https://doi.org/10.3390/resources2040489>
- Klenert, D., Funke, F., & Cai, M. (2023). Meat taxes in Europe can be designed to avoid overburdening low-income consumers. *Nature Food*, *4*(10), 894–901. <https://doi.org/10.1038/s43016-023-00849-z>
- Korteland, M., de Bruyn, S., de Koning, J., van de Pol, J., Sinke, P., & de Vries, J. (2023). *Pay as you eat dairy, eggs and meat: Internalising external costs of animal food products in France, Germany and the EU27*. CE Delft. <https://cedelft.eu/publications/pay-as->

you-eat-dairy-eggs-and-meat-internalising-external-costs-of-animal-food-products-in-france-germany-and-the-eu27/

- Kortleve, A. J., Mogollón, J. M., Harwatt, H., & Behrens, P. (2024). Over 80% of the European Union's Common Agricultural Policy supports emissions-intensive animal products. *Nature Food*, 5(4), 288–292. <https://doi.org/10.1038/s43016-024-00949-4>
- Laderchi, R., C., Campen, L., DeClerck, Bodirsky, L., B., Collignon, Q., Crawford, S., M., Dietz, S., Nagenborg, S., Pilditch, T., Popp, A., Wedl, ... V. (2024). *The Economics of the Food System Transformation* [Global Policy Report]. Food System Economics Commission (FSEC).
- Magyarország Kormánya. (n.d.). *Folytatódik a rendszerváltás utáni legnagyobb állattartó telep fejlesztési program*. Magyarország Kormánya. Retrieved October 22, 2025, from <https://kormany.hu/hirek/folytatodik-a-rendszervaltas-utani-legnagyobb-allattarto-telep-fejlesztési-program>
- Maró, Z. M., Török, Á., & Czine, P. (2025). Examining consumer preferences for basic foodstuffs in a highly inflationary economic environment: The case of price-capped chicken breast fillet in Hungary. *Heliyon*, 11(1), e41279. <https://doi.org/10.1016/j.heliyon.2024.e41279>
- Mengesha, I., & Roy, D. (2025). Carbon pricing drives critical transition to green growth. *Nature Communications*, 16(1), 1321. <https://doi.org/10.1038/s41467-025-56540-3>
- Ministry for the Environment and Ministry for Primary Industries. (2022). *Pricing agricultural emissions: Consultation document*. Ministry for the Environment and Ministry for Primary Industries.
- Ministry of Food, Agriculture and Fisheries of Denmark. (2021). *Emissions from the agricultural sector will be reduced by 55 to 65 percent*. Ministry of Food, Agriculture and Fisheries of Denmark. https://en.fvm.dk/Media/638484225533540724/Fact_Sheet_1_ny.pdf
- Mohammadzadeh Valencia, F., Mohren, C., Ramakrishnan, A., Merchert, M., Minx, J. C., & Steckel, J. C. (2024). Public support for carbon pricing policies and revenue recycling options: A systematic review and meta-analysis of the survey literature. *Npj Climate Action*, 3(1), 74. <https://doi.org/10.1038/s44168-024-00153-x>
- New Zealand Ministry for the Environment. (n.d.). *Climate Change Response (Emissions Trading Reform) Amendment Act 2020 No 22 (as at 06 August 2022), Public Act – New Zealand Legislation*. New Zealand Legislation. Retrieved October 19, 2025, from <https://www.legislation.govt.nz/act/public/2020/0022/latest/whole.html>
- O'Donoghue, C., Li, J., Cserhádi, I., Elek, P., Keresztély, T., & Takács, T. (2017). The Distributional Impact of VAT Reduction for Food in Hungary: Results from a Hungarian Microsimulation Model. *International Journal of Microsimulation*, 11(3), 2–38. <https://doi.org/10.34196/ijm.00187>
- Oebel, B., Stein, L., Michalke, A., Stoll-Kleemann, S., & Gaugler, T. (2025). Towards true prices in food retailing: The value added tax as an instrument transforming agri-food

- systems. *Sustainability Science*, 20(5), 1705–1722. <https://doi.org/10.1007/s11625-024-01477-7>
- OECD. (1975). *The Polluter Pays Principle*. OECD.
- OECD. (2015). *Public Goods and Externalities: Agri-environmental Policy Measures in Selected OECD Countries*. OECD. <https://doi.org/10.1787/9789264239821-en>
- OECD. (2017). *OECD Environmental Performance Reviews: New Zealand 2017*. OECD. <https://doi.org/10.1787/9789264268203-en>
- OECD. (2024). *Consumption Tax Trends 2024: VAT/GST and Excise, Core Design Features and Trends*. OECD. <https://doi.org/10.1787/dcd4dd36-en>
- OECD. (2025, June 29). *Environment at a Glance: Hungary*. OECD. https://www.oecd.org/en/publications/environment-at-a-glance-country-notes_59ce6fe6-en/hungary_3af06cba-en.html
- OECD & Food and Agriculture Organization of the United Nations. (2025). *OECD-FAO Agricultural Outlook 2025-2034*. OECD Publishing. <https://doi.org/10.1787/601276cd-en>
- Pigou, A. C. (1932). *The Economics of Welfare* (Fourth Edition). <https://oll.libertyfund.org/titles/pigou-the-economics-of-welfare>
- Rewe Group. (2023, July 31). *Environmental costs: The pioneering, Europe-wide study based on PENNY's "true costs" campaign week*. REWE Group. <https://www.rewe-group.com/en/press-and-media/newsroom/press-releases/environmental-costs-the-pioneering-europe-wide-study-based-on-pennys-true-costs-campaign-week/>
- RICHTER, S. (2023). *HUNGARY: In the grip of high inflation* [Forecast Report]. The Vienna Institute for International Economic Studies. <https://wiiw.ac.at/hungary-in-the-grip-of-high-inflation-dlp-6533.pdf>
- Rusman, A., Heuberger, L., Huzen, M., Victor, L., Steffen, R., Connor, B., & Danai, A. (2023). *External Costs of Animal Sourced Food in the EU*. Impact Institute.
- Sandmo, A. (1974). A Note on the Structure of Optimal Taxation. *The American Economic Review*, 64(4), 701–706. <https://www.jstor.org/stable/1813321?seq=1&cid=pdf->
- Sandmo, A. (1975). Optimal Taxation in the Presence of Externalities. *The Swedish Journal of Economics*, 77(1), 86–98. <https://www.jstor.org/stable/3439329>
- Scheffler, M., & Wiegmann, K. (2022). *Reform of the VAT rates for animal and plant products: An analysis based on five selected Member States*. Öko-Institut e.V., Greenpeace.
- Scherger, S. (n.d.). *A New EU Emissions Economy? A Policy Guide to Agriculture Emissions Pricing in the European Union*. Institute for Agriculture and Trade Policy.
- Siegmann, A. (2024). The farmers' revolt in the Netherlands: Causes and consequences. *European View*, 23(2), 156–166. <https://doi.org/10.1177/17816858241288396>

- Sotte, F., & Brunori, G. (Eds.). (2025). *European Agricultural Policy: History and Analysis*. Springer Nature Switzerland. <https://doi.org/10.1007/978-3-031-83313-7>
- Springmann, M., Dinivitzer, E., Freund, F., Jensen, J. D., & Bouyssou, C. G. (2025). A reform of value-added taxes on foods can have health, environmental and economic benefits in Europe. *Nature Food*, 6(2), 161–169. <https://doi.org/10.1038/s43016-024-01097-5>
- The World Bank. (2009). *Minding the Stock: Bringing Public Policy to Bear on Livestock Sector Development* (Nos. 44010-GLB). The World Bank - Agriculture and Rural Development Department.
- True Price. (2023). *True Price experiment at Albert Heijn To Go*. True Price. <https://static.ah.nl/binaries/ah/content/assets/ah-nl/core/about/duurzaamheid/paper-true-price-experiment-albert-heijn-to-go-june-4th.pdf>
- Valenduc, C. (2020). Carbon pricing versus environmental tax incentives: Is it “or” or “and”? *Reflète et Perspectives de La Vie Économique*, LVIII(4), 39–62. <https://doi.org/10.3917/rpve.594.0039>
- Verschuuren, J., Fleurke, F., & Leach, M. C. (2024). Integrating Agricultural Emissions into the European Union Emissions Trading System: Legal Design Considerations. *Sustainability*, 16(12), 5091. <https://doi.org/10.3390/su16125091>
- Vollebergh, H. (2012). *Environmental taxes and Green Growth—Exploring possibilities within energy and climate policy*. PBL Netherlands Environmental Assessment Agency.
- Vörös-Illés, I., Péter, K., Szomoru, G., & Rózsa, A. (2025). *PÉNZÜGYI HÍRLEVÉL XVIII. évfolyam* [Financial Report]. AKI.
- Wirsenius, S., Searchinger, T., Zions, J., Peng, L., Beringer, T., & Dumas, P. (2020). *COMPARING THE LIFE CYCLE GREENHOUSE GAS EMISSIONS OF DAIRY AND PORK SYSTEMS ACROSS COUNTRIES USING LAND-USE CARBON OPPORTUNITY COSTS*. World Resources Institute.
- World Bank. (2022). *State and Trends of Carbon Pricing 2022*. World Bank. <http://hdl.handle.net/10986/3745>
- World Bank. (2025). *State and Trends of Carbon Pricing 2025*. World Bank. DOI: 10.1596/978-1-4648-2255-1
- World Bank Group. (n.d.). *World Bank Open Data—Hungary*. World Bank Open Data. Retrieved November 26, 2025, from <https://data.worldbank.org/country/hungary>
- World Bank Group. (2023a, October 30). *GHG Emissions Coverage*. Carbon Pricing Dashboard. <https://carbonpricingdashboard.worldbank.org/compliance/coverage>
- World Bank Group. (2023b, October 30). *Price*. Carbon Pricing Dashboard. <https://carbonpricingdashboard.worldbank.org/compliance/price>