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Grounding a legal research agenda on the EU mitigation of livestock emissions – A systematic literature review

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Abstract

Livestock farming constitutes a significant source of greenhouse gas (GHG) emissions, presenting a challenge to the fulfilment of regional and international climate change mitigation. However, research on the mitigation of livestock emissions remains underrepresented in environmental legal scholarship. The current exploratory study aims to bridge this gap by systematically addressing legal research focused on reducing GHG emissions from livestock. Given the distinct characteristics of various regional contexts, this work places a particular emphasis on the European Union (EU). Indeed, while maintaining ambitious climate change mitigation obligations, the EU records unhealthily high levels of animal food production and consumption. Furthermore, considering both its strong enforcement powers and the central role it plays as one of the main producers and consumers of animal food products worldwide, the EU is in a privileged position for conditioning global animal food systems. The article begins by outlining the scale and features of livestock's impact on climate change. It then reviews the existing legal literature on the mitigation of livestock emissions, with a special focus on EU-specific analyses. After highlighting insights from current legal scholarship, assessing its alignment with scientific evidence, and identifying research gaps, the article proposes the development of a legal research agenda focused on the EU mitigation of livestock GHG emissions, informed by four preliminary observations. The observations clarify that: 1- the livestock sector has traditionally been neglected in climate change law and policy documents; 2- there is shortage of legal research on the mitigation of livestock emissions at the EU level; 3- curbing livestock related GHG emissions will have a major role to play for the EU to meet international and regional climate change mitigation obligations; 4- at the EU level, there is no possibility to decouple livestock production and consumption from GHG emissions.

Keywords*: GHG emissions, Mitigation, Climate change, Livestock.*

1. Introduction: on law and livestock

Despite being "at odds with the imperative to restrict global temperature rise in order to avert catastrophic climate change", livestock production, consumption, and private and public funding are on the rise at the global level (OECD & FAO, 2020; Our World in Data, 2023; Kortleve *et al*., 2024).

It is worth noting that not even the European Union, long deemed to be a global leader in the fight against climate change, is doing well on this regard. Indeed, livestock emissions still constitute the lion's share of European agricul-

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tural emissions, and the EU keeps spending over 80% of its Common Agricultural Policy budget to support emission-intensive animal products (European Commission *et al*., 2020; Kortleve *et al*., 2024). This is done, at least by façade, in the hope that investments in animal agriculture will increase livestock productivity and finally curb its associated greenhouse gas (GHG) emissions.

While due distinctions need to be made between high- and low-income countries when it comes to identifying best ways to reduce livestock emissions,[1] it is crucial to observe that climate change law and policy documents have traditionally disregarded the livestock sector (Donahue, 2008; Bailey *et al*., 2014; Kristiansen *et al*., 2020; Rose *et al*., 2021). The discrepancy between, on the one hand, overwhelming scientific evidence on the need to urgently reduce global livestock production and consumption related GHG emissions (thereinafter *livestock emissions*) and, on the other hand, the shortage of law and policy documents addressing the issue at stake, is concerning, and it suggests the existence of significant regulatory gaps.

This situation might be particularly alarming at the EU level. Indeed, the EU, while maintaining relatively ambitious climate change mitigation obligations, still records unhealthily high levels of animal food production and consumption. Furthermore, considering both its strong enforcement powers and the central role it plays as one of the main producers and consumers of animal food products worldwide, the EU is in a privileged position for conditioning global animal food systems.

This article begins by recognizing that, despite the urgent need to mitigate livestock GHG emissions, the livestock sector has largely been neglected by legal scholars addressing climate change mitigation both at the global and EU level. Indeed, while most climate legal scholarship has focused on sectors such as energy, industry, transportation, and building, the agricultural sector in general, and the livestock sector in particular, appears to have been generally overlooked (Klass, 2013; Boute, 2023).

Against this background, this article seeks to examine the extent to which legal scholars have delved into the issue of livestock emissions. It aims to derive valuable insights from their work, assess how well their analyses align with existing scientific knowledge, and focus particularly on the scholars' examination of the issue at the EU level. To do so, this work will critically review the relevant legal literature on the mitigation of livestock emissions, derive preliminary observations, and propose a research agenda based on these findings.

This process is essential for several key reasons. First, it highlights the urgency of the issue for both academics and legislators, thereby fostering greater awareness and engagement. Second, it provides legal scholars and lawmakers with insights into the most discussed methods for reducing livestock emissions. Third, it allows for a reflection on the extent to which legal scholars' recommendations are consistent with scientific findings on the optimal methods for reducing livestock emissions. Fourth, it offers a broader perspective on how comprehensively legal scholars have addressed the challenges associated with mitigating livestock emissions thus far. Finally, it identifies gaps in current research, highlighting areas that necessitate further scholarly exploration.

Importantly, as the literature review will reveal, the mitigation of livestock emissions remains a relatively uncharted issue in EU legal scholarship. While relevant nuances to this general observation will be provided along the article, this research will not investigate over the reasons behind this general trend. Nonetheless, it is important to note that while the general tendency to overlook this sector could once be justified by the difficulty of tracking livestock emissions, advancements in emission account-

[1] As section §2 will clarify, efforts to increase production efficiency will hardly allow to achieve any climate change mitigation target in those (mostly high-income) countries, where livestock production methods have already reached a mature level of efficiency. Moreover, in high-productivity countries where animal food consumption already exceeds national dietary guidelines, reduction in animal food production and consumption patterns would also bring significant environmental and health co-benefits. (Scherer *et al*., 2019; Springmann *et al*., 2020; van der Veen *et al*., 2022).

ing techniques may render this justification obsolete (Moran *et al*., 2011; Nejad *et al.*, 2024). Instead, problems of political nature still persist, and may contribute to justifying law scholarly general distance from the issue at stake. These include the unpopularity of tackling major agri-food producers' economic interests and their ability to frame reliance on unhealthy levels of meat consumption as a matter of freedom or cultural tradition, which in turn fuels public resistance to dietary changes[2].

Accordingly, section §2 will focus on the features of livestock impact on climate change, both at the global and EU level. While primarily descriptive, this section plays a central role by providing scientific evidence on the urgent need to curb livestock emissions and outlining the pathways available to achieve this goal. Following this, section §3 will offer a systematic review of legal literature on the mitigation of livestock GHG emissions. This review will provide insights into the features of legal scholars' research, while section §4 will provide reflections on their alignment with scientific evidence[3]. Additionally, it will help identifying existing research gaps. Finally, noting a significant lack of legal research specifically addressing the EU context, section §5 will advocate for the development of a legal research agenda focused on the EU mitigation of livestock emissions. It will also synthesize four preliminary observations that could serve as the foundation for this agenda.

2. Livestock contribution to climate change

2.1. *Global and EU livestock emissions: on track towards climate neutrality?*

The considerable challenge represented by increasing livestock production and consumption levels on a global scale became apparent since Delgado *et al*.'s publication of the work "Livestock to 2020 – The Next Food Revolution" (Delgado *et al*., 1999). Already in 1999, indeed, it was clear that relying on this intrinsically polluting and inefficient food technology in an increasingly contaminated planet with a growing population conflict with any definition of sustainability. In the words of Delgato *et al*.:

> "A revolution is taking place in global agriculture that has profound implications for our health, livelihoods, and environment. Population growth, urbanization, and income growth in developing countries are fuelling a massive global increase in demand for food of animal origin. […] The Livestock Revolu-

[2] As journalist Arthur Nelsen and Damian Carrington from the Guardian have reported, livestock lobbies and biggest animal food producing states have played a major role at the FAO level in order to undervalue the role of animal farming's contribution to climate change (link to the articles: https://www.theguardian.com/environment/2023/oct/20/ex-officials-at-un-farming-fao-say-work-on-methane-emissions-was-censored; https://www.theguardian.com/environment/2023/oct/20/the-anti-livestock-people-are-a-pest-how-un-fao-played-down-role-of-farming-in-climate-change?CMP=Share_AndroidApp_Other; https://www.theguardian.com/environment/2024/mar/18/bewildering-to-omit-meat-eating-reduction-from-un-climate-plan; https://www.theguardian.com/environment/2024/apr/19/un-livestock-emissions-report-seriously-distorted-our-work-say-experts). This brought scientist as Paul Behrens and Matthew Hayek to denounce that the FAO has 'seriously distorted' the content of their research and underestimated the potential benefit arising from a reduction in animal food production and consumption levels (link to the article: https://www.theguardian.com/environment/2024/apr/19/un-livestock-emissions-report-seriously-distorted-our-work-say-experts). Furthermore, an inquire conducted by Unearthed and revised by the Guardian reveals that the "Dublin Declaration of Scientists on the Societal Role of Livestock" (i.e., a document prising the positive effects of animal food production and consumption signed by allegedly independent scientists), was actually designed by, and to serve the interests of, the livestock industry (link to the article: https://unearthed.greenpeace.org/2023/10/27/dublin-declaration-meat-livestock-industry/). All this aligns with findings from the report: *New Merchants of Doubts*, published in 2024 by the Changing Markets Foundation. According to the 2024 Report, the big meat and dairy industry continues downplaying the sector's impact, slowing down environmental regulations, and setting their own political agendas through distracting, delaying, and derailing.

[3] Specifically, this work will evaluate whether the measures and policies proposed in legal scholarly research aimed at mitigating livestock emissions align with the requirement for reducing livestock emissions in high-income countries by reducing livestock production and consumption patterns.

tion will stretch the capacity of existing production and distribution systems and exacerbate environmental and public health problems" (1999, p. 11).

This article acknowledges the multifaceted impacts of current global animal food production and consumption systems on environmental, health, and social inequalities[4]. However, provided its specific research scope, it will exclusively focus on their implications for climate change.

It is challenging to determine a definitive estimate of the global contribution of livestock to climate change. The 2006 report by the Food and Agriculture Organization (FAO), *Livestock's Long Shadow*, was the first major international document to highlight the sector's environmental impact, estimating that livestock was responsible for 18 percent of global GHG emissions (FAO, 2006). However, subsequent reports have revised this estimate. In the 2013 *Tackling Climate Change Through Livestock*, the FAO adjusted the figure to 14.5 percent, esteem which was reaffirmed in the 2022 report *Methane Emissions in Livestock and Rice Systems* (FAO, 2013; FAO, 2022). Independent studies have yielded slightly differing estimates. Twine, in 2020, suggested that emissions from animal agriculture account for at least 16.5 percent of total anthropogenic GHG emissions, while Xu *et al*., in 2021, estimated this contribution to be as high as 19.6 percent (Twine, 2021; Xu *et al*., 2021). The variability in these figures can be attributed to differences in methodologies, as well as potential political and economic pressures that may influence the portrayal of the livestock sector's role in GHG emissions (Twine, 2021). Despite these variations, it is clear that the sector is a significant contributor to climate change, with estimates consistently indicating that its contribution lies between 14.5 and 19.6 percent of total human-induced GHG emissions.

The identification of a precise figure expressing livestock contribution to EU wide GHG emissions is also problematic. In 2010, the report *Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions* published by the Joint Research Centre of the European Commission highlights the complexities involved in this estimation. The report notes that while livestock emissions from the agricultural sector account for 85 percent of the sector's total emissions, this figure rises to 175 percent when including indirect, related emissions from energy use, industries, and land use, land-use change, and forestry (LULUCF) (Adrian *et al*., 2010). Accordingly, the report states that, if "the livestock sector (land use and land use change excluded) accounts for 9.1 percent of total emissions (all sectors) according to the inventories, considering land use change, the share increases to 12.8 percent" (2010, p. 28).

This nuanced approach was not echoed in the more recent European Commission report, *Future of EU Livestock: How to Contribute to a Sustainable Agricultural Sector?*, published ten years later. The latter report does not account for indirect, related emissions and simplistically notes that while the EU-28 agricultural sector generated 10 percent of the region's total GHG emissions, the livestock sector was responsible for 81-86 percent of these emissions (European Commission *et al*., 2020). Yet another accounting method was employed in an independent study by Bellarby et al, which estimates that GHG emissions from all livestock products range from 12 to 17 percent of total EU-27 emissions (Bellarby *et al*., 2013). It follows that, esteems for livestock contribution at the EU level present even wider margins of uncertainty than global ones, as they range from a minimum of 8.1 to a maximum of 17 percent of total EU emissions.

At this point, it is crucial to underscore that, provided the substantial contribution of livestock activities to climate change, existing livestock emissions trend might contrast, *inter alia*, with

[4] The current animal food production and consumption system negatively affects, *inter alia*, water consumption and contamination, land use, deforestation, and habitat and biodiversity loss. Intensive animal farming is a main driver of antibiotic resistance, while animal food consumption contributes to cancer outbreak and cardiovascular diseases. Importantly, the existing animal food production chain also exacerbates inequalities in terms of distribution of food resources, and it is a main diver of land grabbing (Mekonnen *et al*., 2012; Machovina *et al*., 2015; Leip *et al*., 2015; Davis *et al*., 2016; Shepon *et al*., 2018; Ritchie, 2019; Hickman *et al*., 2021; World Health Organization, 2023).

the achievement of EU's climate change mitigation obligations. Indeed, the EU is internationally obliged, by the Paris Agreements, to contribute to holding "the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C" (2015, Art.2(1)(a)). Moreover, the European Climate Law establishes that "GHG emissions and removals regulated in Union law shall be balanced within the Union at the latest by 2050" (Regulation (EU) 2021/1119, Art.2(1)). Studies, including those by Westhoek et al. and Lee *et al*., beyond highlighting the significant potential for reducing EU GHG emissions through decreased animal food production, also emphasize the *necessity* of reducing livestock emissions for the EU to meet its commitments under the Paris Agreement (Westhoek *et al*., 2014; Lee *et al*., 2019).

It follows that mitigating livestock emissions will be crucial for the EU to achieve its climate change mitigation obligations. Consequently, there arises a necessity for clarity regarding the optimal approach to achieve this objective. Specifically, the EU must ascertain whether mitigating livestock emissions should be pursued through solely enhancing production efficiency or must encompass reductions in animal food production and consumption.

2.2. *The intrinsically high carbon footprint of livestock: debunking the decoupling myth*

The high carbon footprint of the livestock sector is directly linked to its inherent resource intensiveness. To illustrate this, it might be considered that, while it respectively bestows only 38 percent and 17 percent of global proteins and calories supply, animal food production occupies four fifths of global agricultural land, and is responsible for 57 percent of GHG emissions associated to global food production (Xu *et al*., 2021; Ritchie & Roser, 2024). As a comparison, the production of plant-based food destined to human consumption, while respectively providing 62 and 83 percent of proteins and calories supply, occupies 16 percent of global agricultural land, and it is responsible for 29 percent of global food emissions (Xu *et al*., 2021; Ritchie & Roser, 2024).

Notably, not all animal food types emit the same amount of GHG. Among animal food products, beef is by far the most GHG-intensive, followed by lamb, cheese, pork, poultry, and eggs (Poore & Nemecek, 2018).

Further, different animal farming practices can impact the amount of associated GHG emission. However, the claim that the intensification of animal farming would lead to a decrease in livestock-related GHG emissions, while having generated discussion, has been subject to substantial contestation. In fact, a productivist approach, which emphasizes efficiency gains, has traditionally advocated for intensifying livestock production[5]. In contrast, scholars adopting extensive-oriented approaches have typically highlighted the biodiversity and ecosystem losses associated with factory farming, as well as its negative impact on human health, and the associated risk of 'rebound effect' (Díaz *et al*., 2019; Benton & Bailey, 2019; European Court of Auditors, 2021)[6]. For sure, a reconversion of farmland currently used for intensive livestock activities into extensive farming, if

[5] The Productivist approach is upheld, *inter alia*, in both the study "Future of EU livestock: How to contribute to a sustainable agricultural sector?" commissioned by the European Commission in 2020, and in the FAO Global Roadmap launched at COP28 in 2023. To identify a solution to the sustainability challenge represented by livestock production, the EU Study goes in the direction of "maintaining (or increasing) commodity production while reducing the net environmental impact" (p. 5). Similarly, the FAO Roadmap identifies, as the first out of ten domains of action, the livestock sector. However, it posits that "the livestock sector requires intensified productivity via improved genetics and feeding practices, aiming to reduce resource usage" (p. 6).

[6] An eloquent definition of the rebound effect has been provided by the European Court of Auditors. According to the Court: "Efficiency gains do not translate directly into lower overall emissions. This is because technological change in the livestock sector has also lowered the production cost per litre of milk, leading to production expansion. This effect, known as the 'rebound effect', reduces the greenhouse gas savings from the technology that would occur without production expansion. The additional emissions caused by production expansion can be even larger than the savings achieved from greater efficiency, which means that the innovation causes overall emissions to increase" (2021, p. 23).

not compensated by an expansion in global farming area, while having positive ecological impact, would also reduce global animal food production and consumption.

In this context, however, it is important to distinguish between high- and low-income countries. Efforts to increase livestock production efficiency could still serve as a relatively accessible initial step for regions and communities which rely on inefficient production practices and have lower levels of animal food production and consumption. In this case, efficiency-oriented measures may be the only viable option, particularly when livestock activities are crucial for supporting rural livelihoods and preventing food insecurity (Herrero *et al*., 2012; Donahue, 2015; Parlasca & Qaim, 2022). Hence, there is some room of manoeuvre in these contexts to mitigate livestock related GHG emissions without curbing animal food supply. However, it will be crucial for these new practices to be introduced with the aim of meeting local communities' right to food, rather than serving profit-maximisation interests of food producers, and thus avoiding the occurrence of a 'rebound effect', where productivity gains are compensated by increased production and, thus, overall emissions (Houzer & Scoones, 2019).

Conversely, efforts to increase production efficiency will hardly allow to achieve any climate change mitigation target in those (mostly high-income) countries, where livestock production methods are already (as) efficient (as possible) (Ripple *et al*., 2013; Parlasca & Qaim, 2022). In fact, as the European Court of Auditors clearly pointed out in its 2021 *Special Report on the Common Agricultural Policy and Climate*: there are "no effective and approved practices that can significantly reduce livestock emissions from feed digestion without reducing production. […] Some of these practices [*i.e.*, animal breeding, feeding, health and fertility management] encourage production expansion, and may thus increase net emissions" (2021, p. 22).

This contributes to explaining why, according to scholars such as Harwatt *et al*., "to align with the Paris Agreement […] it is important that human diets shift from livestock-derived foods to livestock replacement foods" (2024, p. 7). Likewise, the 2024 report *Towards EU Climate Neutrality* by the European Scientific Advisory Board on Climate Change (ESABCC) asserts that achieving EU climate change mitigation targets requires, among other measures, "reduced livestock production and sustainable and healthy diets" (2024, p. 156).

It is also important to emphasize that reducing livestock production and consumption in high income countries, such as the EU, would not risk to result in food insecurity. Conversely, it would go in the direction of meeting national dietary guidelines, thus unleashing environmental and healthcare co-benefits including a decreased insurgency of colorectal cancer, cardiovascular diseases, and antibiotic resistance (Westhoek *et al*., 2014; Hickman *et al*., 2021; van der Veen *et al*., 2022).

Apparently, the notion that efficiency-oriented technological and organizational changes can decouple livestock production from its associated emissions is nothing but a convenient narrative. Increasing production efficiency is not a viable method for significantly reducing livestock emissions within the EU and other high-income countries. Consequently, while the previous subsection emphasized the necessity of reducing livestock emissions for the EU to meet its climate change mitigation obligations, this subsection clarifies that pathways for achieving such reductions require a shift towards decreased patterns of animal food production and consumption.

However, given the consistent upward trend in animal food production and consumption over recent decades[7], alongside projections of further increases, the European Union faces an escalating risk of non-compliance with its climate commitments (OECD & FAO, 2020; Komarek, 2021; Our World in Data, 2023). This troubling scenario points to notably deficient regulatory frameworks

[7] Between 1961 and 2021, European meat production passed from 29.5 to 60 million tonnes per year. Furthermore, between 2001 and 2020, EU animal food demand moved from 86 million tonnes to 95.3 million tonnes per year.

for mitigating livestock emissions. Therefore, it is imperative to delve into the legal literature on this matter to gain insights from relevant research, assess its alignment with scientific evidence, and identify eventual research gaps.

3. Livestock and climate change: reviewing the legal literature

3.1. *Method*

The systematic literature review provided in the current section will adopt a narrow thematic scope, while maintaining a wide geographical scope of analysis (look at Siddaway *et al*., 2019). On the one hand, a narrower thematic scope of analysis involves to exclusively consider those law articles which are entirely devoted to the mitigation of livestock emissions. Indeed, while there is an increasing body of legal literature addressing the mitigation of agricultural emissions (Verschuuren, 2018; Verschuuren, 2022; Van Hoof, 2023), as well as the broader ecological or ethical impacts of livestock activities (Nollkaemper, 2023; Stucki, 2023; Talenti, 2023; Verschuuren, 2024), the number of legal works entirely dedicated to the mitigation of livestock emissions remains relatively scarce. This scarcity creates a substantial research gap that warrants focused attention.

On the other hand, while this study aims to provide a particular focus on legal scholars' analysis of the EU level, the systematic review will also encompass works extending beyond the confines of the EU. This decision is justified by two main points. First, previous studies have highlighted that early legal research on livestock emissions originated outside the EU (Talenti, 2022). Therefore, to gain a more comprehensive understanding of legal scholars' initial approaches to these topics, an analysis of the non-EU context is deemed necessary. Second, although, as the first section of this work indicated, the mitigation of livestock emissions should follow different approaches in different regional contexts, it is important to recognize that the global (animal) food system is a complex and composite entity. The increasing demand for animal food and its detrimental climate, environmental, and social consequences are global phenomena. Thus, maintaining a broader view on how legal scholars have approached these issues is crucial.

Relevant works have been identified by inserting the keywords 'livestock', 'cattle', 'meat', 'animal farming', 'animal agriculture', 'diets' (*i.e.*, group one), as well as 'climate change', 'carbon emissions', 'methane emissions', 'climate law' (*i.e.*, group two) in the legal research databases *HeinOnline* and *Lexis*. References in the title to both group one and group two keywords was identified as precondition for the selection of works, as well as their focus on climate change *mitigation* (articles focusing on *adaptation* have not been considered). Moreover, as duly justified in the following lines, results were filtrated so to only account for law journals publications.

HeinOnline and Lexis were chosen as reference databases due to their access to a particularly wide range of international law journals (more than 2,800 and 15,000, respectively), which therefore allows this literature review to have a broad reach. It is important to recognize that US journals are overrepresented in both databases. Therefore, to counterbalance this US-bias, and considering this article's particular interest in the EU level, the same keywords criterion has been used to search for further works in top environmental law journals based in the largest European livestock producing countries (in this case, keywords have been inserted both in English and in the main language of the journal) *i.e.*, France (for which the journal *Revue juridique de l'environnement* has been selected), Germany (*Zeitschrift für Umweltrecht*), Italy (*Rivista Quadrimestrale di Diritto dell'Ambiente*), Spain (*Revista de Derecho Ambiental*) (Vinci & Killmayer, 2022). Furthermore, provided the UK long permanence in the EU, also one of its main environmental law journals (*Transnational Environmental Law*) has been addressed for analysis. This allows to grasp whether, and eventually to what extent and how, environmental law journals in EU larger livestock producing countries have addressed this crucial matter.

It is essential to highlight one feature and address two limitations of this method. Firstly,

as just explained, this literature review focuses exclusively on legal databases and journals, automatically excluding sources from related disciplines (such as public policy, governance, management, and economics) that could undoubtedly offer valuable insights into mitigating livestock emissions. This is done because, as outlined in the introductory section of this article, the primary aim of this review is not simply to explore methods for effectively regulating and reducing livestock emissions. Instead, it aims to evaluate the extent of legal scholars' engagement in research on livestock emissions mitigation, the comprehensiveness of their analysis, and how well their recommendations align with scientific findings on available mitigation pathways. Hence, while this literature review's only focus on law journal databases might be seen, at first, as a limitation of the method adopted in this literature review, it is actually an intended feature, that allows it to align with its purposed objectives. Indeed, while it is important to acknowledge that law journals may include contributions from non-legal scholars and that legal scholars may publish relevant works in non-legal journals, focusing on legal journals still serves as a reasonable proxy for assessing legal scholars' engagement with and general approach to this issue. Furthermore, as law journals are typically managed by legal scholars, it is reasonable to presume that even articles written by non-legal scholars in these journals have received their approval and, therefore, generally reflect the methods or approaches of legal scholarship.

The first limitation of this method lies in its reliance on the analysis of predominantly Western-based law journals. As a result, the ensuing literature review will primarily reflect the existing state of legal scholarship from Western perspectives. However, this limitation does not pose a significant problem. Indeed, this research seeks to understand the extent to which legal scholars have engaged in investigating the issue of livestock emissions, while giving particular consideration to the EU level. Given the need to distinguish between different regional contexts and the similarities among high-income countries, a predominant focus on the mitigation of livestock emissions in Western countries might be particularly relevant for legal scholarship focusing on the EU. In contrast, legal studies conducted in lower-income countries or regions might provide insights that are not equally applicable in EU contexts[8].

The second limitation concerns this method's neglection of those documents which, because of their format (*i.e.*, books, policy reports), title (*i.e.*, not containing the identified keywords), or journal of publication (*i.e.*, there can be relevant contributions in relevant journal not included in the *HeinOnline* and *Lexis* databases or in the five national journals taken in considerations) would be excluded from the literature review. However, on the one hand, this literature review does not pretend to be fully exhaustive. Instead, it aims to provide a thorough overview of the way in which legal scholars have generally addressed the issue at hand.

On the other hand, it is important to acknowledge the continued relevance of works such as *Climate Change, Cattle, and the International Legal Order* by Williams, as well as book chapters like Verschuuren's *Cultivated Meat and Dairy as a Game-Changing Technology in the Agricultural and Food Transition in the EU: What Role for Law?*, and reports such as Harwatt *et al.*'s *Options for a Paris-Compliant Livestock Sector*. Although these sources will be excluded from the systematic literature review due to their format, they warrant particular attention for their insights into how emerging legal instruments can be employed to mitigate emissions from the livestock sector.

Accordingly, this section will review legal works focused on the mitigation of livestock emissions, categorizing them by their geographical scope of analysis (i.e., national, sub-nation-

[8] High-income countries present similar situations, such as animal food production techniques already as efficient as possible, and animal food consumption levels above the global average. Therefore, legal insights gathered in western, non-EU contexts, can still provide valuable information for EU scholarship.

al, supra-national, or international). This classification is based on a geographical element, not only because it maintains a relatively high level of objectivity (i.e., it is possible to provide a straightforward distinction between the national, sub-national, supra-national, or international dimensions) but due to the structural similarities that can influence regulatory frameworks for mitigating livestock emissions at different geographical levels. Importantly, for each work, the review will assess whether it addresses production-based emissions, consumption-based emissions, or both. This distinction is relevant as it highlights the aspect of the animal food chain on which different scholars concentrate. Furthermore, studies that consider both production and consumption-based emissions will be positively evaluated, as they align with scientific recommendations to adopt a systemic approach when accounting for animal food emissions (Herrero *et al*., 2016; Clark & Tilman, 2017).

The literature review will also identify the types of measures proposed by legal scholars to curb livestock emissions. Given the inherent complexity of reducing livestock emissions, the adoption of a more comprehensive portfolio of measures will be viewed favourably. The review will also differentiate between studies that offer a general examination of the livestock governance framework (i.e., considering multiple legal domains or linking existing frameworks to broader political and economic contexts) and those focusing on specific issue analyses, such as addressing particular problems within the livestock governance system (e.g., public subsidies for animal food, public land grazing programmes) or proposing targeted measures (e.g., the introduction of a carbon tax, or the substitution of traditional meat with cultured meat). General examinations of the livestock governance framework often correlate with studies addressing both production and consumption-side emissions, and they tend to suggest a wider array of instruments for tackling emissions. It is important to note that studies providing a broad analysis of the livestock governance framework have the advantage of offering a holistic perspective, seeking structural solutions to the systemic inefficiencies within the livestock governance system.

After synthesising the main findings of the analysed studies, the characteristics of each group will be examined, the alignment of the legal literature with scientific evidence will be evaluated, and existing research gaps will be identified.

3.2. *Analysis*

Studies at the national level represent the broadest group of legal works dedicated to mitigating livestock emissions. Most focus on the United States, with the exception of Johnson's work, which examines the issue in Australia. Among these studies, the distribution between those focusing on production-side emissions (Walters, 2019; Janicek, 2021), consumption-side emissions (Johnson, 2015; Luetkemeyer, 2017; Chenyang, 2019; Sforza, 2020), and both production and consumption-side emissions (Donahue, 2008; Donahue, 2015; McCormack, 2021; Rutinel & Quaade, 2022) is quite balanced. Four out of ten studies focus solely on reducing livestock emissions through market measures (Luetkemeyer, 2017; McCormack, 2021; Janicek, 2021; Rutinel & Quaade, 2022). One study focuses on reducing animal food consumption, and related emissions, by providing information through food labels (Sforza, 2020), while another explores the possibility of relying on litigation (Walters, 2019). Four studies consider a combination of instruments, emphasizing market measures but also including strategies such as school education, information dissemination, public procurement, and institutional changes (Donahue, 2008; Donahue, 2015; Johnson, 2015; Chenyang, 2019). The study by Johnson in particular stresses the need for greater collaboration between environmental, agricultural, and health ministries.

Only three national-level studies attempt to provide a broad examination of the livestock governance framework, (Donahue, 2008; Donahue, 2015; Johnson, 2015). In contrast, the remaining national-level studies focus on targeted issues, such as public land grazing, meat subsidies, meat taxes, and carbon offset measures. All the analysed studies acknowledge the need to reduce GHG emissions through lower

animal food production and/or consumption levels. Indeed, with the partial exception of Sforza's work, which looks at cultured meat[9], no study advocates for reducing emissions by increasing production efficiency.

At the sub-national level, only two studies focusing on the mitigation of livestock emissions were identified, both from the US. Hoffmann (2016) focuses on consumption-side emissions, while Karimi (2018) considers both production and consumption-based emissions. Both studies identify a range of measures to curb livestock emissions, from market measures to command-and-control approaches, as well as information and education. Hoffmann's study addresses public livestock grazing in the Great Basin, while Karimi's work provides a general overview of the livestock governance framework, as it also considers the role of political actors, such as Non-Governmental Organizations, and research in lab-grown meat. Importantly, both studies agree that reducing livestock numbers is essential to mitigating GHG emissions.

At the EU level, three studies were identified. One focuses on consumption-side emissions (Bahr, 2015), while two address production-side emissions (Talenti, 2023; Williams, 2024). None of these studies examine both production and consumption-side emissions comprehensively. Bahr's work exclusively advocates for market instruments to address livestock emissions, specifically, a meat tax, while Talenti calls for moderate institutional changes, particularly regarding the structure of the EU's Effort Sharing and Land Use, Land-Use Change, and Forestry (LULUCF) Regulations, proposing changes to targets, flexibility mechanisms, and margins for inter-sectoral compensation. Meanwhile, Williams' work, though not identifying any specific measures to address livestock emissions, provides a non-exhaustive analysis of the EU livestock governance framework, which nonetheless extends beyond a single targeted issue. The remaining studies focus on analyses of specific issues: Bahr considers a meat tax, and Talenti assesses climate targets for livestock emissions. Like the national and subnational-level studies, all EU studies focus on reducing emissions through decreased animal food production and consumption.

The final category includes studies examining the interaction between domestic and international legal systems (Winebarger, 2012; Benitez, 2022) and those focused on the international legal system (Torrez, 2014; Talenti, 2022; Campos Lima, 2024; Campos Lima, 2025). Three of these works address both production and consumption-based emissions (Benitez, 2022; Campos Lima, 2024; Campos Lima, 2025), two more focus on production-based emissions (Winebarger, 2012; Talenti, 2022), and one deals only with consumption (Torrez, 2014). While two of the studies (Winebarger, 2012; Torrez, 2014) focus primarily on market-based measures, two others incorporate proposals for institutional changes. Talenti, for instance, combines amendments to the Paris Agreement with educational initiatives, while Campos Lima (2025) advocates for a reconceptualization of the principle of Common but Differentiated Responsibilities and Respective Capabilities to include responsibility for consumption, accompanied by information dissemination strategies aimed at influencing consumer behaviour. Information-based measures also feature prominently in Campos Lima's 2024 contribution, which further suggests the use of market mechanisms to reduce livestock emissions. In contrast, Benitez offers a critical assessment of the existing legal framework but refrains from proposing specific reforms.

Notably, this is the only group where studies that take a broad governance approach outnumber those that focus on specific issues, such as stopping public subsidies for livestock production (Winebarger, 2012) or imposing a tax on animal

[9] Whether focusing on cultured meat is seen as a way to reduce animal food production or simply make it more efficient depends on how cultured meat is categorized. If cultured meat is viewed as belonging to the animal food category, increasing its production to reduce livestock emissions could be seen as a strategy for improving efficiency. However, if cultured meat is considered distinct from traditional animal products and separate from livestock, substituting traditional meat with cultured meat can still be viewed as an effort to reduce animal food emissions by lowering livestock production and consumption.

Geographical scope of analysis	*Research author*	*Increasing efficiency (E), reducing production/ consumption (R), or both (E&R)*	*Accounting for Emissions from Consumption (C), Production (P), or both (C&P)*	*Type of identified measure: market (M), education (E), information (I), public procurement (PP), command and control (CC), litigation (L), institutional change (IC)*	*General Examination of Livestock Governance Framework (GEGF) or Targeted Issue Analysis (TIA)*
Subnational	1. Hoffmann (Great Basin, 2016); 2. Karimi (California, 2018).	1. R 2. R	1. C 2. P & C	1. M, I, CC 2. M, E, CC	1. TIA (land grazing) 2. GEGF
National	1. Donahue (US, 2008); 2. Donahue (US, 2015); 3. Johnson (Australia, 2015); 4. Luetkemeyer (US, 2017); 5. Chenyang (US, 2019); 6. Walters (US, 2019); 7. Sforza (US, 2020); 8. McCormack (US, 2021); 9. Janicek (US, 2021); 10. Rutinel & Quaade (US, 2022).	1. R 2. R 3. R 4. R 5. R 6. R 7. R (cultured meat) 8. R 9. R 10. R	1. P & C 2. P & C 3. C 4. C 5. C 6. P 7. C 8. P & C 9. P 10. P & C	1. M, E 2. M, E 3. M, PP, I, IC 4. M 5. M, I 6. L 7. I 8. M 9. M 10. M	1. GEGF 2. GEGF 3. GEGF 4. TIA (meat tax) 5. TIA (land grazing) 6. TIA (law of public nuisance) 7. TIA (cultured meat) 8. TIA (stop subsidies) 9. TIA (land grazing) 10. TIA (carbon offset protocol)
Supranational (EU)	1. Bahr (2015); 2. Talenti (2023); 3. Williams (2024).	1. R 2. R 3. R	1. C 2. P 3. P	1. M 2. IC 3. -	1. TIA (meat tax) 2. TIA (mitigation targets) 3. GEGF
International	1. Winebarger (2012); 2. Torrez (2014); 3. Benitez (2022); 4. Talenti (2022); 5. Campos Lima (2024); 6. Campos Lima (2025).	1. R 2. R 3. R 4. R 5. R 6. R	1. P 2. C 3. P & C 4. P 5. P & C 6. P & C	1. M 2. M 3. - 4. IC, E 5. M 6. I, IC	1. TIA (stop subsidies) 2. TIA (meat tax) 3. GEGF 4. GEGF 5. GEGF 6. GEGF

food products (Torrez, 2014). As in the other categories, all proposed measures to reduce livestock emissions involve lowering production and consumption levels.

4. Discussion

The systematic literature review identified twenty-one law research articles entirely devoted to the mitigation of livestock emissions. These works have been inserted in Table 1. Notably, there has been a surge in this area of research, with more than half of the identified works published between 2019 and 2025.

A fair balance has been found between the number of works focusing on either production or consumption-side emissions, and those focusing on both. Similarly, a balanced situation characterises the distribution between studies providing a general examination of the livestock governance framework and those concerned with targeted issue analysis.

4.1. *Overall observations*

Studies conducted at the national level, beyond indicating a relatively strong engagement by US legal scholars with livestock emissions mitigation, do not seem to rely on particularly comprehensive approaches. Indeed, while they almost all rely on market measures as instruments for the mitigation of livestock emissions, they generally focus on specific issues such as land use and subsidies, while rarely offering a comprehensive analysis of the livestock governance framework.

Sub-national studies, while very limited in number, offer comprehensive analyses of local livestock systems, and generally advocate for a broad range of measures, including information, education and, importantly, command and control. The adoption of this comprehensive approach in this category of studies seems to suggest that, when the scope of analysis is focused on the local dimension, proposed action usually goes beyond market mechanisms. Citizens are not merely seen as consumers, but as informed individuals who must be educated about the environmental and health impacts of their dietary choices. This approach also highlights the necessity of imposing safety limits on local animal food production. Indeed, to avoid detrimental practices, such as the creation of intensive farming centres which could negatively affect local communities, and which would not be *ipso facto* prevented by the establishment of market measures, local actions require constraining animal food production within certain non-negotiable safety limits (*i.e.*, command and control).

The literature on the supra-national level is also quite limited. This is the only group of studies missing any work simultaneously focusing on both livestock production and consumption-side emissions. Moreover, only one study at the EU level has provided an examination of the livestock governance framework going beyond single, targeted issue analysis. The measures most commonly discussed remain focused on market mechanisms, reflecting the EU's traditional economic role. However, over the last two decades, and even more after the launch of the European Green Deal, the EU seems to be turning into something broader than a mere economic actor (Chiti, 2022). Studies on livestock emissions mitigation could benefit from adopting a more comprehensive analytical perspective and proposing measures beyond market mechanisms. This would be justified, *inter alia*, in light of the EU's relatively high climate change mitigation obligations (Regulation (EU) 2021/1119, Art.2(1)). Moreover, it would be required provided the crucial role, discussed in the second section of this article, for the EU to mitigate livestock emissions in order to comply with these obligations (IPCC, 2023; Richardson *et al.*, 2023).

Finally, studies on the international level exhibit quite diverse analytical approaches, addressing either production, consumption, or both. Notably, this is the cluster identifying the highest number of studies advocating for changes in the structure of international institutional arrangements. Moreover, this is the only group in which the number of studies adopting a broader perspective on the livestock governance framework outnumbers those focusing on targeted issue analyses.

4.2. *Insights at the EU level*

From the revised literature, it emerges that legal research on both the sub-national and international level is generally characterised by bolder and more drastic responses to the problem of livestock emissions. This might be due to the fact that the impact of livestock activities on climate change is particularly evident both in specific regional contexts, where local communities are clearly affected by the consequences of a changing climate, and at the global level. Indeed, given the intrinsically global nature of the phenomenon under scrutiny, a plethora of studies have been conducted and aggregated data on the general consequences of climate change on global ecosystems[10]. However, both local and international

[10] Reports produced at the UN level are particularly important on this regard. See, inter alia, IPCC, *Sixth Assessment Report – Synthesis Report* (2023).

approaches to addressing livestock governance present notable limitations. A localized perspective often leads to the identification of downstream solutions which, while hardly accepting to compromise on the health of directly affected communities and ecosystems, may fall short in addressing the upstream structural causes embedded in the global livestock production system. Conversely, adopting a global perspective enables the pursuit of upstream changes that could potentially reshape the foundations of global economic and political systems. Yet, a significant challenge for international action lies in the limitations of international law itself, particularly its relatively weak enforcement capacity.

Upstream solutions could be envisioned at the domestic level, particularly by most powerful states. In these cases, enforcement capacities are notably robust. Domestic action, however, also implies limits which are, mostly, of political nature. Indeed, the establishment of strong regulatory frameworks for the reduction of livestock emissions at the domestic level risk being unpopular. This is so because it might be costly in the short run, and may affect national population, whose general sensitivity to the detrimental impact of livestock activities could be relatively lower than in specific local contexts which are particularly affected by it. Furthermore, it is important to recognize that states differ significantly in their enforcement capacities, with some struggling to resist the pressures exerted by the growth-oriented global economic system as well as the interests of both private and state actors that it serves[11].

While the tension between establishing scientifically sound climate policies and the traditional functioning of representative democracies warrants further exploration, the role of the European Union (EU) in this context is particularly intriguing given its unique institutional nature and political mandate (Eckersley, 2020; Pickering *et al*., 2020; Mittiga, 2022; Lysaker, 2024). Indeed, while it is endowed with relatively strong enforcement powers[12], the EU is tasked to treat particularly technical dossiers. This obliges it, at least de jure, to adopt scientifically sound policies, with the consistency of its climate measures evaluated, inter alia, by the ESABCC.

Therefore, given its jurisdiction over a region that plays a crucial role in animal food systems, combined with its specific institutional nature, ambitious climate change mitigation obligations and robust enforcement mechanisms, the EU appears well-positioned to undertake a structural rethinking of livestock governance systems. This could enable the EU to drive a reduction in livestock emissions both within and beyond its borders by promoting the required transition in animal food systems. This transition would contrast sharply with the typically profit-driven and growth-oriented global economic system, aligning instead with scientific evidence, examined in the second section, that advocates for achieving mitigation of livestock emissions through reduced levels of animal food production and consumption.

Against the significant potential for the EU to mitigate livestock emissions, the scarce level of legal scholars' engagement on this issue results particularly glaring. The scarcity of legal research on the EU's mitigation of livestock emissions has been well noted, with only one of the identified works offering a general examination of the livestock governance framework. Even that analysis, however, remains incomplete, underscoring significant research gaps that require urgent attention. It is therefore essential for environmental legal scholars to explore the EU's potential to

[11] The global economic system is grounded in the paradigm of perpetual growth, with dominant environmental protection frameworks often resting on the scientifically unfunded assumption of green growth (Ward *et al*., 2016; Bookchin, 2017; Hickel & Kallis, 2019; Haberl *et al*., 2020; FreireGonzález *et al*., 2024). As a result, it may be particularly challenging, especially for relatively weaker states, whether low-income or high-income, to formulate and implement livestock emissions mitigation policies that are based on reducing livestock production and consumption.

[12] Both the European Commission and EU Member States (passing through the Commission), when they have considered that a Member State has failed to fulfil an obligation, may initiate an infringement procedure against the latter, and ultimately bring the case before the European Court of Justice (Treaty on the Functioning of the European Union, 1992, Arts. 258-260).

contribute to climate action by addressing emissions from the livestock sector.

5. Conclusion: launching a legal research agenda on the EU mitigation of livestock GHG emissions

Having observed that livestock emissions are on the rise at the global level, and that a distinction shall be made between high- and low-income countries when it comes to the identification of strategies for the mitigation of emissions, this article has firstly outlined the peculiarities of livestock contribution to climate change, both at the global and EU level. Afterwards, it endeavoured in a review of law scholarly literature entirely dedicated to the mitigation of livestock emissions.

First, this process highlighted the crucial role that the mitigation of livestock emissions must play in addressing climate change. As outlined in the second section, achieving both international and EU climate change mitigation obligations will require a significant reduction in livestock emissions. Second, the article synthesises the main features of legal research on the mitigation of livestock emissions, distinguishing among different geographical levels of analysis (*i.e.*, sub-national, national, regional, and international).

Third, the study has noted and expressed appreciation for legal scholars' adherence to scientific findings when proposing measures for the mitigation of livestock emissions. The second section of the article outlined that, according to scientific literature, it is not feasible to achieve absolute decoupling of livestock production and consumption from emissions. Correspondingly, all the proposed measures identified in the reviewed legal literature aim to reduce livestock emissions through a reduction in livestock consumption, production, or both.

Fourth, section §4 reflects upon the comprehensiveness of the approach adopted by legal scholars in addressing the mitigation of livestock emissions at different levels. As noticed, proposed actions are particularly bold both at the local and international level, with the problem of local actions being mainly downstream, and the problem of the international level lacking strong enforcement powers. While strong enforcement power exists at the national level, problems arise from the general unpopularity of policies aimed at reducing livestock, the varying enforcement capacities of different states, and the difficulty for smaller economies to oppose the growth-oriented pressures coming from the global economic system.

Importantly, section §4 also observed that the EU could be in a particularly privileged position to promote the required transition in animal food systems due to its unique institutional nature, strong enforcement capacities, and central role as a global player in animal food systems. Despite this, this research found that the potential for the EU to drive a transition in animal food systems, thereby promoting a reduction in animal food production and consumption levels and effectively mitigating livestock emissions, is not adequately reflected in scholarly literature. Research at the EU level is particularly limited, with no studies addressing both production- and consumption-side emissions, and very limited work providing a general examination of the livestock governance framework.

This article has therefore identified a significant gap concerning the scarcity of legal research conducted on the mitigation of livestock emissions at the EU level. While the very existence of this gap might prompt reflections on the reasons behind legal scholars' general disinterest in this crucial issue, addressing it is particularly important. This is the reason why this article finally proposes the establishment of a legal research agenda on the EU mitigation of livestock emissions. This agenda should not only aim to provide a comprehensive evaluation of the effectiveness of existing regulatory frameworks for the mitigation of livestock emissions but also explore pathways towards the sustainable transition of animal food systems. Such a transition should align with best available scientific knowledge, encompass both production and consumption side emissions, and consider a broad examination of the livestock governance framework. The legal research agenda on EU mitigation of livestock emissions could be grounded in four preliminary observations raised throughout this work, which provide both justification and guidance for its establishment.

Specifically, the first two observations highlight transitory issues (i.e., research and policy gaps) that need to be addressed. The latter two observations identify structural challenges that must not be overlooked by policymakers and legislators. Together, these insights form the foundation for a comprehensive research framework aimed at bridging existing gaps and addressing long-term structural needs.

The *first preliminary observation* is that the livestock sector has traditionally been neglected in climate change law and policy documents. Indeed, this insight, already raised in works which pre-existed this article, was underscored in the introductory section, and could constitute a point of departure for this new research agenda. Afterwards, the *second preliminary observation*, stands in the identification of a research gap in legal scholarship on the mitigation of livestock emissions at the EU level. Specifically, the systematic literature review has shed light on the complete lack of works focusing on both animal food production and consumption at the EU level, and shortage of works adopting a general examination of the livestock governance framework.

The *third preliminary observation* links a legal objective with relevant scientific findings, as it underscores that curbing livestock related GHG emissions will have a major role to play for the EU to meet international and regional climate change mitigation obligations. This observation basically constitutes the legal rationale justifying the establishment of this new research agenda, with evidence supporting it having been identified in the second section of this work. Lastly, the *fourth preliminary observation* highlights that, at the EU level, there is no possibility to decouple livestock production and consumption from GHG emissions. It follows that, while the third observation clarifies that reducing livestock emissions is crucial for the EU to meet its GHG mitigation commitments, the fourth observation indicates that curbing animal food production and consumption is essential to achieve this reduction. This last preliminary observation is based on purely scientific considerations. Importantly, as this study points out, the impossibility to reduce, in high-income countries, livestock GHG emissions without tackling production and consumption levels has already been acknowledged in all scrutinized legal works. Accordingly, this insight should be explicitly recognized in the research agenda on the EU mitigation of livestock emissions, and it should constitute the underlying ontology of any regulatory framework aimed at mitigating livestock emissions.

In conclusion, developing a robust research agenda based on these preliminary observations can address the existing research gap on EU mitigation of livestock emissions. This will facilitate more focused engagement from scholars, policymakers, and the public on this critical issue, offering valuable insights for establishing regulatory frameworks that effectively contribute to achieving climate change mitigation obligations.

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