

## EXPLORING THE IMPACT OF CLIMATE CHANGE ON THE ASSOCIATIVE STRUCTURES OF ROMANIAN AGRICULTURE: A PROSPECTIVE APPROACH TOWARDS ACHIEVING SUSTAINABILITY

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### Abstract

*This study aims to examine the probable consequences of climate change on the interrelated systems of agriculture in Romania, specifically focusing on the domain of animal husbandry. The increase in carbon and methane emissions, together with the consequent alterations in the climate system, have presented challenges in establishing and maintaining public-private partnerships within the corporate sector. The main objective of this study is to investigate the significance of collaboration between public and private entities in mitigating the effects of climate change on animal husbandry using a forward-looking methodology. From 2007 to 2020, Romania's agri-food waste management business was found to have the highest methane emissions. The mean emissions of the agri-food sector in Romania amounted to 130.46 kt, with a 4.45% increase in methane emissions seen between 2007 and 2020. The aforementioned statement underscores the necessity for partnerships between public and commercial entities in leveraging resources and technologies to advance sustainable practices and mitigate methane emissions. Promoting a sustainable agricultural framework necessitates the implementation of sustainable legislation, the adoption of suitable waste management practices, and the progression of technological developments. This paper highlights the significance of adopting a collaborative approach to attain sustainability within Romania's agricultural sector, while taking into account the obstacles presented by climate change.*

**Keywords:** climate change, associative structures, agri-food sector, sustainable development.

**DOI:** 10.24818/CAFEE/2023/12/04

## **Introduction**

The occurrence of climate change phenomena has garnered substantial interest from the global population in recent years, resulting in important implications for both the natural environment and human civilization. This particular scenario poses a noteworthy obstacle within the context of the public-private partnership, since it has the capacity to directly impact the availability of water resources and animal feed. The hazards linked to climate change might pose substantial challenges in terms of the establishment and upkeep of animals in ideal circumstances, hence resulting in adverse outcomes for both the private sector and society at large (Elliott et al., 2014). The rise in greenhouse gas emissions, particularly carbon dioxide, resulting from human activities such as industrial production and transportation, is a significant driver of climate change.

The emissions in question are known to be a contributing factor to the phenomenon of global warming, which in turn leads to substantial alterations in the climate system (Scown & Nicholas, 2020). These alterations include the escalation of average temperatures, modifications in patterns of precipitation, and the elevation of sea levels. The alterations in the environment exert a direct influence on essential natural resources, namely water and feed, which play a crucial role in supporting the development and upkeep of cattle in agricultural settings and households (Gil et al., 2019). The accessibility of water resources plays a pivotal role in the success of the livestock industry. Insufficient water availability can have detrimental effects on animal well-being, resulting in reduced milk and meat output. Moreover, the phenomenon of global warming and climate change have the capacity to exert an influence on the characteristics of water resources, both in terms of their quality and quantity (Vu et al., 2020). This is accomplished through the amplification of evaporation rates and the reduction of precipitation levels. This scenario has the potential to result in escalated expenditures related to the acquisition and retention of water, so exerting an adverse influence on the financial viability of cattle farming. Furthermore, the phenomenon of climate change can potentially exert an impact on the accessibility of food resources for wildlife (Thomas et al., 2021).

Droughts and floods have the potential to inflict harm upon crops, resulting in diminished agricultural output and subsequently leading to a decrease in the accessibility of animal feed. This scenario has the potential to result in elevated food expenses, hence exerting adverse effects on the long-term viability of agricultural operations and households that depend on animal husbandry as a source of livelihood. Climate change poses a multitude of threats that are extensive in scope and involve a wide range of factors that can impact the accessibility of water and food resources for wildlife (Agbedahin, 2019). The presence of fluctuations in temperature and precipitation can exert an influence on the geographical distribution, abundance, developmental stage, and accessibility of plant species that are crucial for sustaining animal feed requirements.

Furthermore, it is highly probable that climate change may induce modifications in the prevailing conditions that impact irrigation and soil fertility, thus exerting an influence on the output of game, pasture, and other livestock (Fader et al., 2018). Furthermore, it is important to acknowledge the presence of threats related to climate change when assessing the effectiveness of animal production. An illustrative instance can be observed in the impact of climate change on the developmental pace of animals, perhaps necessitating a broader temporal framework and more resources from producers in order to achieve desired outcomes (Thomas et al., 2021). Furthermore, the introduction of novel plant and animal species to unfamiliar environments, as well as alterations in temperature patterns, can give rise to undesirable competitive dynamics, so adversely impacting the ecological functioning of both fauna and flora. The mitigation of these hazards can be achieved by the implementation of a

public-private partnership that fosters the interchange of knowledge and research (Baquedano et al., 2022). This collaboration aims to enhance the understanding of climate change and explore potential solutions to establish and sustain optimal living conditions for animal populations (Faichuk et al., 2022).

This form of partnership can additionally foster the exchange of knowledge and recommendations pertaining to the implementation of preventive measures aimed at mitigating the risks linked to climate change, including climate change adaptation and enhancing the system's capacity to withstand emerging threats (Bryan et al., 2015). Furthermore, this collaboration has the potential to enhance producers' ability to get financial resources and cutting-edge technologies, thereby enabling them to effectively address and mitigate the adverse impacts of climate change on their producing activities. The phenomenon of climate change presents a significant challenge to the sustainability of the public-private partnership in the domain of animal husbandry, primarily due to its adverse impact on the accessibility and adequacy of water and feed resources (Valenti et al., 2018). It is imperative to acknowledge and mitigate these risks by implementing sustainable policies and practises that are geared towards the reduction of greenhouse gas emissions and preservation of natural resources. Furthermore, the synergistic partnership between public and private sector entities can yield substantial outcomes in advancing sustainable practises and facilitating climate change adaptation (Constantin et al., 2021; Jantke et al., 2020; Lyeonov et al., 2019).

## **1. Materials and Methods**

This article examines the quantity of methane (CH<sub>4</sub>) emissions generated by the agricultural and veterinary industries in Romania, as well as the 27 member states of the European Union. The aforementioned data was acquired through a diverse range of information sources, encompassing official publications issued by European organisations, online databases, and scholarly investigations. In order to determine the quantity of methane (CH<sub>4</sub>) emissions originating from the agricultural sector within the 27 member states of the European Union, data spanning from 2010 to 2019 were gathered from the European Commission's Joint Research Centre (JRC) and the European Institute of Statistics (Eurostat). Data from the previous decade were utilised in order to provide a more comprehensive outlook and discern patterns of growth. Data were collected on crop output (measured in tonnes), total area of agricultural land (measured in hectares), and methane emissions (measured in kt) for each country inside the European Union (Bojnec & Fertő, 2019). The aforementioned statistics were utilised in the computation of the methane emissions-to-crop output ratio, as well as the methane emissions-to-total agricultural land area ratio.

In order to examine the quantity of methane emissions generated by the livestock industry in Romania, official data provided by the Ministry of Agriculture and Rural Development were utilised. The dataset encompassed details pertaining to the many categories of livestock reared, such as cattle, sheep, pigs, birds, and others. It also encompassed the aggregate population of animals within each category, as well as the corresponding quantities of methane emitted by these animals. The researchers utilised data from the time span of 2015 to 2019, as it represented the most current information available during the investigation. Methane emissions (in kilotons) were computed for each livestock type by employing conversion constants that are specific to each respective category. This facilitated a more comprehensive examination of the influence of each category on overall emissions. In order to conduct a study on the quantity of methane (CH<sub>4</sub>) emissions produced by various activities within the agri-food industry in Romania, data from the Environmental Protection Agency, reports from the Institute of Statistics, and prior scholarly research were utilised. The primary

sources of methane emissions in the agri-food sector have been identified as agriculture, animal husbandry, biological waste storage, and food processing. Data regarding the quantity of methane generated was gathered for each individual activity, and further calculations were performed to determine the cumulative emissions in kilotons (kt). The aforementioned data were utilised for the purpose of identifying the principal sources of emissions within the agricultural sector. Statistical software, such as Microsoft Excel, was utilised to process the data and conduct the requisite computations for all three analyses.

Furthermore, a comparative analysis was conducted between our collected data and the findings of other contemporary studies (Council of the European Union, 1987). Additionally, a broader range of information sources were consulted to validate and corroborate the obtained results. The data that was gathered and examined in this particular area has facilitated the generation of dependable and pertinent findings concerning methane emissions within the agriculture industry of both the European Union and Romania. Moreover, the methodologies and strategies employed in this research can be applied in subsequent investigations to effectively monitor and assess the progression of methane emissions from agricultural and animal activities. Furthermore, by the implementation of a thorough examination, we successfully discerned pivotal elements that lead to the release of methane in the agricultural domain.

The factors encompassed in this analysis consist of the population of animals, practises related to feed management, and systems employed for managing manure. Through a comprehensive understanding of these aspects, policymakers and stakeholders can formulate precise strategies aimed at mitigating methane emissions and minimising the environmental repercussions associated with agricultural practises. Moreover, the results obtained from this investigation can establish a fundamental reference point for forthcoming scholarly inquiries and surveillance endeavours. Consequently, this will enable a more precise evaluation of advancements made in mitigating methane emissions within the agricultural domain.

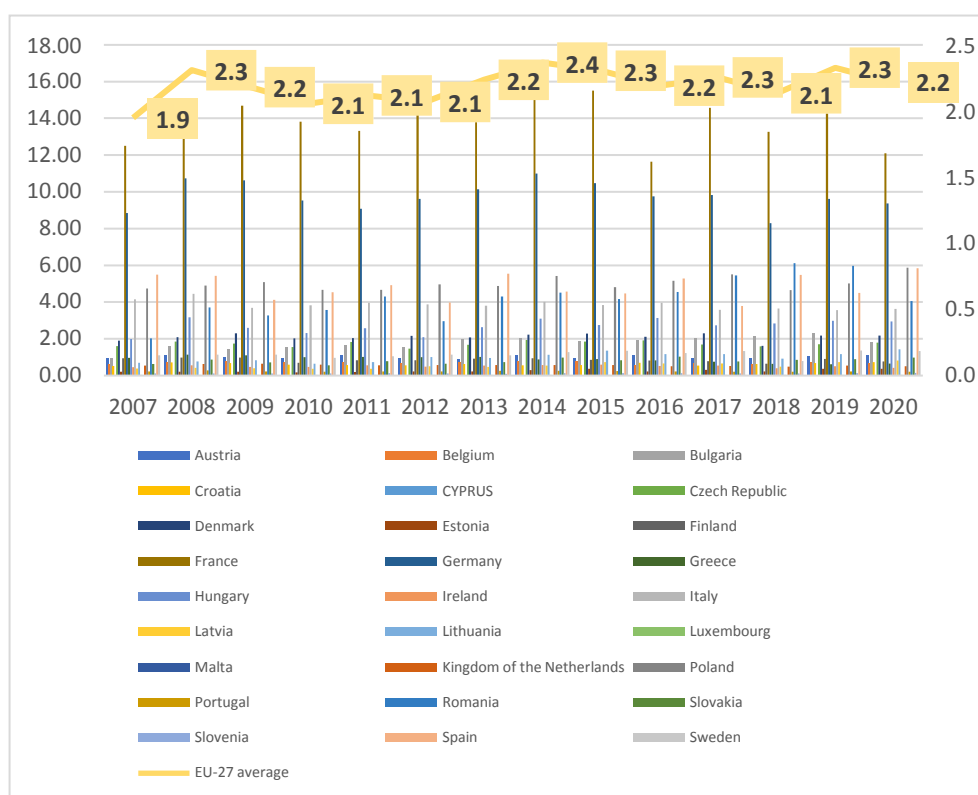
## **2. Results and Discussion**

The release of methane gas plays a substantial role in the occurrence of global climate change, and the agricultural industry has been recognized as a key factor in the generation of these emissions. It is essential to recognize that avoiding a comprehensive assessment of the methane emissions stemming from various agricultural sectors is not viable (Mekonnen & Hoekstra, 2012). The development of effective policies and initiatives to reduce methane emissions is of utmost importance due to their detrimental environmental impacts and contribution to global climate change (Istudor et al., 2019).

Moreover, the significance of mitigating methane emissions within the agriculture industry extends beyond solely its environmental consequences. Unchecked methane emissions can potentially result in significant economic and social implications. As an illustration, the release of methane from cattle production has the potential to engender heightened health hazards for both animal and human populations, with the detriment to infrastructure and property. Moreover, the emission of methane can significantly contribute to the degradation of air quality, hence exacerbating respiratory ailments and other health concerns among communities residing in close proximity to agricultural facilities. Hence, the identification of efficacious strategies for minimizing methane emissions in the agricultural sector is imperative, as it serves the dual purpose of addressing climate change and protecting public health. Graphical data in Figure 1 illustrates the cumulative methane (CH<sub>4</sub>) emissions generated by the plant sector across EU Member States, denoted in kilotons (kt). The dissemination of this data offers fundamental insights and facilitates the comprehension of their dispersion across the European bloc. This enables the comparative analysis of methane

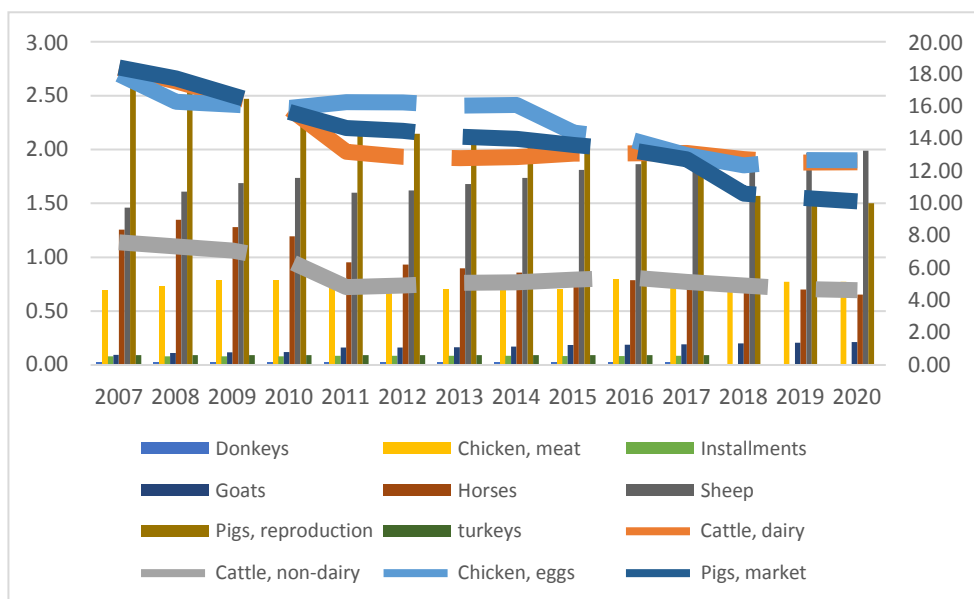
emissions among different countries, thereby facilitating the identification of both the highest and lowest emitting nations.

Consequently, this information serves as a foundation for devising and executing cost-effective and efficient strategies to manage methane emissions throughout the European Union region. Based on the data analysis, it can be observed that France occupies the leading position in terms of its contribution to the indicator of greenhouse gas emissions stemming from agricultural activities, particularly within the vegetable sector. The mean quantity of methane released, as determined with respect to the reference year of the analysis, is 13.89 kilotons, spanning the time period from 2007 to 2020. Germany is positioned in the second place, with a total of 9.78 kilotons of methane emissions. Poland ranks third in terms of methane emissions, with a recorded value of 5.02 kt, while Spain occupies the fourth position with 4.85 kt of methane emissions. Romania occupies the lowest position in the ranking, exhibiting a methane emission quantity of 4.21 kt within the vegetable sector.



**Figure 1. Graphic representation of the amount of Emissions (CH<sub>4</sub>) produced by the plant sector in the 27 member states of the European Union (Kilotones (kt)).**

*Source: Author's processing based on data available on the Food and Agriculture Organization of the United Nations (FAO) platform, 2023  
(<https://www.fao.org/faostat/en/#data/GA>)*



**Figure 2. Graphical representation of the amount of Emissions (CH<sub>4</sub>) produced by the livestock sector in Romania, by category of animal husbandry (Kilotones (kt)).**

*Source: Author's processing based on data available on the Food and Agriculture Organization of the United Nations (FAO) platform, 2023 (<https://www.fao.org/faostat/en/#data/GA>)*

Figure 2 illustrates the quantification of methane emissions (CH<sub>4</sub>) in kilotons (kt) attributed to animal husbandry practises in Romania, specifically focusing on the period spanning from 2007 to 2020. The data presented in the figure is categorised according to different sectors. The generation of greenhouse gas emissions in the livestock business is mostly attributed to three primary sectors: the production of eggs from chicken farming, the dairy output from cattle farming, and the selling of pigs on the open market.

The average methane emissions resulting from the production of eggs from chicken farming were seen to be the greatest, with a value of 14.99 kt. In comparison, the dairy industry and the free-market pig sector exhibited lower average methane emissions of 14.08 kt and 14.03 kt, respectively. The primary source of methane emissions, throughout the period of 2007-2020, is attributed to the poultry industry's egg production sector, which recorded an average emission level of 14.99 kt. In the aforementioned time, the milk production sector and the pig farming sector, both targeted for commercialization on the open market, exhibit a close proximity in terms of methane emissions. The estimated methane emissions for the milk production sector stand at roughly 14.08 kt, while the pig farming sector is anticipated to emit around 14.03 kt.

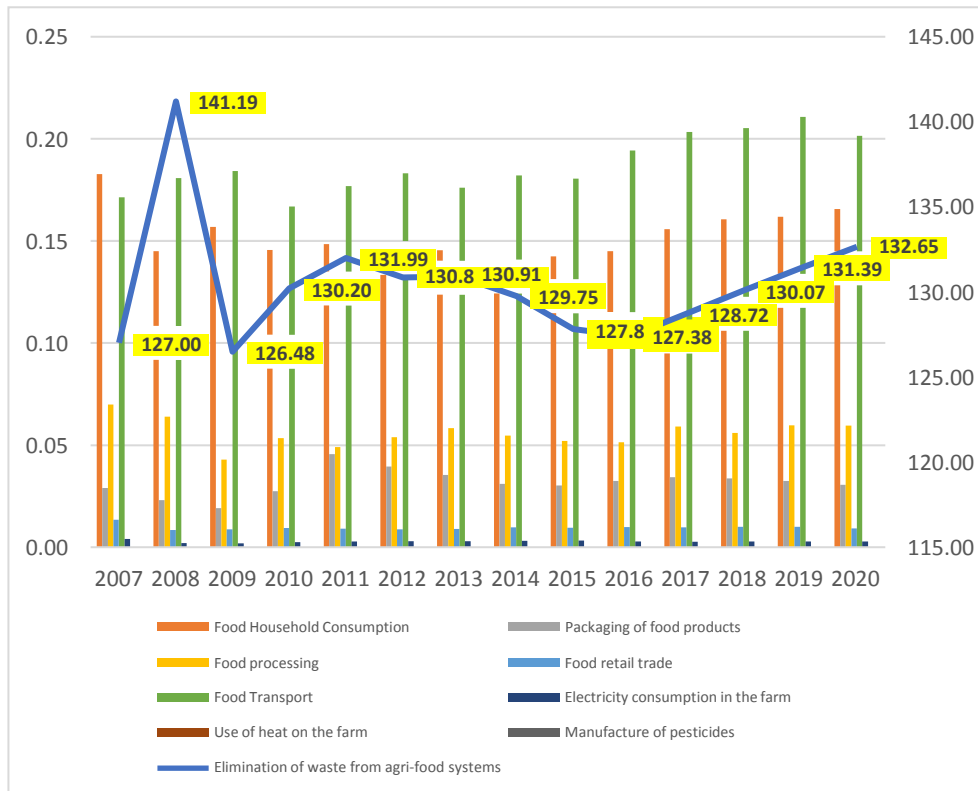
Nevertheless, it is crucial to acknowledge that the domain of poultry farming specifically dedicated to egg production exhibits a notable distinction by presenting substantially reduced methane emissions. In fact, there was a noteworthy 32% decline in methane emissions seen in this sector throughout the period spanning from 2007 to 2020. The decrease in emissions within the poultry industry can be attributed to the adoption of sustainable practises that ensure the well-being of animals and mitigate environmental consequences. Therefore, producers have embraced enhanced chicken feeding methodologies, enhanced living

conditions, and deployed waste control technologies. By implementing these strategies, the poultry business has successfully mitigated methane emissions, so contributing to environmental preservation and fostering sustainability within the grill sector. The dairy cattle industry was the second largest contributor to greenhouse gas emissions, generating an average of 14.08 kilotons. However, there was a significant decrease of approximately 30% in methane emissions from this sector compared to the year 2007. The pig breeding sector, which is primarily focused on commercial transactions, ranks third among sectors in terms of its contribution to greenhouse gas emissions.

Over the analysed period, the average emissions from this sector amounted to 14.03 kt. Notably, this sector experienced the most significant reduction in methane emissions, with a decrease of approximately 45% in 2020 compared to 2007. The notable decline in methane emissions within the commercial pig breeding sector can be ascribed to the adoption of sustainable practises in the business, with the aim of facilitating market commercialization. In recent years, farmers have adopted sophisticated technologies and enhanced the management of animal waste, resulting in a reduction in the ecological footprint. Furthermore, supplementary strategies have been employed to oversee and control methane emissions in swine facilities. These activities have yielded positive outcomes, so contributing to environmental preservation and mitigating the sector's impact on climate change. Moving forward, it is imperative that the pork sector maintains its commitment to investing in sustainable technology and practises.

This is necessary to sustain the ongoing decline in methane emissions and to safeguard the overall well-being of animals reared on pig farms. Furthermore, it is imperative for governments to allocate financial resources and formulate regulations that foster the widespread adoption of these environmentally beneficial technology. The conducted investigation revealed that Romania experienced emissions of methane, a greenhouse gas, as a result of cattle product production from 2007 to 2020. The primary contributors to these emissions were the poultry industry for egg production, the cattle industry for milk production, and the free market for pig production. Encouragingly, a notable decline in emissions has been seen, particularly in the poultry sector (32%) and the cattle sector (30%). During this period, there was a huge decrease of 45% in pig production. The observed declines can be ascribed to the adoption of sustainable practises as well as advancements in technology. Given this consideration, it is imperative that the pig industry derives comparable advantages and allocates resources towards research and development in order to establish environmental effect monitoring systems, employ renewable energy sources, and embrace sustainable farming practises.

Public-private partnerships (PPPs) have the potential to significantly contribute to the promotion of these changes. They can facilitate the linkage between potential foreign investors and offer resources such as funding and grants that are pertinent to the advancement of renewable energy projects and the adoption of sustainable agricultural practises. Additionally, the utilisation of public-private partnerships has the potential to facilitate the advancement of essential legislative modifications within the sector, while also fostering a conducive atmosphere for foreign investments. Through the facilitation of investor-authority connections and the provision of pertinent agreements and grants, the partnership possesses the capacity to significantly expedite the shift towards a sustainable energy and agricultural framework.



**Figure 3. Graphic representation of the amount of Emissions (CH<sub>4</sub>) generated by the types of activities in the agri-food sector in Romania (Kilotones (kt)).**

*Source: Author's processing based on data available on the Food and Agriculture Organization of the United Nations (FAO) platform, 2023 (<https://www.fao.org/faostat/en/#data/GA>)*

The combined vegetable and livestock sectors make a substantial contribution to greenhouse gas emissions, mostly because to the significant release of methane. Nevertheless, it is worth noting that the agri-food waste management industry has exhibited the biggest magnitude of methane emissions from 2007 to 2020. The agri-food sector in Romania exhibited an average emissions level of 130.46 kt, with a notable increase of 4.45% in methane production in 2020 compared to 2007. This information is depicted in Figure 3, which presents the kiloton measurements of methane emissions (CH<sub>4</sub>) generated by the agri-food sector in Romania. This finding suggests a notable rise in methane emissions within the agriculture industry throughout the previous 13-year period. The observed trend is cause for concern due to the fact that methane possesses a far higher potency as a greenhouse gas compared to carbon dioxide, hence exacerbating the issue of climate change. Finding sustainable methods to reduce methane emissions and mitigate environmental damage is of utmost importance for the agriculture business. The reduction of methane emissions can be achieved by the implementation of enhanced waste management practises and irrigation systems, the utilisation of sophisticated technologies in agricultural production, and the promotion of ecologically sustainable farming methods. Furthermore, the dissemination of knowledge and the cultivation of awareness among farmers regarding the adverse consequences of methane



emissions can significantly contribute to the successful implementation of these strategies and the establishment of an environmentally sustainable agricultural ecosystem. In order to mitigate the hazards associated with pollution and methane emissions, the establishment of a collaborative effort between public and private entities is crucial. This partnership serves the purpose of facilitating the adoption of effective waste management practises, as well as establishing clear objectives and performance indicators through the implementation of monitoring programmes.

Ultimately, this collaborative approach plays a significant role in the development and execution of an appropriate waste management strategy. To mitigate the methane emissions generated by the agri-food sector, diverse strategies for collaboration between the public and commercial sectors have been devised and put into practise. These partnerships encompass collaborations wherein the public and private sectors assume complementary responsibilities to collectively pursue a specific common purpose, such as the mitigation of greenhouse gas emissions. The concept of public-private partnership refers to the collaborative efforts between public authorities and the private sector, either domestically or internationally, to effectively implement, monitor, and evaluate policies and programmes with the objective of mitigating greenhouse gas emissions.

### **Conclusions**

The phenomenon of climate change presents substantial obstacles to the establishment and maintenance of public-private partnerships within the domain of animal husbandry. Climate change has a direct influence on the accessibility and calibre of water supplies and animal feed, resulting in unfavourable consequences for both the private sector and society at large. The increase in emissions of greenhouse gases, specifically carbon dioxide, is a significant catalyst for climate change, leading to modifications in the climate system, including elevated temperatures, shifts in precipitation patterns, and the escalation of sea levels. The alterations have a direct impact on water resources and the availability of food for wildlife, resulting in decreased productivity and heightened costs for the cattle sector. Climate change has a significant impact on the distribution and availability of plant species that are essential for animal feed, as well as the developmental rate of animals. In order to address these potential hazards, it is imperative to establish a collaborative alliance between public and private entities.

This cooperation would serve to bolster the acquisition of knowledge, facilitate research endeavours, and effectively implement proactive measures aimed at prevention. This collaboration has the potential to offer financial resources and state-of-the-art technologies to effectively address and alleviate the detrimental consequences of climate change. The implementation of sustainable policies and practises, in conjunction with the collaboration between the public and private sectors, plays a pivotal role in ensuring the long-term viability of animal husbandry among the challenges posed by climate change. The essay emphasises the substantial impact of methane emissions on global climate change, with a specific focus on the agriculture sector. The statement underscores the importance of conducting thorough evaluations and implementing efficient strategies to mitigate the release of methane, given its significant environmental and economic consequences.

The presented document offers empirical evidence on methane emissions within the vegetable and animal sectors in Romania. The data reveals a notable decrease in emissions within the poultry and cattle businesses, while conversely indicating an upward trend in methane emissions within the agri-food waste management sector. The proposition posits that the implementation of sustainable practises, improvements in technology, and collaborations between public and private entities are crucial in mitigating methane emissions

and fostering a sustainable agricultural framework. Furthermore, it underscores the significance of effective waste management, efficient irrigation systems, and heightened knowledge among farmers in order to decrease methane emissions and develop an agricultural ecosystem that is environmentally sustainable. Farmers have the ability to reduce the utilisation of chemical fertilisers and pesticides, which are significant contributors to methane emissions, by using sustainable practises such as organic farming and crop rotation. Furthermore, the use of technological innovations, such as precision agriculture and smart irrigation systems, has the potential to mitigate water inefficiency, thus leading to a reduction in methane emissions originating from flooded rice paddies.

The establishment of partnerships between public and private institutions can effectively allow the exchange of valuable knowledge and research findings, thereby empowering farmers to make well-informed decisions and successfully implement sustainable solutions. In order to establish a sustainable agricultural framework, it is imperative to engage in a collaborative endeavour that places utmost importance on environmental stewardship and guarantees the enduring sustainability of our food production systems.

### **Acknowledgement**

This paper is a result of the research project entitled "Research on the institutional capacity of the public-private partnership to participate actively in the performance of agriculture in terms of yield, economy, social and environment/ ADER Code 22.1.1." (Cercetări privind capacitatea instituțională a parteneriatului public privat de a participa active la performarea agriculturii în plan randamental, economic, social și de mediu / cod ADER 22.1.1.). This paper was co-financed by The Bucharest University of Economic Studies during the PhD program.

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