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IMPLEMENTATION OF AGRICULTURAL INNOVATION TO CONFIRM CLIMATE NEUTRALITY AND RELATED ISSUES

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Abstract. The European Union (EU) and its Member States have set themselves the goal of achieving climate neutrality throughout the EU by 2050. The agricultural sector is one of the emitters of greenhouse gases. To meet its climate neutrality targets of reducing global temperature rise to below 2°C and limiting it to 1.5°C, the EU has adopted the Green Deal and the Farm to Fork strategy based on it. The set goals create the need to develop and implement new innovations. The agricultural sector will face a number of innovative approaches in the future, including the digitalization of agriculture and the use of biotechnology, expertise from microbiology. The agricultural sector will face significant changes in farming methods. The aim of the study is to explore agricultural innovations to promote climate neutrality, the tasks are to assess the differences in the definition of innovation, the problems of their implementation and the challenges in agricultural crop production and to identify the current situation in Latvian agriculture compared to Lithuania and Estonia in terms of greenhouse gas emissions (GHG) emissions. The share of GHG generated by agricultural sector in Latvia is relatively high compared to the EU average. Among the Baltic States, the share of Latvia's GHG emissions in Latvia is almost 20%, which is higher than in Estonia, but lower than the GHG emissions generated by the Lithuanian agricultural sector. According to Food and Agriculture Organization (FAO) data, the Lithuanian government has invested the most in agriculture compared to Estonia and Latvia. Investments of Latvian and Estonian governments in agriculture can be assessed as similar.

Keywords: Green Deal, climate change, agriculture, innovations in agriculture, innovative products.

JEL code: Q16, Q57

Introduction

Global climate change and deteriorating environmental conditions have become an existential threat to Europe and the world. To overcome these threats, the EU has launched the European Green Course, a development strategy aimed at transforming the EU into a competitive, accessible and sustainable economy. The European Green Course, launched at the end of 2019, sets out the expected action plan to achieve carbon neutrality, resource efficiency and zero pollution in the EU by 2050 (Johnson et al., 2021).

The EU's Green Course is the programmatic presentation of the European Commission's strategy to implement the United Nations (UN) agenda 2030 (Cortignani et al., 2021). The UN's ambitious climate protection targets are at the heart of the European Green Course and are in line with the EU's commitment to global climate action under the Paris Agreement to protect global temperature increase below 2° C and limit them to 1.5° C (Rowan & Pogue, 2021).

The main task of the Green Course is to ensure a common framework for environmental policy in the EU in order to achieve carbon neutrality by 2050. Integrating existing policies and exploiting potential technology synergies and trade-offs is needed to address all the objectives of the EU Green Course to address complex and interconnected environmental, economic and societal challenges. The main priority of the green course is the restoration of the soil and aquatic environment. The green course will also affect agricultural production, which is considered to be a major source of air, water and soil pollution, contributing to biodiversity loss and contributing to climate change and overexploitation of natural resources (Bieroza et al., 2021).

To meet the targets set as soon as possible and reduce the differences in emissions, the European Green Course has set ambitious net emissions targets for 2050. These commitments aim to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels (Rivas et al., 2021). The ambition of the

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Green Course is to make the EU the world's first climate-neutral continent by 2050, combining ambitious climate action with economic growth and prosperity (Dolge & Blumberga, 2021).

To ensure a sustainable transition to the agricultural sector and the implementation of the objectives of the green regime, a farm-to-table strategy has been launched and a revised Common Agricultural Policy will be introduced in 2023. Negative effects of the agricultural product on the climate and the environment within the framework of the "Farm to Fork" strategy. Consequently, this strategy aims to improve both the health of the population and the environment by moving towards sustainable food systems. The strategy aims to reduce the use of pesticides and antibiotics by 50% and to reduce nutrient losses by 50% by year 2030, leading to a reduction in fertilizer use of at least 20%. Each Member State will develop an integrated nutrient management action plan setting out what nutrient load reductions are needed to achieve the objectives of this strategy (European Commission, 2020).

The **aim** of the study is to explore agricultural innovations to promote climate neutrality. Accordingly, the **tasks** are as follows: to assess the differences in the definition of innovation, the problems of their implementation and the challenges in agricultural crop production and to identify the current situation in Latvian agriculture compared to Lithuania and Estonia in terms of GHG emissions and find out what the amount of investment of the Latvian government in agriculture has been in comparison with other Baltic states.

Materials and methods

The monographic or descriptive method, the graphic method and the logically constructive method have been used in the formation of this article.

Theoretical explanation of the concept of "innovation"

Innovation is an idea, process or object created by individuals or organizations. The development of an innovation is to improve a product or entity and to improve the quality of a procedure or product. However, implementing innovation is always seen as a difficult task. Dissemination of innovation is the process by which stakeholders are informed about new products, technologies or innovative techniques through various communication channels (Nordin et al., 2014).

The term "innovation" refers to both the process and the achievement of results. For this reason, society is no longer satisfied with the mere creation of knowledge as a result of various research projects; society demands that this knowledge be put into practice to create or deliver value or foster the emergence of new knowledge to promote the development of new technologies. The concept of innovation requires clarifying and understanding the perceptions and development dynamics of different actors, as each innovation process influences the behaviour of other players in diverse and changing aspects. Over time, theoretical approaches to the study of innovation have changed, from relatively simple and linear approaches to complex processes that already study innovation systems involving a growing number of stakeholders in agriculture (Barrantes & Yague, 2015).

Innovation can be seen as the development of new products or services; the development of alternative business models and strategies; the creation of new knowledge; and/or the development of alternative modes of supply. Innovation in this study is understood as new products, new services and new technologies/processes. Product and service innovation is seen as introducing new products or services to meet user requirements and market needs. It is seen as a new production process and new technologies to increase revenue. This innovation is identified as a change in the final product that needs to be continuously improved and renewed to ensure that the product is on the market. Process innovation is the

transformation of new elements in a process and operation, such as creating material or new instrumentation, that results in a change in the company's products and / or services and their production methods (Ho et al., 2018).

The task of innovation system design is to clarify and understand the relationship between manufacturers, users, governments and authorities. In this cognitive process, problems are identified, and solutions are jointly sought and created in a collective cognitive process that involves the mutual interchange of knowledge. Therefore, in modern innovation theory, innovation is based not only on discovering but also on collaboration and interactive learning among members in the innovation system (such as farmers, researchers and intermediaries). However, learning does not always involve the discovery of new technical or scientific principles, it can also be based on activities that transform or adapt existent ability (Fieldsend et al., 2020).

In order to implement the EU's vision of an EU-wide innovation engagement strategy and to involve all stakeholders, including EU partner institutions, national parliaments, the business sector, non-governmental organizations, cities, communities and citizens across Europe, it is vital to create and involve Triple Helix innovation centres – academic personnel, industry and government (Rowan & Pogue, 2021).

In order to achieve the country's strategic, innovation-based development goals, it is necessary to significantly promote the implementation of agricultural scientific and technological innovations by promoting agricultural development through efficient production, product safety, natural resource economy and environmentally-friendly improvements (Xu et al., 2017).

Innovation in agriculture

Achieving the strategic goals and needs of the EU Green Deal requires significant innovation and change. The term "revolutionary innovation" refers to technologies and changes that are not always associated with the transformation of green and environmentally friendly technologies or large-scale energy systems. Achieving the ambitions set out in the Green Deal will require significant social, economic and also industrial change, which can only be brought about by revolutionary innovation. The development of innovation, as well as the public transfer of knowledge, is vital to promote the development of environmentally friendly solutions to complex environmental issues, the search for alternatives to metallic nanomaterials, or the creation of ecologically friendly biocides or disinfectants (Rowan & Pogue, 2021).

Changes in agricultural systems and the associated fundamental reorganization of the food system have taken place over several decades. The challenges of the Green Deal require that farming systems become "mission-oriented", given their link to sustainable food systems in the future. These changes and related innovations will be forced to address significant societal and global challenges, such as ecosystem integrity, biodiversity, climate change mitigation and adaptation (Klerkx & Begemann, 2020).

Agricultural innovation is a complex process influenced by many factors (Kebede & Zizzo, 2015). On a larger scale, the challenges of agriculture and land use are still perceived as unclear and complex and are encountered at various levels, from the field, the territory, and finally, to the global food chains. Essential examples are the unsustainable management of agricultural land, which contributes to soil degradation and other harmful effects on the environment related to the impacts of climate change on agriculture, or to maintain the sustainability of rural areas in times of rapid economic, demographic and technological change (Turner et al., 2017). The agricultural sector is not considered to be a typical field of research for scientists. Entrepreneurship and innovation researchers are considered to have a long tradition of focusing on new technology sectors, research into new technologies, analysis of innovative service companies and also

entrepreneurs. It should be noted that most research related to agriculture tends to study the benefits of production rather than innovation (Barth et al., 2021).

The objectives of the Green Deal and the Strategy "Farm to Fork" require agriculture to find effective solutions to preserve both the environment and the sustainability of agriculture, as well as productivity, in order to provide food and agricultural products for the EU as a whole and for each EU Member State individually. There are currently two possible solutions: the digitalization of agriculture and the use of biotechnology.

It is widely believed that digital agriculture will be a revolution that will bring about a gradual change in the economy. Digital agriculture is expected to improve efficiency and sustainability, as well as the much-needed increase in regional and social well-being. It is widely believed that technological innovation is an important way of tackling societal challenges, from employment in rural areas to global climate change. However, digital agriculture can also have negative consequences. The social and ethical implications of introducing digital agriculture must be considered. As agriculture moves towards the "implementation" of the digital revolution, attention must be paid to the indirect effects on farmers and communities (identities, job roles, workforce) (Fleming & Mauger, 2021).

As an alternative view, biotechnological innovation could reduce the risk of organic farming due to yield differences from integrated or organic farming methods. Modern biotechnology focuses on changes in the deoxyribonucleic acid (DNA) of plant cells. These changes are used to increase plant productivity and provide resistance to various diseases. Crops are constantly exposed to pathogens and pests. Biotechnological solutions are one way of protecting plants, as the use of synthetic pesticides in organic farming is prohibited. The risk of pest damage is exceptionally high in tropical climates, which favour the rapid spread of pathogens and plant pests. Pest prevalence is expected to continue to increase. If current prevalence trends driven by climate change continue, the areas of many crop-producing countries will be completely saturated with pests and pathogens by 050. It should be noted that some of the methods used in organic farming to control crop losses are said to have questionable effects on consumer health and the environment. Approaches to genome editing could have a rapid and positive impact on the persistence of pests and diseases in crops without adversely affecting the environment and health; in other words, they could achieve agricultural objectives that would encourage the contribution of organic farming (Purnhagen et al., 2021).

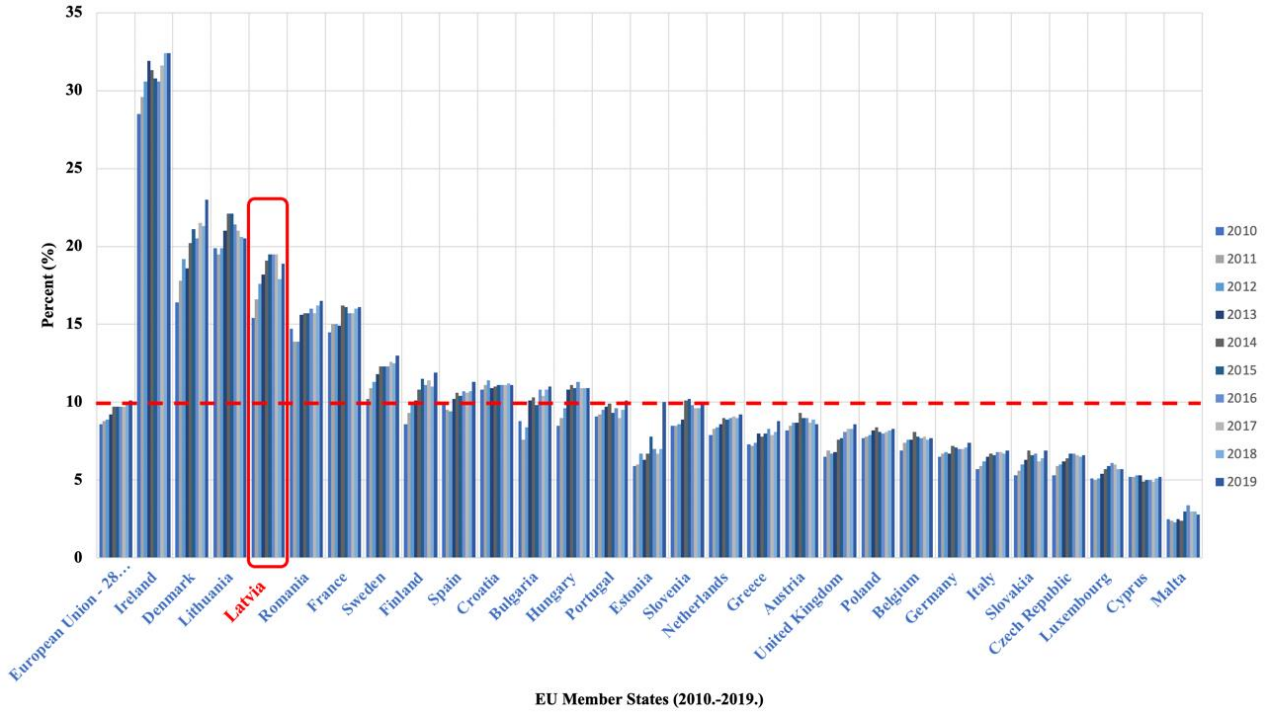
The use of biotechnology is also encouraged by adopting the Fertilizer Circulation Regulation (Regulation (EU) 2019/1009), which was the first piece of legislation in the EU's circular economy package. The fertilizer industry is based on several essential principles. One of the basic principles of the circular economy is the introduction of alternative fertilizers, minimizing the use of chemical fertilizers and replacing them with hitherto unused biomass, such as crop residues from livestock and slaughterhouse residues or food processing residues (Chojnacka et al., 2020).

Food and agricultural biotechnology is linked to technologies and innovations aimed at improving plants, animals and micro-organisms, as well as their cultivation, processing and use, with a view to increasing their economic, social and health value. The biotechnology sector includes a wide range of innovations, including new technologies that are being used in response to changing consumer demands for food production and consumption, food security and preventive health care for humans and animals, food security (Dahabieh et al., 2018).

Proportion of GHG emissions from the agricultural sector and investment in the sector

One of the biggest challenges for Latvian agriculture in the framework of the Green Deal and the "Farm to Fork" strategy will be to reduce greenhouse gas emissions. In order to understand which steps need to be taken to achieve this goal, it is necessary to look at the situation in Latvia in comparison with other EU countries.

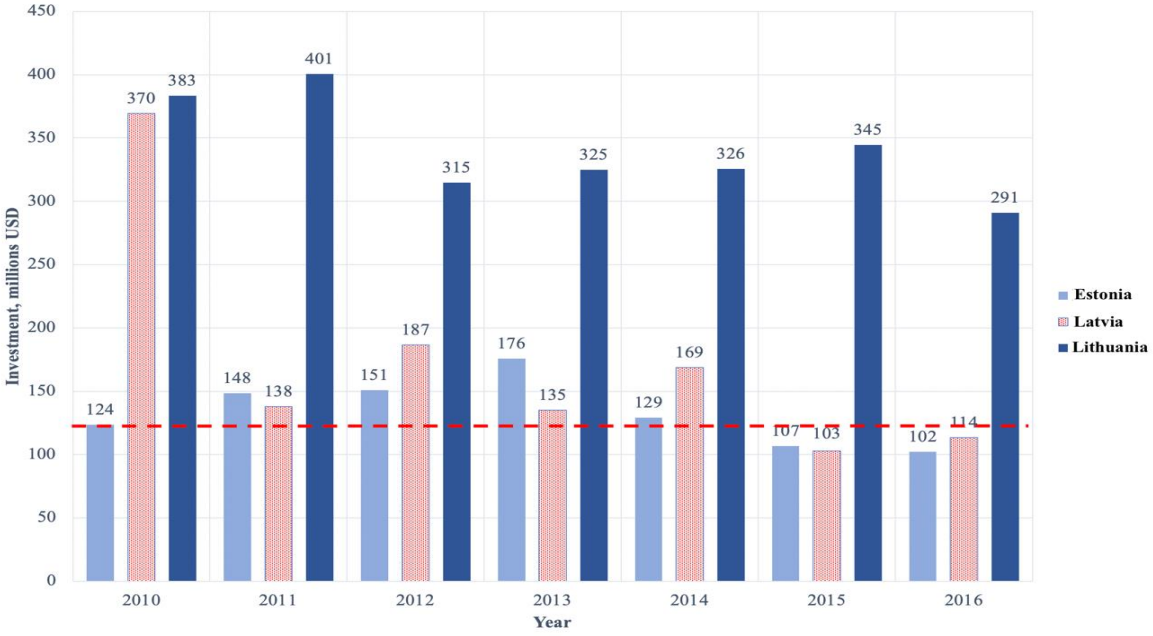
Figure 1 summarizes the average of the EU Member States and the EU-28, which provides information on the percentage of GHG emissions generated by the agricultural sector in the period from 2010 to 2019. Compared to the EU-28 average, the Latvian agricultural sector has the 4th largest share of GHG emissions between all countries in terms of GHG emissions. The largest proportion is in Ireland, Denmark and Lithuania. The agricultural sector in these countries accounts for more than 20% of the country's total GHG emissions. The Maltese agricultural sector accounts for the lowest share of GHGs, not exceeding 5% of the country's total GHG emissions. Comparing the share of GHGs generated by agriculture in the Baltic States, it should be noted that the lowest share of GHGs is generated by Estonian agriculture, but the highest - by Lithuania.



Source: created by the authors based on Eurostat, 2022

Fig. 1 **National "rating" by the share of GHG emissions generated by the agricultural sector, % of the total GHG emissions generated in the country (2010-2019)**

Figure 2 summarizes the investments made by the Estonian, Latvian and Lithuanian governments in the agricultural sector in millions of USD according to the FAO. The collected information shows that the Estonian government has invested the least in the agricultural sector of the Baltic States, but the Lithuanian - the most. The Latvian government has invested almost as much as the Estonian government in the agricultural sector, except for the year 2010, as Latvia's investment in agriculture in 2010 was USD 370 million, which was the largest investment between the years 2010 and 2016.



Source: created by the authors, FAO, 2022

Fig. 2 **Investment in the agricultural sector, millions of dollars (2010-2016)**

The largest investments in the agricultural sector in the Baltic States between 2010 and 2016 were made by the Lithuanian government in years 2010 and 2011, amounting to USD 383 million and USD 401 million, respectively, while investments by the Estonian government amounted to only USD 124 million. The Estonian government has been increasing its investment every year between the years 2010 and 2013, however, from the year 2014 the investment is declining.

The Latvian government's investments in agriculture are ambiguous, as the information gathered suggests that there is no specific strategic plan for investment in the agricultural sector. A similar situation is observed in Lithuania. However, it should be noted that the Lithuanian government has invested almost the total investment of the Estonian and Latvian governments taken together in the agricultural sector during the period under review, with the exception of the year 2010.

The responsible institution in Latvia for the implementation of the United Nations Framework Convention on Climate Change is the Ministry of Environmental Protection and Regional Development, whereas the Ministry of Agriculture is responsible for Latvia's agriculture and its development.

The authors of the work believe that the uncertainty of investments and low state investment in Latvian agriculture is related to the responsible mini-trivia in mutual communication and investment distribution. Consequently, this may significantly hinder the introduction of innovative products in agriculture and lead to a reduction in the competitiveness of Latvian agriculture among the Baltic States in the coming years.

Conclusions

1) The European Union pays a great attention to tackling global climate change by seeking to establish a common position and common criteria in order to achieve the goals set for climate neutrality.
2) In order to implement innovations, it is necessary to understand how the participants involved in the innovation process will react to change. The process of implementing an innovation is complex.
3) Agriculture is one of the emitters of greenhouse gases. The Green Del and the 'Farm to Fork' strategy will significantly change traditional and long-established farming methods.

4) Achieving climate neutrality in agriculture will require at least two technological approaches: the digitalization of agriculture and the use of biotechnology for agriculture, possibly including bio-engineering or microbiological solutions.

5) Food and agricultural biotechnology is a set of areas of innovation that is directly linked to environmental sustainability issues and the transition to organic farming and has a positive influence and impact on the circular economy.

6) The share of GHG emissions from the agricultural sector in Latvia is relatively high compared to the EU28 average, among the Baltic States the share of GHG emissions from Latvia is almost 20%, which is higher than in Estonia but lower than the GHG emissions from the Lithuanian agricultural sector.

7) According to FAO data, the Lithuanian government has invested the most in agriculture compared to Estonia and Latvia. Investments of Latvian and Estonian governments in agriculture can be assessed as similar.

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