International Journal of Design & Nature and Ecodynamics
Vol. 19, No. 3, June, 2024, pp. 927-935
Journal homepage: http://iieta.org/journals/ijdne

The Production Safety Strategies for Enhancing Food Quality Through Ecological Imperatives in the Context of National Security

Olga Melnyk[1], Mykola Popov[2], Oksana Bashtannyk[3], Nazariy Lapychak[4], Larysa Kurnosenko[5], Halyna Khavarivska[6*]

[1] Department of Foreign Trade and Customs, Lviv Polytechnic National University, Lviv 79059, Ukraine
[2] Department of Public Administration and Regionalism, Odesa Polytechnic National University, Odesa 65010, Ukraine
[3] Department of History and Political Theory, Dnipro University of Technology, Dnipro 49000, Ukraine
[4] Department of Public Administration, Interregional Academy of Personnel Management, Kyiv 19000, Ukraine
[5] Department of Social Sciences and Humanities, Odesa Polytechnic National University, Odesa 65010, Ukraine
[6] Department of Public Policy and Governance, Lviv Polytechnic National University, Lviv 79059, Ukraine

Corresponding Author Email: halyna.s.khavarivska@lpnu.ua

https://doi.org/10.18280/ijdne.190322

Received: 8 April 2024
Revised: 9 May 2024
Accepted: 14 May 2024
Available online: 25 June 2024

Keywords:
ecological nature, ecological imperatives, safety, public policy, food products, environment, governance, food, quality, modeling, food national security

ABSTRACT

The purpose of the article is to identify key ecological imperatives that affect the environment by changing the rules for food quality standardization. The object of the study is the Polish environment. The scientific challenge is to identify the most significant ecological imperatives and propose a new strategic approach to responding to them at the national level. To do this, the research methodology involves the use of a survey method of leading experts and scientists in the field of ecology and food security to determine these imperatives. A method for solving problems through ranking and a synthesis method for building the model itself. As a result of the study, the most significant ecological imperatives were identified that affect the environment in such a way that they change the rules for standardizing the quality of food products. A model of response priority and ecological imperatives was constructed. Four different government-level strategies are proposed to respond to the impacts of specific ecological imperatives. The main results of the study are presented in the form of a model of how to correctly operate and organize environmental imperatives in the context of building the right security strategies. Practical application is possible in the system of ensuring national food security. The study is limited by considering the environment of only one country. Prospects for further research should concern not only ecological imperatives, but also technogenic ones.

1. INTRODUCTION

1.1 Ecological imperatives in sustainable food production

In modern society, environmental imperatives and their provision are of particular importance. The very influence of environmental imperatives is aimed at preserving biodiversity, natural resources and reducing negative anthropogenic and technogenic impacts on the environment. The integration of modern environmental imperatives into business and production strategies and management (in particular in the food production industry) makes it possible to significantly reduce the negative impact of these on the natural environment. In particular, this may become especially relevant in reducing the phenomena of soil degradation, water pollution and deforestation. This approach to food production not only allows for the formation of a system for the rational use of natural resources, but also ensures the formation of a high level of resilience of food systems to problems caused by climate change and other natural disturbances. This policy may in the future increase the availability and quality of food products.

The essence of ecological imperatives in the context of improving food quality and security lies in the recognition that environmental health and human well-being are inextricably linked. As the global population continues to grow, the demand for food products that are not only nutritious and safe but also produced in an environmentally sustainable manner is increasing. The adoption of ecological imperatives in food production is not just a strategy for environmental conservation; it is a fundamental shift towards ensuring the health and well-being of the planet and its inhabitants. Through concerted efforts to align food production practices with ecological imperatives, there is a unique opportunity to forge a sustainable future that balances the needs of the environment with those of humanity.

1.2 Enhancing food quality and safety through ecological imperatives

The increasing global emphasis on food security underscores the critical need for integrating robust production safety strategies with ecological imperatives to enhance food

quality. This is particularly pertinent in the context of national security, where the stability of food systems directly influences social and economic stability. This article explores the multifaceted approaches that can be adopted to safeguard food production processes, enhance the quality of food, and ensure that these strategies are sustainable and aligned with environmental conservation goals. By investigating the intersection of production safety, ecological sustainability, and national security, we aim to highlight innovative practices that can lead to a resilient food supply chain. Ecological imperatives play a vital role in shaping production safety strategies as they prompt the adoption of practices that not only prevent contamination and ensure the safety of food products but also contribute to the conservation of natural resources and biodiversity. In the era of climate change and heightened environmental degradation, it is imperative that food production systems adapt to become more ecologically friendly and resilient.

Environmental imperatives should be considered as the most urgent needs and requirements, the implementation and compliance of which is the key to the stability and well-being of the environment. These imperatives are based on the principle of balance of natural systems. Their implementation provides for measures to protect the permanence of ecosystems, preserve biodiversity and create a framework for safe human impact on the environment.

The degradation of ecosystems can lead to a significant reduction in the quality of food available. For example, soil erosion and nutrient depletion, consequences of unsustainable farming practices, can lead to crops that are less nutritious and more susceptible to diseases. Furthermore, the reliance on chemical pesticides and fertilizers, while boosting production in the short term, can contaminate food and water sources, posing health risks to consumers and further harming the environment. Ecological imperatives advocate for a shift towards more sustainable and regenerative farming practices that protect and enhance soil health, reduce dependence on chemical inputs, and safeguard water quality, thus ensuring that food products are both safe and of high quality.

Incorporating modern environmental imperatives into food production processes and technologies is an important aspect of biodiversity conservation. The conservation of biodiversity in the agricultural system is a pressing issue. So today the issue is being addressed by a number of processes and techniques: from the development of innovative methods of pollination, further pest control and to the support of environmentally stable soil systems. Reducing biodiversity through monoculture practices can lead to significant negative environmental impacts. Among these negative consequences, the dominant role is played by the decrease in resistance to pests, parasites and diseases, which becomes a significant problem for the quality and safety of food products. At the same time, adapting polyculture practices will restore soils, preserve the natural environment, and improve food quality and safety. The transition from monoculture to polyculture requires a fundamental change in the farming paradigm. This must happen through the introduction of new methods that will be aimed not only at meeting consumer needs, but also at maintaining the sustainability and environmental friendliness of agriculture. Thus, aligning environmental imperatives with food production strategies not only improves food quality and safety, but also contributes to achieving sustainable development goals.

1.3 Structure of the article

The purpose of the article is to identify key ecological imperatives that affect the environment by changing the rules for food quality standardization. The object of the study is the Polish environment. Firstly, Poland represents a compelling case study for examining the integration of ecological imperatives into food production, given its diverse agricultural landscapes and significant role in European food markets. The country's agricultural sector is a major component of its economy, providing a unique opportunity to explore how changes in environmental practices and policies can influence food quality standards at both a national and regional level. By identifying key ecological imperatives within the Polish context, the study aims to showcase practical examples of how environmental sustainability can be enhanced through targeted policy and practice changes, ultimately leading to improved food quality and security (Figure 1).

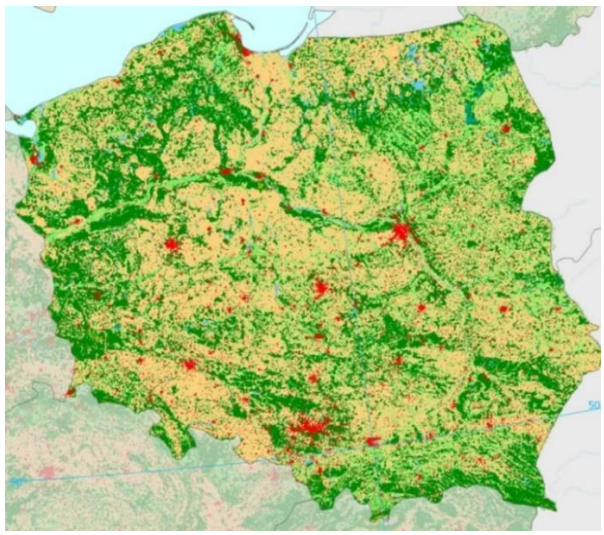

Figure 1. Poland ecosystem map

Selecting Poland as the object of study allows for a detailed examination of the challenges and opportunities that come with transitioning towards more sustainable food production practices in a context that is representative of many European countries. Through this localized study, the article aims to contribute to a broader understanding of how aligning food production with ecological imperatives can lead to tangible improvements in food quality and environmental health.

The structure of the article involves a literature review, presentation of own results and their discussion.

2. LITERATURE REVIEW

2.1 Ecological imperatives in enhancing food quality and security

The literature review draws on a diverse array of sources to build a comprehensive understanding of the intersection between ecological imperatives and food quality and security. Huang et al. [1], who provide a foundational perspective on the global declines in ecological security under the influence of climate change, emphasizing the critical need for sustainable practices in various sectors, including agriculture. This sets the stage for examining the environmental reporting

practices within industrial and supply chain processes as discussed by Yildiz and Yercan [2], highlighting the significance of transparency and accountability in achieving sustainable development. Juzefovič [3] introduces the concept of creativity and aesthetics in ecological education, suggesting that fostering an appreciation for ecological imperatives through education can lead to more sustainable behaviors, including those related to food production and consumption. Complementing this, Jørgensen [4] delves into the application of ecological models for assessing sustainability, offering insights into the methodologies that can be employed to evaluate and enhance the sustainability of food systems . Zhan et al. [5] further explore the concept of ecological security through the lens of functionality, organization, and stability, providing a model that could be adapted for assessing ecological imperatives in the context of food production.

In exploring the specific context of Poland, Trocka-leszczyńska and Jablonska [6] study the contemporary architectural design of ecological hotels, shedding light on the country's approach to integrating natural solutions and sustainability into its infrastructure, which can be paralleled in the agricultural sector. The consumer perspective is brought into focus by Wunderlich and Gatto [7], who examine how perceived environmental impacts influence food choices, underlining the importance of consumer awareness in driving demand for sustainably produced food. Bommarco et al. [8] introduce the concept of ecological intensification, which aims to harness ecosystem services for food security, offering a pathway towards achieving both ecological sustainability and food security . Abdullahi et al. [9] provide a modern take with their bibliometric analysis of IoT applications in smart agriculture, showcasing how technology can aid in achieving ecological imperatives by enhancing efficiency and sustainability in food production. The role of environmental impact management in the development of ecological tourism, as discussed by Borutska et al. [10], although focused on tourism, offers valuable insights into the broader implications of environmental management practices that could benefit the agricultural sector.

Lastly, Stankevičienė et al. [11] discuss the development and management of creative ecologies in the context of the creative economy, which, while not directly related to agriculture, emphasizes the importance of innovation and creativity in solving ecological challenges—a principle that is increasingly being applied to sustainable food production. Together, these sources provide a multidisciplinary foundation for understanding how ecological imperatives can be integrated into strategies to improve the quality and security of food products, with a particular focus on the Polish environment.

In examining the complex interplay between ecological imperatives and production safety strategies, it is essential to contextualize recent scholarly contributions within the broader discourse of environmental sustainability and food security. This literature review synthesizes findings from recent research, providing a foundational understanding of the dynamics at play in the enhancement of food quality through ecological means, particularly within the ambit of national security. The study by Wunderlich [12] on the food supply chain during the pandemic offers critical insights into how disruptions in global and local food systems can catalyze shifts in food production practices, and exacerbate food loss and waste. This research is particularly relevant in understanding the vulnerabilities of food production systems to external shocks and the necessity for resilient strategies that can sustain food quality standards under varying conditions. Additionally, Alazzam et al. [13] delve into the state management of rational environmental use within the bioeconomy, highlighting the ecological aspects pivotal to commercial development. Their findings underscore the importance of integrating ecological imperatives into economic strategies, which is essential for ensuring sustainable food production systems that do not compromise ecological integrity or national security.

The work by Kryshtanovych et al. [14] address the public and environmental impacts of military actions on regional development, revealing how such disturbances can detrimentally affect the ecological frameworks supporting sustainable food production. The restoration of these frameworks is critical in maintaining not only ecological balance but also food security in affected regions, thereby aligning with national security interests. Furthermore, the exploration of institutional dynamics in regional development by Bazyliuk et al. [15] and the impact of international tourism by Sylkin et al. [16] contribute additional dimensions to our understanding of how different regional and international factors can influence food production safety strategies. Both studies highlight the methodological nuances in assessing and enhancing the effectiveness of ecological and production safety measures across various contexts.

2.2 Identifying key gaps in research on ecological imperatives and food quality

Based on the results and objectives of the study, three main gaps can be delineated (Table 1).

Table 1. The main gaps in the scientific and practical literature

The Main Gaps	Characteristics
Integration of technogenic factors with ecological imperatives	One significant gap in both the scientific and practical literature is the limited exploration of how technogenic factors—those arising from human activity and technological advancement—interact with ecological imperatives in the context of food quality standardization
Comprehensive models for national-level response strategies	Another gap identified is the absence of comprehensive models for developing and implementing national-level strategies that respond to ecological imperatives affecting food quality

Addressing these gaps in the literature could significantly enhance our understanding of the complex interplay between ecological imperatives and food quality standardization, leading to more effective strategies for ensuring food safety and sustainability in the face of environmental challenges.

3. METHODOLOGY

The first method of our chosen methodology is an optimization study conducted among leading experts in the field of food security and ecology. Due to the use of this method, we received the most relevant information from experts in the field we were researching. The experience and knowledge of experts have become decisive in the process of shaping the most relevant and important environmental

imperatives influencing the production and process of food standardization in Poland. During the survey, we obtained both qualitative and quantitative data, which made it possible to systematize and conduct a comprehensive expert analysis on environmental imperatives. To systematically evaluate and prioritize the ecological imperatives identified through the surveys, a method for solving problems through ranking is employed. This analytical tool is instrumental in organizing the identified imperatives according to their significance and impact on the environment and food quality standards. The method for solving problems through ranking allows for the breakdown of complex ecological issues into manageable components, facilitating a clear understanding of the relationships and relative importance of different imperatives. This method is chosen for its ability to handle multifaceted environmental data and produce a structured prioritization of ecological challenges, which is essential for the development of effective response strategies. The Synthesis Method is utilized for the construction of the model itself, integrating the findings from the surveys and hierarchical analysis into a coherent framework. This method involves the combination of various elements of the research - expert opinions, priority rankings of imperatives, and strategic responses into a unified model that encapsulates the study's findings. The synthesis process is crucial for translating the complex interplay of ecological imperatives and their impacts into actionable strategies. It ensures that the model reflects the nuanced realities of ecological imperatives in Poland and provides a clear roadmap for addressing them at the national level.

The survey instrument developed for this research was meticulously crafted to elicit detailed responses on the ecological imperatives impacting food production safety standards. The questionnaire was divided into sections, each designed to explore different facets of ecological and food security concerns, such as the impact of agricultural practices on biodiversity, the role of climate change in food production, and the effectiveness of current food quality regulations in addressing ecological challenges. Respondents were asked to rank the significance of various ecological imperatives based on their expert judgment and provide qualitative data on potential strategies for addressing these issues. Additionally, the survey included scaling questions that allowed for the quantification of expert opinions and the prioritization of responses, facilitating the synthesis of a strategic model to guide national policy decisions effectively. This structured approach ensured that the data collected was both quantifiable and conducive to creating a robust model of response priorities regarding ecological imperatives.

4. RESULTS OF RESEARCH

As a result of the survey of experts, we identified the following set of ecological imperatives:

1. Biodiversity Loss. The decline in biodiversity, including pollinators crucial for the agriculture sector, undermines ecosystem services essential for food production. Preserving biodiversity is vital for sustaining agricultural productivity and resilience.

2. Soil Degradation. Soil erosion, compaction, and loss of soil fertility due to overuse of chemicals and poor farming practices threaten the very foundation of food production. Promoting soil conservation and sustainable soil management practices is imperative.

3. Water Scarcity and Pollution. Over-extraction of water resources for agriculture, coupled with pollution from agricultural runoffs, affects the availability and quality of water. Efficient water use and the implementation of cleaner farming practices are necessary.

4. Climate Change. Altered precipitation patterns, extreme weather events, and shifting climate zones affect crop yields and food production stability. Adapting to and mitigating the impacts of climate change are crucial for food security.

5. Chemical Pollution. The overuse of pesticides and fertilizers leads to pollution of land and water, affecting human health and ecosystems. Reducing chemical dependency through integrated pest management and organic farming is essential.

6. Energy Use in Agriculture. The high energy consumption and greenhouse gas emissions from conventional agriculture demand a shift towards more sustainable, energy-efficient farming practices.

7. Genetic Erosion. The loss of genetic diversity in crops due to the predominance of monoculture and the underutilization of traditional varieties reduces resilience to pests, diseases, and changing environmental conditions. Preserving and utilizing plant genetic resources is fundamental.

8. Waste Management. Food production and processing generate significant waste, contributing to pollution and resource inefficiency. Implementing sustainable waste management practices, including recycling and composting, is imperative for reducing environmental impact.

Let's assign them a mathematical notation in the form Eq. (1):

$$E=f\{e_1, e_2, e_3, e_4, e_5, e_6, e_7, e_8\} \quad (1)$$

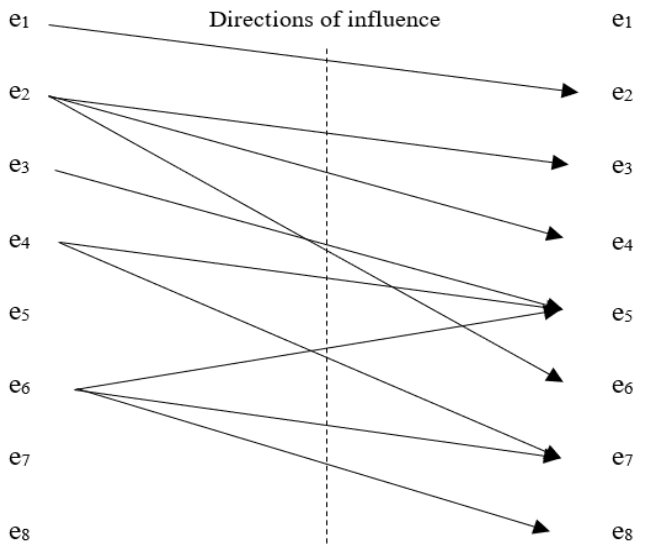

Figure 2. Directions of influence of imperatives and their dependence

Now we are building a diagram of the relationships between these ecological imperatives, in which, in addition to the number of the graph, the directions of the direct effects of each are given (Figure 2).

It should be noted that the data from Figure 2 make it possible to calculate the weight values of the direct and indirect effects of ecological imperatives. Thus, let r_{ij} be exactly the number of such influences (1 when the influences are direct and 2 when indirect). At the same time, if there is a

direct dependence, we put «3», and if, according to experts, the dependence between ecological imperatives is indirect, then «4». At the same time, v_i is the weight of the imperative. Note that for the calculation we will accept the following conditional values for the weighting coefficients in conventional units: $v_1 = 10$, $v_2 = 5$, $v_3 = -10$, $v_4 = -5$. We denote the total weight values by Eq. (2):

$$B=\sum_{i=1}^{4} r_{ij} v_i \ (j=1,8) \tag{2}$$

In this case, as can be seen from Figure 2, for some imperatives, due to the lack of connections, the value will be zero. The above formula serves as the basis for obtaining weighted ranking values Eq. (3):

	$r1j$	$r2j$	$r3j$	$r4j$	$B1j$	$B2j$	$B3j$	$B4j$
$e1$	1	3	0	0	10	15	0	60
$e2$	3	3	1	0	30	15	–10	70
$e3$	1	0	1	1	10	0	–10	30
$e4$	2	0	1	1	20	0	–10	40
$e5$	0	0	3	1	0	0	–30	0
$e6$	3	0	1	1	30	0	–10	45
$e7$	0	0	2	1	0	0	–20	10
$e8$	0	0	1	1	0	0	–10	20

(3)

It should be noted that $B_{3j} < 0$ and $S_{4j} < 0$, since according to the given initial conditions $v_3 < 0$ and $v_4 < 0$. As can be seen from Eq. (3), we obtain the resulting weight of ecological imperatives, which serves as the basis for establishing the level of priority Eq. (4):

$$\begin{gathered} B_1=[10+15+0+0]+[30+5]=60 \\ B_2=[30+15-10+0]+[30+5]=70 \\ B_3=[10+0-10-5]+[30+5]=30 \\ B_4=[20+0-10-5]+[30+5]=40 \\ B_5=[0+0-30-5]+[30+5]=0 \\ B_6=[30+0-10-5]+[30+5]=45 \\ B_7=[0+0-20-5]+[30+5]=10 \\ B_8=[0+0-10-5]+[30+5]=20 \end{gathered} \tag{4}$$

Having determined the significance of ecological imperatives Eq. (5), we build a model of priority of impact on the environment and product quality (Figure 3).

However, this may not be enough to select a government strategy to take these imperatives into account. You should also take into account such variables as: resource provision and the state's readiness for change (Figure 4).

1. Integrated Agro-Ecological Transition. The government can initiate comprehensive education and training programs for farmers on sustainable practices. Funding is allocated for developing renewable energy sources specific to agricultural needs and for setting up marketplaces for sustainably produced food products.

2. Incentivized Readiness Program. Implement a pilot project in select regions showcasing the economic and environmental benefits of sustainable practices. Financial incentives, such as tax breaks or grants, are offered to early adopters. Establish a national campaign highlighting the importance of food security and sustainable practices.

3. Resource Mobilization through Partnerships. The government can act as a facilitator, setting up frameworks for public-private partnerships focused on sustainable agriculture. It could also seek funding and technical assistance from international bodies and development banks. Voluntary certification schemes for sustainable practices could attract private sector investment.

4. Gradual Integration and Public Engagement. Start with sectors or regions where sustainable practices can be easily integrated without significant disruption. Use mass media and social media campaigns to educate the public on the importance and benefits of food security and ecological sustainability. Engage community leaders and influencers to champion the cause.

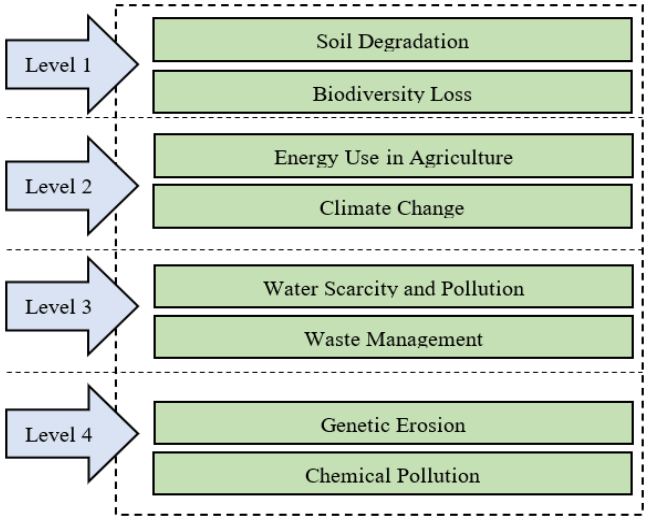

Figure 3. Model of priority of environmental impact and product quality

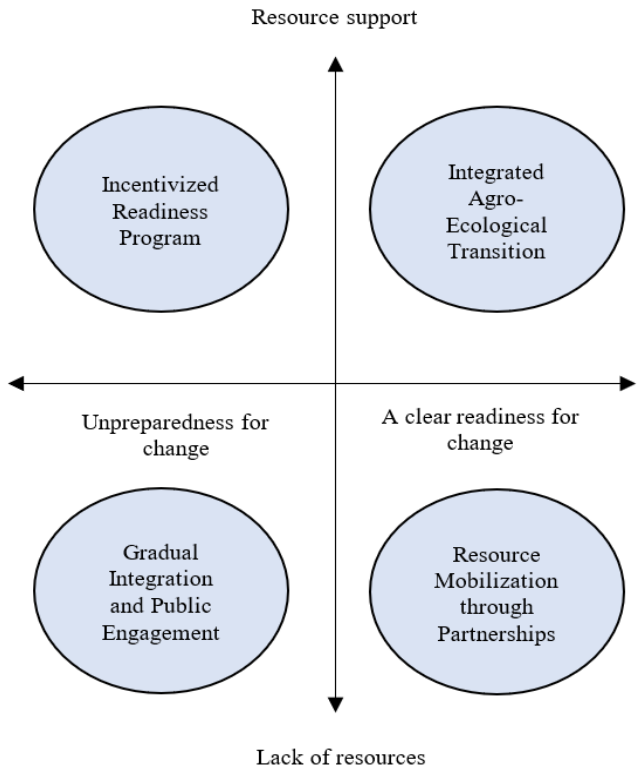

Figure 4. Coordinate system for determining the national food security strategy

5. DISCUSSIONS

The next, no less important step of our research is to compare the results obtained with individual research results in this area. Such a comparison will confirm the scientific novelty and relevance of our results in modern academic discourse. Auci et al. [17] explored the role of innovation in climate change adaptation and its impact on technical efficiency within the European agricultural sector. Their analysis emphasizes the importance of innovation for enhancing agricultural sustainability and resilience to climate change, themes that resonate with our study's identification of ecological imperatives and proposed strategic responses. However, while Auci et al. [17] primarily focus on the broader European context and technological innovation, our study delves into specific ecological imperatives, suggesting that future research could benefit from integrating these perspectives to explore how innovation can directly address ecological challenges in food production. Shanmugasundaram et al. [18] discuss the application of modern technologies in smart agriculture, highlighting the potential of these technologies to revolutionize food production through increased efficiency and sustainability. This aligns with our findings regarding the necessity of adopting new strategies to respond to ecological imperatives. However, our study extends this narrative by constructing a model of response priorities specifically tailored to ecological imperatives, indicating that while technology plays a crucial role, the strategic framework within which it is deployed is equally vital for addressing the ecological challenges effectively [17, 18].

Salamatov et al. [19] and Kačerauskas [20] explore the sociocultural dynamics of sustainable development and the role of creative environments, respectively. These studies underscore the significance of sociocultural factors and education in fostering sustainable development, echoing our study's emphasis on the need for strategic approaches that incorporate ecological imperatives into national policy. Our findings suggest a practical application by proposing government-level strategies, highlighting the intersection between sociocultural dynamics, education, and policy-making in addressing ecological challenges. he works of Ovchinnikova et al. [21] and Medynska et al. [22] discuss the innovative development of the agroindustrial complex and the optimization of ecological taxation, respectively. These studies provide insights into mechanisms that can support the implementation of ecological imperatives through innovation and economic incentives. While our study proposes strategic responses to ecological imperatives, the literature suggests that further exploration into how innovation and taxation could support these strategies is necessary, indicating a potential area for integrating our findings with broader economic and innovation-driven approaches [19-23].

Lastly, Carlier and Moran [24], and Przybytniowski [25] address the economic security of enterprises in the agricultural sector and landscape ecology's role in greenway design, respectively. These studies highlight the importance of economic considerations and ecological connectivity in sustainable agriculture. Our research aligns with these concerns by proposing strategies that consider the economic and ecological dimensions of food production. However, our focus on national-level responses to ecological imperatives suggests a complementary perspective, advocating for a holistic approach that integrates economic security and ecological considerations into a unified strategic framework.

The study by Pushak et al. [26] focuses on the economic security of enterprises in the agricultural sector, emphasizing the importance of assessing and managing risks to enhance security and stability. Alazzam et al. [27] explore the integration of advanced information models into e-commerce platforms, emphasizing the necessity for compliance with global digitalization trends and legal frameworks. This research highlights how digital tools and platforms can enhance operational efficiency and compliance in a rapidly evolving global market. In contrast, our study focuses on ecological imperatives within the food production sector, examining how these can be strategically managed to improve food safety and quality, which are crucial components of national security [27]. While their work is confined to economic aspects, our study broadens the perspective by incorporating ecological imperatives, showing that ecological and economic security are interdependent. Our findings suggest that integrating ecological considerations into the standardization processes directly contributes to more resilient food production systems, which is a crucial aspect of economic security in agriculture.

Similarly, the researches [28, 29] on state policies for energy security and environmental protection reveals a strategic alignment with our results, particularly in the approach to integrating environmental protection into broader security strategies. Both studies underscore the necessity of a holistic approach to policy-making that includes sustainable practices as a means to enhance overall security, albeit our focus is more narrowly tailored to food production.

Table 2. The innovations in our article

Innovations	Characteristics
Integrated Model of Response Priority and Ecological Imperatives	One of the primary innovations of this study is the development of an integrated model of response priority and ecological imperatives. This model represents a novel approach to categorizing and prioritizing ecological imperatives based on their impact on food quality standardization and the environment
Strategic Framework for Government-Level Responses	Another significant innovation introduced by this study is the proposition of four distinct government-level strategies to address the impacts of specific ecological imperatives. This strategic framework is tailored to the nuanced challenges identified within the Polish environment, showcasing an innovative approach to policy development that is both specific and adaptable. Each strategy is designed to mitigate particular ecological challenges through a combination of regulatory, economic, technological, and educational interventions

On another front, Tubishat et al. [30] discuss the efficiency of open systems in commercial relations, highlighting the regional legal aspects necessary for sustainable development. This study complements our own by illustrating the broader applications of legal and open system strategies in managing sustainability, where our findings provide a focused application within the food production sector. Lastly, the exploration of cyber-environments in protecting intellectual property brings a different dimension of security and sustainability, emphasizing the modern challenges in digital realms [31]. Qiu et al. [32] present a decision-making model that prioritizes low-carbon policies, emphasizing the

importance of climate change mitigation in sustainable development. Economic cycles significantly influence environmental emissions, which in turn affect food quality and safety. Fakhri et al. [33] explore the effects of economic cycle shocks on polluting emissions in developing countries through a panel vector autoregression analysis . The study highlights the necessity of incorporating ecological imperatives into national policies to ensure the long-term sustainability of food production systems. While this aligns with our study in terms of addressing contemporary challenges, our focus on ecological imperatives provides a tangible, environmentally centered perspective that adds depth to the discourse on sustainable development and security (Table 2).

In conclusion, our study's emphasis on identifying and responding to ecological imperatives in food quality standardization within the Polish context contributes to the broader discourse on sustainable agriculture. By comparing our findings with the referenced literature, it is evident that while there is a convergence of themes around innovation, technology, sociocultural dynamics, and economic considerations, our study offers a unique perspective through its focus on strategic national-level responses to ecological challenges. This discussion highlights the importance of a multidimensional approach that encompasses technological, sociocultural, and economic strategies to effectively address the ecological imperatives impacting food production and quality standards.

6. CONCLUSIONS

To summarize the above, our research conducted a critical and detailed analysis of existing environmental imperatives, in the context of the Polish environment. During the study, the influence of these imperatives on the standards governing food quality was identified and analyzed. Through a carefully selected methodological framework, which includes the selection of experts in the field of ecology and food security, ranking and synthesis methods, we have identified key environmental imperatives that have a dominant influence and determine changes in the food quality standardization system. The identification of these imperatives has culminated in the construction of a model delineating response priorities, alongside proposing four strategic governmental responses to these identified ecological challenges. Our results bring to the fore the crucial ecological imperatives that directly influence food production and quality standards within Poland, signifying a pivotal step toward rethinking national strategies in food safety and environmental conservation. By prioritizing these imperatives and integrating them into the fabric of national policy and practice, Poland can pioneer a sustainable approach to food production that not only meets current food security demands but also safeguards the environment for future generations. The strategic framework proposed offers a roadmap for governmental and regulatory bodies to mitigate the adverse effects of these imperatives on food quality, through the implementation of targeted policies and practices that promote sustainability and resilience in food systems.

The practical implications of our findings are manifold. By adopting the outlined strategies, Poland can enhance its food quality standards to reflect a deeper alignment with ecological sustainability, thereby setting a precedent for environmentally conscious food production that could inspire similar adaptations globally. This strategic pivot could not only improve the national food security posture but also bolster Poland's standing as a leader in sustainable agricultural practices on the international stage. Furthermore, the emphasis on ecological imperatives in shaping food quality standards underscores the importance of integrating environmental considerations into the core of national food policies, which can lead to a more harmonious relationship between agriculture and ecosystem health.

However, the study's scope, confined to the Polish environment, introduces certain limitations. While offering in-depth insights into Poland's specific context, the findings may not be directly transferable to other countries with different ecological, economic, and social landscapes. This limitation points towards the necessity for further research that broadens the investigation to include technogenic imperatives and their interplay with ecological factors in a wider array of geographical and cultural contexts. Such research could enrich the global understanding of sustainable food production practices and their implementation across diverse ecosystems.

In conclusion, this study contributes significantly to the discourse on ecological imperatives and their pivotal role in shaping food quality standards. By proposing actionable strategies and highlighting the need for an integrated approach to address these imperatives, it paves the way for enhancing the sustainability and resilience of food systems in Poland and beyond. The limitations of the study, while underscoring the specificity of its findings, also open avenues for broader investigations that could further elucidate the complex dynamics between ecological and technogenic imperatives in global food security and environmental stewardship. Future research could explore how technogenic influences, such as industrial agriculture practices, chemical use in farming, and the proliferation of non-biodegradable materials, interplay with ecological concerns to impact food quality and safety. Investigating these intersections is crucial as they significantly affect ecosystem health and thus food security.

REFERENCES

[1] Huang, J., Yu, H., Han, D., Zhang, G., Wei, Y., Huang, J., An, L., Liu, X., Ren, Y. (2020). Declines in global ecological security under climate change. Ecological Indicators, 117: 106651. https://doi.org/10.1016/j.ecolind.2020.106651

[2] Yildiz, T., Yercan, F. (2011). Environmental reporting of industrial and supply chain business processes within the context of sustainable development. Business: Theory and Practice, 12(1): 5-14. https://doi.org/10.3846/btp.2011.01

[3] Juzefovič, A. (2015). Creativity and aesthetic applied to ecological education. Creativity Studies, 8(1): 12-24. https://doi.org/10.3846/23450479.2014.1000410

[4] Jørgensen, S.E. (2016). Application of ecological models for assessment of sustainability. International Journal of Design & Nature and Ecodynamics, 11(3):153-167. https://doi.org/10.2495/DNE-V11-N3-153-167

[5] Zhan, L., Guo, X., Li, T., Liu, X., Lu, C., Zhang, N., Lu, Z. (2022). Ecological security measurement based on functionality-organization-stability in inland of Three Gorges Reservoir area. Journal of Environmental Engineering and Landscape Management, 30(3): 433-449. https://doi.org/10.3846/jeelm.2022.17408

[6] Trocka-leszczy Ska, E., Jablonska, J. (2015). Tendencies

in contemporary architectural design of ecological hotels in poland - A study of natural solutions. International Journal of Design & Nature and Ecodynamics, 10(2): 114-126. https://doi.org/10.2495/DNE-V10-N2-114-126
[7] Wunderlich, S., Gatto, K.A. (2016). Consumers' food choices and the role of perceived environmental impact. International Journal of Sustainable Development and Planning, 11(6): 989-995. https://doi.org/10.2495/SDP-V11-N6-989-995
[8] Bommarco, R., Kleijn, D., Potts, S.G. (2013). Ecological intensification: Harnessing ecosystem services for food security. Trends in Ecology & Evolution, 28(4): 230-238. https://doi.org/10.1016/j.tree.2012.10.012
[9] Abdullahi, H.O., Mahmud, M., Hassan, A.A., Ali, A.F. (2023). A bibliometric analysis of the evolution of IoT applications in smart agriculture. Ingénierie des Systèmes d'Information, 28(6): 1495-1504. https://doi.org/10.18280/isi.280606
[10] Borutska, Y., Vashchyshyn, M., Zhurba, I., Leskiv, H., Taranenko, H., Panteleiev, M. (2023). State environmental impact management in ecological tourism development. International Journal of Design & Nature and Ecodynamics, 18(5): 1247-1254. https://doi.org/10.18280/ijdne.180527
[11] Stankevičienė, J., Levickaitė, R., Braškutė, M., Noreikaitė, E. (2011). Creative ecologies: developing and managing new concepts of creative economy. Business, Management and Economics Engineering, 9(2): 277-294. https://doi.org/10.3846/bme.2011.19
[12] Wunderlich, S.M. (2021). Food supply chain during pandemic: Changes in food production, food loss and waste. International Journal of Environmental Impacts, 4(2): 101-112. https://doi.org/10.2495/EI-V4-N2-101-112
[13] Alazzam, F.A.F., Aldrou, K.K.A.R., Berezivskyy, Z., Zaverbnyj, A., Borutska, Y. (2023). State management of the system of rational environmental use in the context of commercial development of the bioeconomy: Ecological aspect. International Journal of Environmental Impacts, 6(4): 155-163. https://doi.org/10.18280/ijei.060401
[14] Kryshtanovych, M., Dragan, I., Grytsyshen, D., Sergiienko, L., Baranovska, T. (2022). The public and environmental aspect of restoring sustainable regional development in the face of the negative impact of military actions on the territory of the country. International Journal of Sustainable Development and Planning, 17(5): 1645-1651. https://doi.org/10.18280/ijsdp.170530
[15] Bazyliuk, V., Shtangret, A., Sylkin, O., Bezpalko, I. (2019). Comparison of institutional dynamics of regional development publishing and printing activities in Ukraine: Methodological and practical aspects. Business: Theory and Practice, 20: 116-122. https://doi.org/10.3846/btp.2019.11
[16] Sylkin, O., Krupa, O., Borutska, Y., Todoshchuk, A., Zhurba, I. (2023). Exploring the impact of international tourism on regional sustainable development: A methodological approach for enhancing effectiveness. International Journal of Sustainable Development and Planning, 18(7): 2089-2096. https://doi.org/10.18280/ijsdp.180711
[17] Auci, S., Barbieri, N., Coromaldi, M., Vignani, D. (2021). Innovation for climate change adaptation and technical efficiency: An empirical analysis in the European agricultural sector. Economia Politica, 38: 597-623. https://doi.org/10.1007/s40888-020-00182-9
[18] Shanmugasundaram, N., Kumar, G.S., Sankaralingam, S., Vishal, S., Kamaleswaran, N. (2023). Smart agriculture using modern technologies. In 2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS), IEEE, Coimbatore, India, pp. 2025-2030. https://doi.org/10.1109/ICACCS57279.2023.10113059
[19] Salamatov, A., Gordeeva, D., Agapov, A. (2021). Sociocultural dynamics of sustainable development: Formation of human potential in the process of integrated ecological and economic training. International Journal of Environmental Impacts, 4(1): 62-76. https://doi.org/10.2495/EI-V4-N1-62-76
[20] Kačerauskas, T. (2016). Environmental discourses and the question of creative environment in a city. Journal of Environmental Engineering and Landscape Management, 24(2): 108-115. https://doi.org/10.3846/16486897.2016.1141097
[21] Ovchinnikova, T.I., Belyaeva, G.V., Kolesnikova, E.Y., Kolomytseva, O.Y. (2017). The system of innovative development of the agroindustrial complex. In Proceedings of the Voronezh State University of Engineering Technologies, 79(4), 313-319 https://doi.org/10.20914/2310-1202-2017-4-313-319
[22] Medynska, T., Loboda, N., Nohinova, N., Oliynyk, N., Borutska, Y. (2024). Optimization of ecological taxation: Role in the formation of environmental protection budgets. International Journal of Environmental Impacts, 7(1): 17-23. https://doi.org/10.18280/ijei.070102
[23] Kryshtanovych, M., Panfilova, T., Khomenko, A., Dziubenko, O., Lukashuk, L. (2023). Optimization of state regulation in the field of safety and security of business: A local approach. Business: Theory and Practice, 24(2): 613-621. https://doi.org/10.3846/btp.2023.19563
[24] Carlier, J., Moran, J. (2019). Landscape typology and ecological connectivity assessment to inform Greenway design. Science of the Total Environment, 651(Part 2): 3241-3252. https://doi.org/10.1016/j.scitotenv.2018.10.077
[25] Przybytniowski, J.W. (2013). Financing instrument for risks managing. Polish experience. Business: Theory and Practice, 14(3): 217-227. https://doi.org/10.3846/btp.2013.23
[26] Pushak, Y., Lagodiienko, V., Basiurkina, N., Nemchenko, V., Lagodiienko, N. (2021). Formation the system for assessing the economic security of enterprise in the agricultural sector. Business: Theory and Practice, 22(1): 80-90. https://doi.org/10.3846/btp.2021.13013
[27] Alazzam, F.A.F., Shakhatreh, H.J.M., Gharaibeh, Z.I.Y., Didiuk, I., Sylkin, O. (2023). Developing an information model for E-Commerce platforms: A study on modern socio-economic systems in the context of global digitalization and legal compliance. Ingénierie des Systèmes d'Information, 28(4): 969-974. https://doi.org/10.18280/isi.280417
[28] Kopytko, M., Sylkin, O. (2023). Modelling information support for combating corruption in the economic security management system of the state. Social and Legal Studios, 6(3): 69-75. https://doi.org/10.32518/sals3.2023.69

[29] Kryshtanovych, M., Tanashchuk, K., Kupchak, V., Zorya, O., Fatiukha, N. (2024). Increasing the effectiveness of state policy in ensuring energy security and environmental protection. International Journal of Energy Production and Management, 9(1): 9-17. https://doi.org/10.18280/ijepm.090102

[30] Tubishat, B.M.A.R., Alazzam, F.A.F., Viunyk, O., Yatsun, V., Horpynchenko, O. (2024). Planning to improve the efficiency of open systems commercial relations to ensure uninterrupted sustainable development: Regional legal aspect. International Journal of Sustainable Development and Planning, 19(3): 1089-1097. https://doi.org/10.18280/ijsdp.190327

[31] Bani-Meqdad, M.A.M., Senyk, P., Udod, M., Pylypenko, T., Sylkin, O. (2024). Cyber-environment in the human rights system: Modern challenges to protect intellectual property law and ensure sustainable development of the region. International Journal of Sustainable Development and Planning, 19(4): 1389-1396. https://doi.org/10.18280/ijsdp.190416

[32] Qiu, Y.J., Bouraima, M.B., Badi, I., Stević, Ž., Simic, V. (2024). A decision-making model for prioritizing low-carbon policies in climate change mitigation. Challenges in Sustainability, 12(1): 1-17. https://doi.org/10.56578/cis120101

[33] Fakhri, I., Meshari, A.Z., Othayman, M.B., Mourad, G., Jamee, A. (2024). The effects of economic cycle shocks on polluting emissions in developing countries: Insights from a panel vector autoregression analysis. Challenges in Sustainability, 12(1): 18-33. https://doi.org/10.56578/cis120102