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Administrative legal regulation of the agro-industrial complex in the context of the “green” transition

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Abstract

This study aimed to determine optimal methods for aligning the national legal framework with international norms to promote sustainable agricultural development and mitigate environmental concerns. The study encompassed a comparative investigation of regulatory frameworks in nations including the United States, Germany, the Netherlands, Denmark, and Japan, recognised for their high environmental standards and successful integration of financial and non-financial incentives. The study results indicated common patterns in the development of extensive legislative frameworks and the application of both financial and non-financial instruments to promote environmental transition. The key challenges of digitalisation were identified: insufficient funding, lack of a unified strategy, and poor interagency coordination. A model for optimising administrative legal regulation has been developed, which includes the introduction of innovative environmental standards, the creation of a system of incentives for green innovations and the development of digital infrastructure. Concrete amendments to Ukrainian legislation were proposed, including amendments to the Law of Ukraine “On Environmental Protection” regarding the monitoring of the impact of agricultural activities and the creation of a unified information system of environmental indicators

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of agricultural enterprises. It was recommended to develop a new Law “On Environmental Certification in the Agricultural Sector” and to amend the Tax Code of Ukraine to introduce tax benefits for environmentally responsible enterprises. The research highlighted the necessity for a holistic strategy in governing the green transition within the agro-industrial sector, considering global trends and digital technologies capabilities. The results inform the establishment of a national policy for the sustainable advancement of the agricultural industry, integrating global trends with distinct local characteristics, thus assuring a holistic approach to the administrative legal regulation of the green transition

Keywords: environmental standards; sustainable production; digital technologies; regulatory instruments; energy efficiency

Introduction

The administrative legal management of the agro-industrial complex is increasingly vital in light of global difficulties during the green transition. The exigencies of climate change, resource depletion, and increasing demand for sustainable products need a reformation of traditional agricultural management practices. The “green transition” involves the introduction of innovative technologies and practices that minimise the adverse environmental impact while increasing production efficiency. The administrative law regulation is crucial for establishing favourable conditions for the sustainable growth of the agriculture sector, reconciling economic interests with environmental mandates and social accountability. This subject’s significance is highlighted by the necessity to establish new legislative frameworks that promote the adoption of green technology and practices in agriculture, so maintaining its competitiveness in the global market and adherence to international environmental norms. Moreover, in the context of global food security and growing pressure on natural resources, effective administrative legal regulation is becoming a tool not only for environmental policy, but also for economic stability and social welfare.

O. Olshanska *et al.* (2022) emphasised the special significance of implementing the bioeconomy on a scientific basis to overcome global

challenges: economic, environmental, and social problems, including the food crisis. The researchers observed that the bioeconomy will enhance sustainable development to secure the long-term competitiveness of agricultural, forestry, food, and chemical sectors, while also alleviating climate change and decreasing greenhouse gas emissions. J. Huseynli *et al.* (2024) extended this understanding by exploring the role of ESG principles in the corporate world and their implications for governments and businesses. The researchers determined that corporations are progressively recognising the importance of addressing environmental and social concerns to attract investors and cultivate sustainable practices. Their examination of investment trends in agricultural companies indicated that they can significantly broaden their operational scope and expedite the adoption of sustainable agricultural practices globally, particularly concerning food security and the necessity for economic diversification.

O. Boki and O. Kovalenko (2024) emphasised the growing role of state regulation in the country’s food sector. The researchers organised the policy documents pertaining to the agro-industrial complex and the food industry, examined their interrelations, and proposed recommendations for policy documents focused on the food industry’s development, targeting post-war

recovery and subsequent innovative advancement. This correlates with findings I. Furman *et al.* (2021), who considered Ukraine's agricultural sector to be one of the critical parts of the economic systems of most market economies. The scholars assert that the agricultural-industrial sector's productive foundation relies fundamentally on comprehensive infrastructural networks and robust scientific research frameworks, which collectively shape the developmental trajectory of Ukraine's agro-industrial complex through systematic structural reorganisation across all subsectors, while optimising the integration of technological innovations, international best practices, and advanced organisational methodologies.

D.A. Saparova (2024) focused on financial instruments aimed at financing green projects, while G.D. Amanova *et al.* (2020) analysed the efficiency of using the reserves of the agricultural sector when integrating energy saving processes. Both studies stressed the significance of public policy in the field of alternative energy sources, noting that agriculture can be a valuable source of green energy through the processing of waste, organic oils, and wood. N. Stoyanets *et al.* (2022) focused on the European practices of integrated development of such territories, emphasising the role of stimulating and investing in effective rural innovation, while M.Z. Karbekova *et al.* (2023) analysed the international practices of managing sustainability risks in the agricultural sector, focusing on the legal regulation of food supply chain risk management and quality assurance procedures.

The study by O. Zgurska *et al.* (2022) examines digital transformation and its effects on the agro-industrial complex, identifying that the national agro-industrial production possesses significant potential for future development through enhanced efficiency in the land, labour, and biological resources. This aspect was complemented by T.D. Searchinger *et al.* (2020), analysed the effects

of agricultural support on climate change mitigation, noting that countries producing two-thirds of the world's agricultural products provided an average of USD 600 billion in annual financial support to agriculture from 2014 to 2016. A. Nurmanbetova *et al.* (2022) examined the role of Kazakhstan's agro-industrial complex within the national economic framework, identifying key challenges and priority objectives for resolution, while analysing the agro-industrial complex's contribution to the nation's GDP, as well as the dynamics and composition of gross agricultural production.

This study aimed to thoroughly analyse existing methods of administrative legal regulation within the agro-industrial complex amid the green transition and to formulate recommendations for enhancing the regulatory framework to promote sustainable agricultural development. To achieve this goal, the subsequent objectives were established:

1. to investigate the existing models of administrative legal regulation of the "green transition" in the agro-industrial complex at the international level;
2. to assess the potential of digital technologies in the transformation of administrative legal mechanisms for regulating the greening of the agro-industrial complex;
3. to systematise the mechanisms of administrative legal regulation of the agro-industrial complex in the context of the "green transition" at the national, regional, and local levels.

Materials and Methods

The investigation into administrative legal regulation of the agro-industrial complex within the context of the "green" transition was predicated upon a systematic methodological approach and sustainable development theoretical framework. This research synthesised theoretical contributions from both Ukrainian and international scholars across environmental law, agricultural

policy, and public administration domains. The methodological architecture encompassed both general scientific and specialised cognitive approaches, with the dialectical method facilitating an examination of the intricate relationship between agro-industrial complex economic development and environmental imperatives, thereby illuminating both contradictions and opportunities within the “green” transition paradigm. Through systematic analysis, the administrative legal regulatory framework was conceptualised as an integrated system comprising regulatory, institutional, and economic elements. The comparative legal methodology proved instrumental in evaluating international administrative legal regulatory practices concerning “green” transition in the agro-industrial sector, enabling a comprehensive comparative analysis of legislative and regulatory frameworks across multiple jurisdictions, including the United States, Germany, the Netherlands, Denmark, and Japan. The selection criteria for these jurisdictions were predicated upon three primary factors: the existence of comprehensive agricultural sector “green” development strategies, innovative regulatory approaches, and robust empirical data regarding implementation efficacy. The following legislative documents were analysed: Agriculture Improvement Act (2018), Climate Protection Programme 2030 of Germany (2019), National Climate Agreement of the Netherlands (2019), Climate Act of Denmark (2021), Green Growth Strategy of Japan (2021). The study also reviewed the Act on the Promotion of Renewable Energy of FAO No. 1392 (2008), Green Projects Scheme (2022), Public Law of the USA No. 97-219 “Small Business Innovation Development Act” (1982) and others. The formal legal method was employed to assess the rules about the environmental dimensions of the agro-industrial complex in Ukraine and the examined nations.

The statistical method was utilised to analyse and analyse quantitative data regarding the environmental impacts of the agro-industrial complex, the efficacy of environmental initiatives, and the economic metrics of the “green transition”. The expert evaluation approach was employed to examine the impact of digital technologies on the creation and execution of administrative law provisions within the framework of environmental sustainability. Within the framework of this method, 35 experts were interviewed, including 15 representatives of agricultural regulatory authorities, 10 academics specialising in agricultural law and digital technologies, and 10 representatives of agrotechnology companies. The criteria for inclusion of experts were as follows: at least 5 years of experience in the relevant field and publications or practical experience in implementing digital technologies in the agricultural sector. The survey was conducted online through a structured questionnaire using the Qualtrics platform. The questionnaire of 25 questions categorised into three sections: evaluation of the current status of digitalisation in administrative legal regulation, future applications of blockchain and AI, and possible hazards and obstacles to the use of digital technology. To assess the consistency of experts’ opinions, a five-point Likert scale was applied, where experts rated their agreement with key statements from 1 – “strongly disagree” to 5 – “strongly agree”. To process the results of the expert survey, descriptive statistics were used, including the calculation of mean values and standard deviations for expert assessments. The study was conducted following the ethical standards set out in the Code of Ethics of the American Sociological Association (1997), the International Code of Conduct for Market, Community and Social Research and Data Analysis ICC/ESOMAR (n.d.), and the European Commission’s (2021) guidelines on ethics and data protection.

The modelling method was applied to develop an optimised model of administrative legal regulation of the green transition in the Ukrainian agro-industrial complex, considering international practices and specific national features. The study was conducted in several stages: collection and analysis of legal acts, scientific publications, and analytical materials; comparative analysis of international practices; conducting an expert survey and analysing its findings; development of recommendations and modelling of an optimised regulatory system. The study was based on international agreements in the field of ecology and sustainable development, as well as on the regulations of Ukraine and the countries under study that governed the agro-industrial complex and environmental aspects of management. In terms of Ukrainian legislation, special attention was paid to the analysis of Law of Ukraine No. 2697-VIII (2019), as well as relevant provisions of the Constitution of Ukraine (1996) and sectoral laws. To analyse the effects of digital technologies on administrative legal regulation, materials from technology companies and industry associations, as well as scientific publications in the field of digitalisation of the agricultural sector were used.

Results

Analysis of existing models of administrative legal regulation of the “green” transition at the international level. The examination of the legal frameworks of the nations analysed indicated a prevalent inclination to establish extensive legislative structures addressing multiple facets of the green transition in agriculture. In the United States, the key document is the Agriculture Improvement Act (2018), which sets priorities for sustainable agricultural development and prescribes extensive investments in the introduction of environmentally friendly technologies. Germany is guided by the Climate Protection Programme 2030 of Germany (2019), which sets ambitious

targets and concrete measures to reduce greenhouse gas emissions in various sectors of the economy, including agriculture. The Netherlands is implementing the National Climate Agreement (2019), which aims to achieve 100% circular agriculture by 2050. Denmark has adopted the Climate Act (2021), setting legally binding targets for reducing emissions and developing organic farming. Japan is implementing an act (Ministry of Economy..., 2020), which envisages achieving zero carbon footprint in agriculture by 2050 and full digitalisation of the agricultural sector.

To stimulate the “green transition”, all the countries under study employ a combination of financial and non-financial instruments. The most prevalent options encompass subsidies and grants for the adoption of eco-friendly technologies, tax incentives for sustainable investments, emissions trading schemes, and training and advisory support programs for agricultural producers. Innovative mechanisms such as the system of green certificates for agricultural enterprises in Denmark, which encourages continuous improvement of environmental performance, and the creation of specialised investment funds to support green start-ups in the Netherlands and the United States have proved particularly effective. For instance, in Denmark, the system of green certificates is governed by the Act on the Promotion of Renewable Energy of FAO No. 1392 (2008), specifically Article 31, which sets out the requirements for certification and the mechanism for issuing certificates. In the Netherlands, the creation of specialised investment funds to support green start-ups is regulated by the Green Projects Scheme (2022), which is described in detail in Article 5.14 of the Income Tax Act (amended 2023). This article defines the requirements for green projects that contribute to sustainable development and the conditions for granting tax benefits to investors who invest in such projects. In the United States, support for green start-ups is

provided through the Small Business Innovation Research (SBIR) programme, which is governed by US Public Law No. 97-219 (1982), particularly Section 9 of this law. According to the provisions of this section, federal agencies with extensive research and development budgets are required to allocate a certain percentage of these funds to finance innovative small business projects, including environmentally oriented start-ups, which contributes to the “green transition” and sustainable development of the US economy.

A significant element of successful implementation of the green transition policy is the availability of effective monitoring and reporting systems. The analysed countries, such as Germany, the Netherlands, and Denmark, have developed mechanisms to track progress and evaluate the effectiveness of the measures implemented,

which is key to achieving sustainable development. Specifically, Germany uses an annual report that contains a detailed analysis of achievements in each sector of the economy, promoting transparency and prompt policy adjustments. Studies confirm that countries with monitoring systems in place achieve better outcomes in reducing greenhouse gas emissions. According to a report by the European Environment Agency, countries with developed monitoring systems, such as Germany and the Netherlands, achieved substantial emissions reductions between 1990 and 2020, while countries with less effective mechanisms showed slower emissions reductions (European Environment Agency, 2021). Table 1 demonstrates the key trends in administrative legal regulation of the green transition in the agricultural sector of the countries under study.

Table 1. Trends in administrative legal regulation of the green transition in the agricultural sector

Country	Legislative initiative	Goals of the “green” transition	Key aspects for the agricultural sector	Instruments and mechanisms
USA	Agriculture Improvement Act (2018).	Promotion of sustainable development in agriculture.	<ul style="list-style-type: none"> ➤ Assistance for initiatives aimed at the conservation and repair of ecosystems. ➤ Promotion of the use of renewable energy on farms. 	Subsidy and grant programmes for farmers taking part in green initiatives.
Germany	Climate Protection Programme 2030 of Germany (2019).	Reduction of emissions from agriculture by 31% by 2030 (compared to 1990).	<ul style="list-style-type: none"> ➤ Implementation of precision farming technologies. ➤ Support for organic farming. ➤ Improvement of the efficiency of fertiliser use. 	<ul style="list-style-type: none"> ➤ Introduction of quotas and standards for greenhouse gas emissions. ➤ Funding for research in environmental innovation.
Netherlands	National Climate Agreement of Netherlands (2019).	<ul style="list-style-type: none"> ➤ Reduction of greenhouse gas emissions by 49% by 2030. ➤ Transition to a circular economy. 	<ul style="list-style-type: none"> ➤ Promotion of sustainable practices in agriculture. ➤ Reduction of the use of pesticides and chemical fertilisers. 	<ul style="list-style-type: none"> ➤ Tax incentives for farmers implementing environmentally friendly technologies. ➤ Research and innovation programmes in climate-smart agriculture.
Denmark	Climate Act of Denmark (2021).	Reduction of emissions by 70% by 2030.	<ul style="list-style-type: none"> ➤ Support for sustainable agricultural practices. ➤ Development of bioenergy on farms. 	<ul style="list-style-type: none"> ➤ A system of state subsidies for farmers who reduce emissions. ➤ State support for research in sustainable agriculture.

Table 1. Continued

Country	Legislative initiative	Goals of the “green” transition	Key aspects for the agricultural sector	Instruments and mechanisms
Japan	Green Growth Strategy Through Achieving Carbon Neutrality in 2050 of Japan (2021).	Achievement of carbon neutrality by 2050.	<ul style="list-style-type: none"> ➤ Support for organic farming. ➤ Investments in highly efficient agricultural technologies. 	<ul style="list-style-type: none"> ➤ Creation of national programmes for the development of sustainable agriculture. ➤ Funding for innovation and research in agri-technology.

Source: compiled by the author

The United States focuses on promoting sustainable development through subsidy and grant programmes for farmers who adopt environmental practices, while European countries set concrete quantitative emission reduction targets ranging from 49% in the Netherlands to 70% in Denmark by 2030. Germany additionally introduces quotas and standards for greenhouse gas emissions, complementing them with funding for research in environmental innovation. Japan, for its part, has set a goal of achieving carbon neutrality by 2050, with a focus on creating national programmes for sustainable agriculture and financing agrotechnological innovations. Common elements for all countries are support for organic farming, implementation of energy-efficient practices, and development of ecosystem conservation programmes, with each country adapting tools and mechanisms to suit its national characteristics and agricultural policy priorities.

The analysis identified several effective techniques of administrative-legal regulation for the “green transition” in the agro-industrial complex, which may be adaptable in other countries, including Ukraine.

1. It is recommended to amend the Law of Ukraine No. 2697-VIII (2019) by supplementing Article 3 “Strategic goals and objectives” with concrete quantitative indicators for the agro-industrial complex. The proposal includes the following objectives: to attain a 25% share of organic farming in total agricultural land by 2030 and

to decrease greenhouse gas emissions in the agricultural sector by 40% by 2030 relative to 1990 levels. This recommendation is based on the successful practices of Germany, where an analogous approach, prescribed in the Climate Protection Programme 2030 of Germany (2019), has led to major progress in greening agriculture.

2. It is proposed to develop a new Law of Ukraine “On Environmental Certification in the Agricultural Sector”, which would include the definition of criteria for assessing the environmental performance of agricultural enterprises, certification procedures, and verification mechanisms, as well as economic incentives for certified producers, such as tax breaks or preferences in public procurement. This recommendation is based on the experience of Denmark, where the system of green certificates regulated by the FAO Act on the Promotion of Renewable Energy No. 1392 (2008), specifically Article 31, has become an effective tool for stimulating the greening of agriculture.

3. It is recommended to amend the Law of Ukraine No. 1560-XII (1991) by adding a section on “Investing in environmental projects of the agricultural sector”. This section should define the legal status of specialised green investment funds, mechanisms for their formation and operation, criteria for selecting projects for financing, and requirements for transparency and accountability of the use of funds. This recommendation is based on the practices of the Netherlands, where

an analogous system regulated by the Green Projects Scheme (2022), specifically Article 5.14, has contributed to a significant increase in investment in green agricultural technologies.

4. It is proposed to amend the Law of Ukraine No. 1264-XII “On Environmental Protection” (1991) by adding a section on “Monitoring and Reporting on the Environmental Status of the Agro-Industrial Complex”. This section must delineate the operational framework of the environmental monitoring system within the agro-industrial complex, enumerate the indicators for evaluating the advancement of the “green transition”, stipulate the requirements for the format and substance of reporting, and outline the mechanisms for data verification and public disclosure. This recommendation is based on the practices of Germany, where the introduction of the Klimaschutzbericht monitoring and annual reporting system has helped to improve the effectiveness of environmental policy in the agricultural sector.

5. It is recommended to develop and adopt the Law of Ukraine “On the System of Agricultural Education and Extension”, which would regulate the functioning of the system of agricultural education and extension, establish qualification requirements for advisors, and define mechanisms for financing and evaluating the effectiveness of programmes. This recommendation is based on the practices of the United States, where an analogous system regulated by the Agriculture Improvement Act (2018), namely Title VII “Research, Extension, and Related Matters”, has proven to be highly effective.

Notably, the effectiveness of these practices in the countries studied is conditioned not only by their content, but also to the overall level of development of the institutional environment, the maturity of market mechanisms, and the elevated level of environmental awareness of society. Therefore, their adaptation in other countries, including Ukraine, will require consider specific

local features, including the structure of the agricultural sector, available resources, and institutional capacity.

Study of the impact of digital technologies on the development and implementation of administrative legal provisions in the context of environmentalisation. The study identified significant deficiencies in the existing digitisation of administrative legal regulation within Ukraine’s agricultural sector. According to the findings of the expert survey, only 8 respondents rated the current level of digitalisation as satisfactory. The overwhelming majority of the surveyed experts (24) emphasised the need to greatly improve both the digital infrastructure and the regulatory framework for the effective implementation of innovative technologies in regulatory processes. An examination of the experts’ comments identified critical obstacles that impede the effective adoption of digital solutions in the realm of administrative-legal regulation within the agro-industrial sector. These include insufficient funding for digital initiatives (27), lack of a unified strategy for digital transformation of the industry (24), low level of interagency coordination (22), and insufficient qualifications of personnel in the field of digital technologies (21).

The study revealed major potential for the digitalisation of a series of administrative legal processes in the agricultural sector. The most promising areas, according to experts, are the automation of reporting and monitoring processes (23 respondents), the creation of unified digital platforms for interaction between government agencies and business entities (28), and the introduction of electronic document management systems and digital signatures (25). Experts emphasised the importance of incorporating environmental indicators into digital systems for the monitoring and regulation of agricultural production, aligning with the principles of the green transition and sustainable sector growth.

The empirical investigation of domain expert perspectives revealed significant opportunities for the integration of blockchain and AI technologies to enhance regulatory oversight transparency and operational efficiency within Ukraine's agricultural framework. Specifically, the qualitative survey data indicated that 29 subject matter experts identified substantial potential in leveraging distributed ledger technologies to implement robust agricultural product provenance tracking systems and facilitate verifiable adherence to environmental compliance protocols. Specifically, respondents noted the potential of blockchain to solve such problems as certification of organic products (27), monitoring the use of pesticides and agrochemicals (25),

and monitoring compliance with crop rotations and other agro-environmental requirements (23).

In terms of the prospects for the use of AI, 26 experts surveyed noted its strong potential for automating decision-making processes and predicting environmental risks in agriculture. Among the concrete areas of AI application, the respondents highlighted the analysis of satellite images to monitor the condition of agricultural land (28), yield forecasting and optimisation of resource use (25), and automated assessment of agricultural producers' compliance with environmental provisions and standards (23). Figure 1 demonstrates experts' evaluations of the capacity of diverse digital technologies to enhance the administrative legal regulation of the agricultural sector:

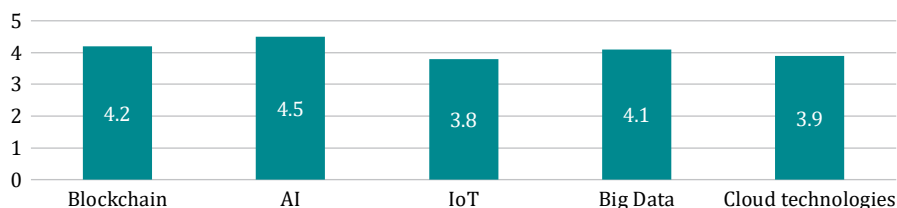


Figure 1. Average expert assessments of the potential of digital technologies in administrative legal regulation of the agricultural sector

Source: the survey was conducted on a 5-point Likert scale

The results of the expert evaluation illustrated in Figure 1 indicate the considerable potential of diverse digital technologies to enhance the administrative legal control of the agriculture industry. The analysis of the data shows a high appreciation of the potential of AI and blockchain technologies, which are considered as powerful tools for automating decision-making processes, analysing large amounts of data, and ensuring the reliability of information. The relatively high standard deviation of these technologies suggests the need for further research and experimental implementation. Big Data and cloud computing technologies also received high scores, highlighting their significance for data processing and storage in agricultural

production and regulatory activities. The Internet of Things (IoT), despite having a lower average score, demonstrates the potential to improve monitoring and control processes. The assessment results underscore the necessity for a holistic strategy in the deployment of digital technologies, emphasising the development of integrated solutions that consider the nuances of agricultural production and the demands of the "green transition". The findings also point to the significance of developing the regulatory framework and creating the appropriate infrastructure, including the development of standards to ensure interoperability of technological solutions and data protection and cybersecurity mechanisms.

The research identified significant risks and obstacles that could hinder the efficient use of digital technology in the administrative legal regulation of Ukraine's agricultural sector. The most significant factor, according to experts, is the lack of digital literacy of staff of both government agencies and business entities (30 respondents). This factor directly affects the speed and quality of the introduction of innovative technologies, as well as on the efficiency of their use in everyday practice. Data protection and cybersecurity issues were identified as the second most significant barrier (29 experts). Considering the sensitivity of the information processed under administrative legal regulation, ensuring an adequate level of data protection is critical to maintaining trust in digital systems and preventing possible misuse.

Experts also paid considerable attention to the economic aspects of digitalisation. Specifically, 25 respondents noted the prohibitive costs of implementing and maintaining digital systems as a substantial barrier. This concern is particularly pertinent for small and medium-sized agricultural firms that may lack adequate financial resources for comprehensive digital transformation. Moreover, 24 experts identified the inadequacy of the regulatory environment as a significant barrier to the implementation of digital technology. Specifically, the experts noted the lack of clear legal mechanisms for the use of electronic evidence, insufficient regulation of procedures for electronic interaction between government authorities and business entities, and uncertainty over the legal status of certain digital instruments (e.g., blockchain-based smart contracts). The dangers linked to the potential adverse effects of digitisation on the environmental facets of agricultural production were especially significant. 22 experts voiced apprehension about the possible rise in energy consumption resulting from the implementation of digital technologies, which could undermine the objectives of the green transition.

Furthermore, 21 respondents pointed to the risk of over-reliance on technology, which could lead to the loss of conventional knowledge and practices of sustainable land use.

Following an examination of expert perspectives and identified issues, a set of recommendations was developed for the efficient incorporation of digital technology into the administrative legal regulation procedures of Ukraine's agriculture industry. 33 specialists assert that the foremost objective is to formulate a comprehensive strategy for the digitalisation of administrative legal regulation within the agricultural sector, taking into account environmental considerations. Such a strategy should include clear goals, stages of digital technology implementation, and mechanisms for monitoring and evaluating the effectiveness of digital transformation. A crucial component of the approach must be the alignment of national legislation with international norms for digital regulation in the agricultural sector.

The second key recommendation, supported by 31 experts, concerns the creation of a single digital platform for interaction between government agencies and business entities in the agricultural sector. Such a platform should enable electronic reporting, obtaining permits, online consultations, and provide access to up-to-date information on changes in legislation and regulatory requirements. Special emphasis must be placed on incorporating modules for monitoring and regulating adherence to environmental regulations and standards within this platform.

The third important recommendation, which was supported by 32 experts, is the implementation of pilot projects on the use of blockchain for the certification of organic products. These initiatives will evaluate the efficacy and security of blockchain technology in practical applications, as well as establish methods for interaction among various stakeholders in the organic supply chain. Successful implementation of pilot projects

can become the basis for the large-scale implementation of blockchain in the system of administrative legal regulation of the agricultural sector.

The fourth recommendation, which was supported by 28 experts, concerns the development and implementation of digital literacy programmes for employees of government agencies and agricultural enterprises. Such programmes should include not only the technical aspects of working with digital tools, but also issues of information security, personal data protection, and legal aspects of using digital technologies in administrative legal regulation.

It is noteworthy to notice the recommendation to establish an incentive system for agricultural firms that actively adopt digital technology and comply with the principles of the “green transition”, as endorsed by 26 experts. Such incentives could include tax breaks, priority access to government support programmes, simplified reporting procedures, etc. This will accelerate the digitalisation of the industry and contribute to the achievement of sustainable development goals.

Development of proposals to improve administrative legal regulation mechanisms. The developed model for optimising the administrative legal regulation of the “green transition” in the agro-industrial complex should be implemented in national legislation by amending the existing regulations of Ukraine and developing new provisions that specify the mechanisms for implementing the proposed reforms. The basis for implementation should be the improvement of Ukraine’s environmental legislation, considering the provisions of the Constitution of Ukraine (1996), the Law of Ukraine No. 1264-XII “On Environmental Protection” (1991) and No. 2697-VIII (2019), as well as provisions on the protection of land, water resources, and atmospheric air. A national strategy for the “green transition” in the agro-industrial complex is offered, grounded in current state environmental strategies,

particularly within the context of the National Environmental Strategy.

The recommendations for national legislation include the development of comprehensive amendments to the Law of Ukraine No. 1264-XII “On Environmental Protection” (1991), namely Articles 13, 16, 31, 35, which would introduce new environmental standards for the agricultural sector. Specifically, it is necessary to add provisions on mandatory monitoring of the environmental impact of agricultural activities, including the collection of data on the use of pesticides, fertilisers, state of soil and water resources (a special unit is established to collect and analyse data based on modern technologies). To implement such mechanisms, it is proposed to amend the Law of Ukraine No. 962-IV “On Land Protection” (2003), supplementing Articles 34, 38, 40 and No. 2697-VIII (2019), supplementing Articles 9 and 12, which stipulates the need to establish new environmental standards for agricultural activities and introduce appropriate environmental monitoring at all levels.

The regional level of regulation envisages the adoption of additional regional environmental development programmes based on the provisions of Law No. 280/97-VR (1997) (Article 26), which will allow the national strategy to be adapted to local conditions. The regional programmes should include the establishment of regional environmental funds and environmental innovation centres to provide financial and technical support to agricultural enterprises in the implementation of environmentally friendly technologies. A significant step is the creation of regional funds that will accumulate funds from environmental taxes and fines to finance local environmental projects. This is possible through amendments to the legislation on local taxes and fees.

The local level of regulation envisages the mandatory introduction of environmental management at agricultural enterprises, which can

be regulated through subordinate regulations based on the provisions of Law 2694-XII “On Labour Protection” (1992), namely Article 18, which would oblige enterprises to develop individual environmental plans. Furthermore, environmental training mechanisms should be developed for employees of enterprises, which would ensure increased environmental awareness and responsibility.

Incentive mechanisms should include amendments to the Tax Code of Ukraine (2010) (Articles 14, 150), which would allow for tax benefits for enterprises that implement environmentally friendly technologies, as well as preferential lending and a system of green bonds to finance environmental innovations. At the same time, a system of sanctions and environmental insurance should be prescribed in legislation to encourage companies to follow the environmental regulations and minimise their environmental impact.

Ensuring transparency and accountability in the regulatory process is an essential aspect of the model. It is recommended to establish a comprehensive information system that would consolidate data on the environmental performance of agricultural operations, inspection outcomes, and implemented response actions, among other relevant information. This system should be accessible to the public, which would help to increase trust in regulatory authorities and encourage companies to take a responsible attitude towards the environment. It is also proposed to introduce a mechanism for public monitoring of the environmental condition of agricultural areas, including the creation of a network of public environmental inspectors and the development of mobile applications for prompt reporting of environmental violations.

The model includes provisions for modifying regulatory policy in response to technological advancements, market fluctuations, and environmental changes. It is proposed to establish

a permanent interagency working group on the green transition in the agricultural sector, which would coordinate the procedure of adapting the regulatory policy and ensure its consistency with Ukraine’s international environmental obligations. A crucial component is the establishment of a set of indicators to evaluate the efficacy of regulatory policy in the realm of agricultural greening, facilitating the swift identification of issues and the modification of regulatory mechanisms.

Discussion

The findings of the study on optimising the administrative legal regulation of the “green” transition in the agro-industrial complex of Ukraine demonstrated a comprehensive approach to solving environmental problems in the industry and are consistent with current global trends in sustainable agricultural development. A key element of the developed model is a differentiated approach to regulating diverse types of farms, which is consistent with the findings of S. Lowder *et al.* (2021), who analysed the structure of agricultural enterprises in several countries and emphasised the need to adapt policies to diverse types of farms. This proposal for a simplified regulatory system and additional incentives for small farms is in line with the recommendations of V. Ricciardi *et al.* (2021), who found that small farms are often more efficient in terms of biodiversity conservation and sustainable use of resources. The system of incentives and sanctions proposed in the model echoes the findings of E.F. Lambin *et al.* (2018), who investigated the effectiveness of various environmental policy instruments in the agricultural sector. The researchers emphasised the significance of combining financial and non-financial incentives, which is fully consistent with the approach. Specifically, the proposal to introduce “green tariffs” for agricultural products is consistent with the findings of E.-M. Meemken and M. Qaim (2021) on the positive influence of

price premiums on the adoption of sustainable practices in agriculture.

The research emphasised transparency and accountability within the regulatory framework, aligning with contemporary trends in environmental policy management. The proposal to establish a consolidated information system for the aggregation of data on the environmental performance of agricultural enterprises aligns with the research conducted by D.C. Rose *et al.* (2021), which highlighted the importance of digitalisation in enhancing the efficacy of environmental monitoring in agriculture. Furthermore, the examined method for establishing a mechanism for public oversight of the environmental status of agricultural regions aligns with the concept of “citizen science”, as explored by S.F. Ryan *et al.* (2018) within the framework of environmental governance. Moreover, the mechanism for adapting regulatory policy to changes in technology, market conditions, and environmental situation, which was proposed in the present study is in line with the principles of adaptive management explored by A. Botequilha-Leitão and E.R. Díaz-Varela (2020). The researchers emphasised the significance of flexibility and continuous learning for the effective management of complex ecological systems, which is fully consistent with the approach.

The analysis of green transition cases in various regions of Ukraine revealed the effectiveness of integrating the efforts of different stakeholders, which is in line with the concept of collaborative governance studied by Ö. Bodin *et al.* (2020). The researchers emphasised the significance of network structures and social capital for effective cooperation, which is in line with the recommendations for developing mechanisms for interaction between distinct levels of government. The conclusions on the significance of creating common platforms for dialogue and exchange of practices between distinct levels of government are also

consistent with the findings of C.J.A.M. Termeer *et al.* (2020), who analysed the mechanisms of vertical integration in environmental governance. Furthermore, a particularly interesting aspect of the study is the analysis of the scaling potential of successful local initiatives. The decisions on the key factors that determine the possibility of scaling up such initiatives to other regions are in line with the findings of P. Nicol (2020), who explored the processes of scaling up agroecological innovations. The researcher also emphasised the significance of a coherent regulatory framework and the development of knowledge sharing infrastructure, which is fully in line with the recommendations.

The SWOT analysis of the integration of local initiatives and centralised regulation revealed both potential opportunities and threats to this process. Specifically, the risk of uneven regional development identified in this study is consistent with the findings of E.B. Barbier and J.C. Burgess (2020), who analysed the spatial aspects of sustainable development. The researchers also emphasised the need to balance centralised regulation with local initiatives to ensure even development. Equally relevant is the emphasis on the development of training and experience exchange programmes for local authorities and agribusiness. J. Klerkx *et al.* (2019) underscored the importance of human capital development for the effective execution of innovations in agriculture.

The study also highlighted the importance of incorporating digital technology into the administrative legal regulation procedures of the agro-industrial complex. This aligns with the findings of C.B. Barrett *et al.* (2021), who examined the capacity of digital technologies to revolutionise food systems. The researchers emphasised the need to develop digital infrastructure and increase digital literacy in the agricultural sector, as well as address the issue of digital inclusion, which is fully in line with the study’s recommendations.

The proposals for the implementation of an environmental certification system for medium-sized enterprises are consistent with the study by P. Schleifer and Y. Sun (2020), who analysed the effectiveness of different certification systems in promoting sustainable practices in global supply chains. The empirical findings underscore the critical importance of contextualising certification frameworks to accommodate both regional specificities and diverse producer typologies, aligning comprehensively with the methodological approach. Furthermore, the study makes a substantial contribution through its rigorous examination of agro-cluster dynamics and their catalytic function in facilitating environmental sustainability transitions. A.E. Pigford *et al.* (2019) emphasised the role of creating common infrastructure and knowledge-sharing mechanisms within clusters, which is in line with the recommendations presented in the current study.

The research also focused on energy efficiency and the advancement of renewable energy sources within the agro-industrial sector. Proposals to promote the adoption of energy-efficient technologies align with the conclusions of V. Smil (2022), who examined the potential for energy transformation in agriculture. The researchers emphasised the need for a systematic approach to improving energy efficiency, which is fully consistent with the optimisation model.

The empirical evidence derived from this investigation into optimising administrative legal frameworks governing ecological transformation within Ukraine's agro-industrial sector demonstrates concordance with contemporary global paradigms in sustainable agricultural development and environmental stewardship. The theoretical model advanced herein acknowledges the inherent complexity and multidimensional character of agricultural ecological transition processes, proposing adaptive regulatory mechanisms characterised by sufficient flexibility. Particular

emphasis on synthesising grassroots initiatives with centralised regulatory approaches aligns with established principles of polycentric governance and collaborative environmental problem-solving methodologies. Nevertheless, the research illuminated several critical challenges and potential vulnerabilities warranting additional scholarly inquiry and strategic intervention. Of particular significance are the persistent tensions between economic imperatives and environmental objectives, coupled with the imperative to ensure equitable regional development trajectories within the context of ecological transformation – both of which remain compelling areas for subsequent investigation.

Conclusions

Through comprehensive empirical investigation, this research accomplished its primary objective of analysing contemporary approaches to administrative legal frameworks governing the agro-industrial sector's ecological transition, while developing evidence-based recommendations for regulatory enhancement to facilitate agricultural sustainability. The investigation encompassed a comparative analysis of administrative legal mechanisms facilitating environmental transformation across multiple jurisdictions, specifically examining regulatory frameworks in the United States, Germany, the Netherlands, Denmark, and Japan. This cross-national examination revealed convergent patterns in the establishment of integrated legislative structures that address multifaceted aspects of ecological transition, utilising both monetary and non-monetary policy instruments to catalyse sustainable development initiatives. The research methodology incorporated an assessment of digital technology's influence on both the formulation and execution of administrative legal provisions within the context of agricultural sector environmentalisation. A systematic expert consultation process illuminated the

substantial transformative capacity of emergent technologies - specifically blockchain systems, artificial intelligence applications, Big Data analytics, and Internet of Things infrastructure - in optimising regulatory oversight and monitoring protocols within agricultural operations. Drawing upon both the international comparative analysis and expert consultation findings, the research culminated in the development of strategic recommendations for enhancing administrative legal mechanisms governing ecological transition across national, regional, and local governance tiers within Ukraine's agro-industrial complex.

The empirical evidence garnered from this investigation bears substantial implications for advancing both theoretical frameworks and practical applications in administrative law governance of the agro-industrial sector, particularly concerning environmental imperatives and digital modernisation initiatives. The conceptualised optimisation framework for regulatory mechanisms encompasses several key elements: implementation of enhanced environmental compliance standards, establishment of incentive structures promoting ecological innovations, development of robust digital infrastructure, and augmentation of regulatory transparency. This framework presents a viable foundation for formulating a

comprehensive strategic approach toward ecological transition within Ukraine's agricultural domain. The comparative analysis of international best practices and their potential adaptation to the Ukrainian context yields particularly significant insights, encompassing both proposed amendments to current legislative frameworks and the formulation of novel regulatory instruments.

The investigation encountered notable methodological constraints, primarily concerning the insufficient availability of comprehensive statistical data regarding the impact of digital technologies on environmental performance indicators within Ukraine's agricultural sector. Such data limitations potentially compromise the precision of predictive models concerning the efficacy of the proposed regulatory frameworks. Consequently, future research endeavours should prioritize the development of robust methodological approaches for quantifying the agricultural sector's digital technology impacts, with the aim of generating statistically significant empirical evidence.

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Conflict of Interest

None.

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Адміністративно-правове регулювання агропромислового комплексу в умовах «зеленого» переходу

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Анотація

Метою дослідження було виявлення оптимальних шляхів адаптації національної правової бази до міжнародних стандартів з метою забезпечення сталого розвитку аграрного сектору та мінімізації екологічних ризиків. У рамках дослідження було проведено порівняльний аналіз моделей регулювання в таких країнах, як Сполучені Штати Америки, Німеччина, Нідерланди, Данія та Японія, які відзначаються високим рівнем екологічних стандартів та ефективним поєднанням фінансових і нефінансових інструментів стимулювання. Результати дослідження виявили спільні тенденції у створенні комплексних законодавчих рамок та використанні комбінації фінансових і нефінансових інструментів для стимулювання екологічного переходу. Експертне опитування показало значний потенціал цифрових технологій для вдосконалення регуляторних процесів. Виявлено ключові проблеми цифровізації: недостатнє фінансування, відсутність єдиної стратегії, низька міжвідомча координація. Розроблено модель оптимізації адміністративно-правового регулювання, яка включає впровадження нових екологічних стандартів, створення системи стимулів для «зелених» інновацій та розвиток цифрової інфраструктури. Запропоновано конкретні зміни до законодавства України, зокрема доповнення до Закону «Про охорону навколишнього природного середовища» щодо моніторингу впливу сільськогосподарської діяльності та створення єдиної інформаційної системи екологічних показників агропідприємств. Рекомендовано розробку нового Закону «Про екологічну сертифікацію в агропромисловому комплексі» та внесення змін до Податкового кодексу для введення податкових пільг екологічно відповідальним підприємствам. Дослідження продемонструвало необхідність комплексного підходу до регулювання зеленого переходу в агропромисловому комплексі з урахуванням міжнародного досвіду та потенціалу цифрових технологій. Отримані висновки можуть бути використані для формування національної політики сталого розвитку аграрного сектору, яка враховувала б як глобальні тенденції, так і місцеві особливості, забезпечуючи комплексний підхід до адміністративно-правового регулювання зеленого переходу

Ключові слова: екологічні стандарти; стале виробництво; цифрові технології; регуляторні інструменти; енергоефективність