Chapter 17

DIGITAL TRANSFORMATION OF CROP PRODUCTION AS A STRATEGY FOR CLIMATE CHANGE ADAPTATION

Shabatura T. S., Stepanova M. M., Yakovenko A. O.
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INTRODUCTION

Modern agriculture operates under conditions of radical climate transformations that increasingly affect the productivity, resilience, and economic efficiency of agrarian systems. Crop production, as the most sensitive subsector to external environmental factors, is under significant pressure from rising average annual temperatures, irregular precipitation, more frequent droughts, and extreme weather events. According to the IPCC[1] and FAO[2], Ukraine belongs to the regions with an elevated level of climate-related risks, which are already evident in the shifting of agroclimatic zones, soil degradation, yield losses, and declining economic stability of agricultural enterprises.

These challenges emphasize the need not only for conventional adaptation measures, such as crop variety changes or the introduction of irrigation, but also for a transition to a new agribusiness model – one that is climate-smart, resource-efficient, and technologically adaptive. In this context, the digital transformation of crop production emerges as a strategic response, enabling prompt reaction to environmental changes, precise planning of agrotechnical operations, and loss minimization through digital tools for monitoring, forecasting, and analytics.

A comprehensive investigation of the potential of digital technologies to enhance the climate resilience of Ukrainian crop production is thus essential. Particular attention should be paid to the application of agrodrones, satellite monitoring, the Internet of Things (IoT), precision agriculture systems, AI-based predictive models, and farm management platforms.

Moreover, international experience in agri-sector digitalization (notably in Israel, the United States, Canada, and EU countries) requires thorough

[1] Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report. Geneva, Switzerland, 2023. URL: https://www.ipcc.ch/ar6-syr/

[2] Food and Agriculture Organization of the United Nations (FAO). The impact of disasters and crises on agriculture and food security. Rome, 2021. URL: https://www.fao.org/3/cb3673en/cb3673en.pdf

analysis, with a view toward its contextual adaptation to Ukraine. It is relevant to assess the potential economic benefits of digital adoption, including yield improvement, cost reduction, risk minimization, and the enhancement of the investment attractiveness of agricultural enterprises under conditions of climate uncertainty and geopolitical turbulence.

The focus should not only be placed on the technological dimension, but also on the need for institutional support, state-backed incentives, the development of digital infrastructure, integration of international expertise, and the formation of partnerships that can ensure effective scaling of innovations. Digital transformation of agriculture must be considered a comprehensive strategy to enhance the adaptability and resilience of the agricultural sector under changing climate conditions.

1. Digital Transformation as a Strategic Response to Climate Challenges in Ukraine's Crop Production

Climate change has caused a noticeable shift in agro-climatic zones. Over the past 30 years, the boundaries of the steppe zone in Ukraine have moved northward by an average of 100–150 km. This shift creates new conditions for cultivating certain crops–such as maize in the Polissia region–but simultaneously increases the vulnerability of traditional agroecosystems to droughts and heat stress. The proportion of years with prolonged dry periods during the summer has increased significantly, reaching 40–60% in the southern regions. These climatic trends complicate the planning of field operations and compromise yield stability[3].

There has been a reduction in the duration of stable snow cover and a decline in the number of days with sub-zero temperatures. These changes are shifting the growing season; however, they do not always lead to increased productivity. While higher temperatures accelerate plant development, this effect–when combined with moisture deficiency–results in crop stress during the grain-filling stage and ultimately leads to reduced yield quality. In the southern regions, a systematic decline in water availability has been recorded. The moisture coefficient has dropped to a critical level (0.4–0.5), classifying these areas as zones of risk-prone agriculture. This trend severely limits the sustainability of traditional farming practices and increases the need for adaptive and resource-efficient technologies[4].

Climate change is contributing to an increase in pest reproduction cycles and the activation of phytopathogens. For instance, there has been a rise in

[3] Перспективи розвитку аграрного сектора України в умовах кліматичних змін : аналітична доповідь / НІСД. 2024. URL: https://niss.gov.ua/sites/default/files/2024-07/ad_klimagrosektor_03_07_24_zminena.pdf

[4] Територіальні органи Державного агентства водних ресурсів України // Державне агентство водних ресурсів України, 15.01.2025. URL: https://www.davr.gov.ua/teritorialni-organi

populations of the European corn borer and locusts, as well as the emergence of "atypical" diseases in wheat and maize–previously observed mainly in southern climates. Elevated temperatures and humidity during specific periods create favorable conditions for the development of fusarium and septoria infections.

According to estimates by the Ministry of Agrarian Policy and Food of Ukraine, average economic losses in the agricultural sector due to climate-related risks may exceed 15–20% of the expected crop value in certain years. In response, farmers are increasingly turning to crop insurance and investing in irrigation technologies, which, in turn, raises the cost of production and affects overall economic sustainability[5].

Within the framework of climate-oriented farming, particular attention is given to the introduction of crop varieties that are resistant to drought and heat stress. Examples include new maize hybrids with shorter vegetation periods and wheat varieties with enhanced heat tolerance. At the same time, digital models–specifically AI-based Decision Support Systems (DSS) – enable the adaptation of sowing dates, fertilizer application rates, and irrigation schedules to specific weather scenarios based on predictive forecasts.

According to the World Meteorological Organization (WMO, 2024)[6], the year 2023 recorded unprecedented levels of global warming: The average annual temperature exceeded the pre-industrial baseline by 1.48°C–the highest value ever observed. This contributed to an increase in the frequency and intensity of heatwaves, droughts, and floods across many regions of the world.

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2023)[7], states that the global average temperature has already exceeded +1.1°C compared to the pre-industrial era. If current trends persist, critical climate thresholds may be crossed by the middle of the 21st century. The agricultural sector–particularly crop production–is identified as the most vulnerable to climate change due to the increasing frequency of extreme weather events and the degradation of natural resources.

NASA research confirms that since 2015, the intensity of extreme weather events–such as droughts and floods–has significantly increased, correlating

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[5] Ministry of Agrarian Policy of Ukraine. Analytical report on the impact of climate on agriculture. Kyiv, 2023. URL: https://minagro.gov.ua

[6] World Meteorological Organization (WMO). 2024 is on track to be hottest year on record as warming temporarily hits 1.5°C. Baku, Azerbaijan, 11 November 2024. URL: https://wmo.int/media/news/2024-track-be-hottest-year-record-warming-temporarily-hits-15degc

[7] Intergovernmental Panel on Climate Change (IPCC). Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee & J. Romero (Eds.)]. IPCC, Geneva, Switzerland, 2023. pp. 1–34. DOI: 10.59327/IPCC/AR6-9789291691647.001. URL: https://www.ipcc.ch/report/ar6/syr/

with rising global temperatures[8]. An analysis of satellite data from 2002 to 2021 revealed an increase in both the frequency and intensity of such catastrophic events, with this trend intensifying notably after 2015, when air temperatures began to rise at record rates. Scientists have ruled out other climatic drivers, including El Niño, thereby confirming a direct link between global warming and the rise in extreme weather events. «Using GRACE and GRACE-FO satellite data, we reveal a significant increase in the intensity of hydroclimatic extreme events worldwide since 2015, closely correlated with rising global temperatures, highlighting the accelerating impact of climate change on the frequency and severity of droughts and floods»[9].

In Ukraine, the climate crisis is intensifying and becoming increasingly systemic. Between 1991 and 2017, the average annual temperature rose by 1.1°C compared to the 1961–1990 baseline. This warming has had a tangible impact on agriculture, forestry, and fisheries across the country[10]. The key challenges include soil degradation, altered precipitation patterns, the emergence of new pests and diseases, and declining yield stability.

Currently, Ukraine is experiencing the lowest levels of soil moisture reserves recorded over the past seven years. Precipitation between November and January totaled only 79.6 mm, compared to the multi-year average of 117 mm, resulting in insufficient soil moisture. Nearly all winter crop seedlings were underdeveloped due to a lack of rainfall during and prior to autumn sowing. In 2025, Ukrainian farmers planted 5.24 million hectares of winter cereals, predominantly winter wheat, which accounts for approximately 95% of the expected harvest. If weather conditions remain favorable, wheat yields may reach up to 25 million tonnes, compared to 22 million tonnes in 2024, primarily due to expanded sowing areas and improved climatic conditions[5].

The analytical report of the National Institute for Strategic Studies of Ukraine (Ivaniuta, 2020)[10] emphasizes the substantial impact of climate change across all sectors of the economy, with the agricultural sector being particularly affected. The report highlights the urgent need to implement adaptation measures, particularly digital technologies, which can optimize resource use, reduce vulnerability to risks, and enhance the stability of agricultural production.

The implementation of digital technologies in Ukraine's crop production is considered a priority adaptation strategy. These technologies include

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[8] NASA Earth Observatory. Climate Change Indicators. NASA, 2023. URL: https://earthobservatory.nasa.gov

[9] Rodell, M., & Li, B. (2023). Changing intensity of hydroclimatic extreme events revealed by GRACE and GRACE-FO. Nature Water, 1(3), 241–248. https://doi.org/10.1038/s44221-023-00040-5

[10] Іванюта С. П. (ред.). Зміна клімату: наслідки та заходи адаптації : аналіт. доповідь / С. П. Іванюта, О. О. Коломієць, О. А. Малиновська, Л. М. Якушенко. - Київ : НІСД, 2020. 110 с. - URL: https://niss.gov.ua/sites/default/files/2020-10/dop-climate-final-5_sait.pdf

precision farming systems, drones and satellite monitoring, weather forecasting using big data, and analytical models based on artificial intelligence. Such approaches help reduce the risk of crop loss, optimize input costs, and ensure stable yields even under growing climate threats.

At the same time, according to WMO data and analytical assessments, geopolitical instability and competition over resources are undermining the level of international technical and financial support. Analysts note that the world is increasingly moving toward a "lose-lose" paradigm, in which declining trust between countries hinders effective responses to shared challenges, particularly those related to climate change[11]. This is particularly critical for countries affected by armed conflicts, such as Ukraine.

In this context, it is of utmost importance to:

– maintain international scientific and technological partnerships;

– promote knowledge and technology exchange in the agricultural sector;

– adapt international practices to Ukrainian realities.

Integrating global climate adaptation experience at the national, regional, and local levels will enable Ukraine to preserve the innovative potential of its agricultural sector, even under conditions of limited access to external assistance.

Thus, in the context of climate change and geopolitical turbulence, the digital transformation of agriculture is not merely a technological trend but a critically important adaptation strategy. The use of digital technologies in crop production helps reduce vulnerability to climate risks, ensures food security, and enhances the efficient use of natural resources. Maintaining international cooperation–even under challenging conditions–is a key prerequisite for building long-term climate resilience in Ukraine's agroecosystems.

2. Key Digital Tools for Climate Change Adaptation in Crop Production

Amid rising climate risks, the digitalization of the agricultural sector has become a key pathway toward enhancing the resilience of agricultural production. Digital farming tools not only improve real-time responses to changing weather conditions but also enable strategic planning based on predictive analytics. The main directions of digital adaptation in crop production are outlined below.

Precision agriculture systems rely on the integration of GPS navigation, microclimate monitoring sensors, soil structure analysis, and spatial data processing. These systems allow farmers to apply fertilizers, seeds, and crop

[11] Євген Глібовицький: «Україна експортуватиме світові культуру поєднання свободи, добробуту і безпеки» // LB.ua. 11.11.2024. URL: https://lb.ua/news/2024/11/11/643999_ievgen_glibovitskiy_ukraina.html

protection agents in a site-specific manner, tailored to the precise needs of each field area.

The use of soil moisture sensors for irrigation management is gaining particular relevance: automated systems can optimize water use by 30–40%, which is critically important under drought conditions[12]. Variable rate technology (VRT) is also widely used, enabling the adaptation of agrotechnical operations to site-specific conditions within a single field. The outcome is not only an increase in crop yields, but also a reduction in input costs and environmental impact.

Unmanned aerial vehicles (UAVS), commonly known as agrodrones, have become an integral component of precision crop monitoring. They provide rapid acquisition of high-resolution imagery, which is processed to generate NDVI maps, detect crop stress zones, and identify weeds and pests at early development stages[13]. This enables timely intervention in the production process with minimal resource expenditure.

Equipped with thermal imaging cameras, drones are also capable of assessing soil moisture levels and detecting localized areas of water deficit. This is particularly important in the context of climate change adaptation, as it allows for targeted irrigation management and reduces water stress on agricultural fields.

Satellite monitoring (based on data from Sentinel-2, Landsat, PlanetScope) is employed for long-term spatial analysis. Multispectral imagery enables the identification of temperature anomalies, crop development dynamics, and the effectiveness of previous agrotechnical interventions. When combined with GIS analysis, it forms an agricultural intelligence system that serves as a foundation for adaptive planning[14].

Predictive analytics is a key tool for long-term adaptive planning. AI-based systems (such as CropX, Climate FieldView, AgroAnalytics) apply machine learning algorithms to analyze large volumes of agricultural data, including historical weather records, soil structure, satellite imagery, and farm-level information.

These systems enable the following:

– modeling yield variability scenarios under different climate conditions;

– conducting automated risk assessments to evaluate the feasibility of implementing new technologies;

– generating agrotechnical recommendations tailored to local conditions.

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[12] What is a soil sensor? // HENGKO. 2022-01-01. URL: https://www.hengko.com/uk/news/what-is-a-soil-sensor/

[13] Агродрони - Assistent Agro Group. URL: https://drone-aag.com.ua/catalog/agrodroni

[14] Satellite Monitoring for Large Agricultural Enterprises // EOS Data Analytics, 2024. URL: https://eos.com/uk/products/crop-monitoring/key-functions/satellite-monitoring/

In addition, integration with agricultural insurance through risk assessment modules ensures the financial resilience of farmers. For example, when critical crop stress levels are detected, the system can automatically generate an insurance notification with geolocation and a photographic report.

Next-generation online platforms – such as EOS Crop Monitoring, OneSoil, xFarm, and Agrohub – have become decision-making hubs for farmers. These platforms integrate satellite data, weather models, drone-derived indicators, and IoT sensor readings into user-friendly, visualized interfaces[15]. As a result, farmers gain real-time access to:

– alerts on critical weather events;

– fertilizer application recommendations based on biomass maps;

– yield forecasts that incorporate both historical and current data;

– field activity tracking and automated agro-analytics.

Integration with mobile applications enables rapid data transfer from the field to a central database, inclusion of machinery operators in the digital data loop, and the development of a transparent decision-making system. This is particularly relevant for medium and large farms, where centralized management of agricultural processes is essential.

The application of these digital solutions enables a shift from reactive to proactive scenario-based management–an essential component for ensuring the climate resilience of agroecosystems. According to estimates by the FAO[16] and the Ministry of Agrarian Policy of Ukraine[17], the comprehensive implementation of digital technologies can:

– increase crop yields by 10–30%;

– reduce the use of resources (water, crop protection products, fertilizers) by 20–40%;

– decrease the carbon footprint of agricultural production;

– improve the accuracy of climate risk forecasting to up to 85%.

In Ukraine, where the agricultural sector plays a pivotal role in the national economy, climate challenges demand immediate adaptation measures. The integration of digital technologies in crop production – such as precision farming systems, drones for crop monitoring, satellite data for weather forecasting, and big data analytics for optimizing agrotechnical operations – can significantly enhance the resilience of agrarian systems to climate change. These innovations contribute to reducing the risks associated with extreme

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[15] Онлайн-платформа «Агро Варта»: новий етап цифрового управління небезпечними відходами // European Business Association, 2025. URL: https://eba.com.ua/zapusk-onlajn-platformy-agro-varta-novyj-etap-tsyfrovogo-upravlinnya-nebezpechnymy-vidkhodamy/

[16] Food and Agriculture Organization of the United Nations (FAO). The impact of disasters and crises on agriculture and food security. Rome, 2021. URL: https://www.fao.org/3/cb3673en/cb3673en.pdf

[17] Ministry of Agrarian Policy of Ukraine. Analytical report on the impact of climate on agriculture. Kyiv, 2023. URL: https://minagro.gov.ua

weather events and ensure yield stability and productivity growth in the face of escalating climate threats.

At the same time, the IPCC emphasizes that the adaptive capacity of the agricultural sector can be significantly enhanced through technological modernization –particularly by leveraging digital solutions[18]. Such solutions include automated monitoring systems, AI-based predictive models, precision application of fertilizers and water, the use of agrodrones, and satellite analytics. These technologies not only reduce environmental pressure but also significantly enhance the climate resilience of agroecosystems – especially in vulnerable regions such as southern and eastern Ukraine.

The concept of "impact chains" offers a structured framework for analyzing how climate stimuli-such as rising temperatures or shifts in precipitation – trigger cascading effects within socio-ecological systems[19]. Its application enables the detailed tracking of cause-and-effect relationships between climatic phenomena and their impacts on crop yields, soil health, and the economic stability of farms. For example, an increase in drought frequency reduces soil moisture levels, which directly affects crop productivity. In response, an effective adaptation strategy involves the implementation of digital soil moisture monitoring systems and automated irrigation technologies.

This methodology deepens the understanding of how climate change mechanisms affect crop production and enables the development of targeted digital solutions to enhance climate resilience. At the same time, it supports the identification of priority directions for technological advancement.

The report by the National Institute for Strategic Studies of Ukraine also recommends the implementation of digital technologies as key instruments for strengthening the resilience of agricultural systems[20]. This involves optimizing resource use, increasing production efficiency, and reducing vulnerability to climate risks. In addition, the importance of integrating international climate adaptation experience and applying it within the Ukrainian context – at national, regional, and local levels – is strongly emphasized.

Thus, in the context of climate transformation and geopolitical instability, the digitalization of crop production is not merely a technological trend but a critically important adaptation strategy. The implementation of modern digital solutions enhances the climate resilience of agricultural systems, reduces losses associated with natural disasters, and ensures the stability of food production. This lays the foundation for a transition toward climate-smart,

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[18] Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report. Geneva, Switzerland, 2023. URL: https://www.ipcc.ch/ar6-syr/

[19] Агропродовольчі ланцюги: систематизація науково-методичних підходів та типізація / БНАУ. URL: https://rep.btsau.edu.ua/bitstream/BNAU/1646/1/agroprodovol%60chi_lancyugy%60.pdf

[20] Перспективи розвитку аграрного сектору України в умовах кліматичних змін / Національний інститут стратегічних досліджень. URL: http://niss.gov.ua/news/komentari-ekspertiv/tsyfrova-transformatsiya-ekonomiky-ukrayiny-lyutyy-2025-roku

resource-efficient, and innovation-driven agriculture.The adoption of these digital solutions enables a shift from reactive to proactive, scenario-based management – an essential component in ensuring the climate resilience of agroecosystems.

3. Economic Efficiency of Digital Transformation in Crop Production: Global and Ukrainian Experience

The economic feasibility of implementing digital technologies in crop production is determined not only by their potential to reduce input costs, but also by their ability to enhance decision-making efficiency, minimize crop losses, and improve the environmental sustainability of agroecosystems. In the context of climate variability, the accuracy of monitoring, forecasting, and adaptive planning becomes strategically important.

Studies show that the adoption of precision farming systems can reduce mineral fertilizer usage by 10–20%, water consumption by 15–25%, and increase crop yields by 8–15%, depending on the crop type and region[21]. The use of unmanned aerial vehicles (agrodrones) provides rapid monitoring of crop conditions, identification of stress zones, and optimization of agrotechnical operations – directly contributing to the reduction of unproductive expenditures and improvement in profitability.

A distinct role is played by the integration of satellite data and IoT-based solutions, which serve as the foundation for agro-analytics and decision support systems (DSS). These technologies grant farmers access to high-resolution field maps, soil moisture levels, temperature data, and crop development stages. When combined with artificial intelligence, they enable the precise timing and method of input application.

The economic efficiency of digital solutions is confirmed by the experience of agricultural enterprises in the EU, the United States, Canada, and Israel, where digital technologies have become key drivers of agricultural productivity. In the medium term, the return on investment (ROI) in digitalization ranges from 2 to 4 years, depending on the scale of implementation and the type of crops cultivated[22].

In the Ukrainian context, the effectiveness of digital solutions is demonstrated by agricultural enterprises in the southern and central regions of the country. For example, Agro-Industrial Production Institute LLC in Odesa Oblast implemented a precision farming system based on drone and satellite data, which resulted in an 18% reduction in crop protection product (CPP) costs and a 12% increase in sunflower yields. Integrated AgroSystems, a company based in Kirovohrad Oblast, utilizes IoT sensors for real-time soil

[21] Точне землеробство в Україні: визначення та перспективи // WeAgro. 2025. URL: https://weagro.com.ua/blog/tochne-zemlerobstvo-v-ukrayini-vyznachennya-ta-perspektyvy/

[22] Череп О. Г., Нагайець С. В., Веремієнко О. О., Семибратова Є. С. Впровадження сучасних цифрових технологій в аграрному секторі України // Актуальні проблеми економіки, 2024. URL: https://eco-science.net/wp-content/uploads/2024/01/1.24._topic_-Cherep-O.H.-Naha%D1%96ets-S.V.-Veremieienko-%D0%9E.%D0%9E.-Semibratova-Ye.S.-133-139.pdf

moisture monitoring, achieving up to 22% water savings during periods of critical drought.

Another example is the agricultural company Mayak in Poltava region, which, in collaboration with an agri-tech startup, implemented a system for forecasting the phytosanitary status of crops using artificial intelligence. This allowed the company to reduce pesticide use without compromising yield, thereby improving its environmental performance and lowering production costs.

For Ukraine – where the share of high-tech equipment in the agricultural sector remains relatively low – the integration of digital tools requires systemic government support, institutional development, and the promotion of public-private partnerships. This will help reduce innovation access barriers for small and medium-sized farms and foster a competitive, climate-resilient model of crop production.

To justify the economic feasibility of digitalizing agricultural production, it is appropriate to analyze key performance indicators related to the implementation of digital technologies in crop production – both in Ukraine and in leading agricultural countries. The table 1 below presents summarized data on the impact of digital solutions on yield levels, resource cost reductions, and the average investment payback period.

Table 1

Average Indicators of the Economic Efficiency of Digital Technologies in Crop Production (% change)

Country	Water savings (%)	Saving PPPs (%)	Yield growth (%)	Payback period (years)
Israel	23	22	23	2.0
United States	25	21	14	2.5
Canada	20	20	13	2.8
EU	20	19	12	3.0
Ukraine	18	18	10	3.5

The highest yield increase was recorded in Israel (20%), which can be attributed to the extensive use of intelligent systems for irrigation management, real-time crop monitoring, and weather tracking[23]. The United States (15%) and Canada (14%) demonstrate comparable yield improvements due to the active adoption of precision farming technologies, IoT solutions, and satellite monitoring systems. EU countries report an average yield increase of approximately 12%, reflecting the effectiveness of the European Green Deal's agricultural policy initiatives[24]. In Ukraine, the yield growth rate

[23] Краплинний полив: з історії Ізраїлю // Fermershop.com.ua, 2023. URL: https://fermershop.com.ua/uk/kapelnyy-poliv-iz-istorii-izrailya-u

[24] Linde N., Balian A., Shabatura T., Gryshova I., Yakovenko A., Hnatieva T. Artificial Intelligence in Waste Management in the Context of Implementing Circular Economy // Grassroots Journal of Natural Resources. – 2024. – Vol. 7, № 3. – P. s149–s172. – DOI: https://doi.org/10.33002/nr2581.6853.0703ukr08. – URL: https://grassrootsjournals.org/gjnr/nr.07-03ukr-08.lindeetal.pdf

stands at 10%, which indicates the positive impact of even partial digital technology adoption – particularly under the challenging conditions of climate change and ongoing military conflict[25].

Similarly, the indicators for resource cost reductions (mineral fertilizers, crop protection products, and water) demonstrate a significant positive effect. In the United States and Israel, savings reach 22–23%, while in EU countries and Canada, the figures range from 20–21%. In Ukraine, resource savings are recorded at approximately 18% – a promising result given the constraints of limited infrastructure and restricted access to high-tech equipment[26].

In terms of investment payback periods, the best results are observed in Israel (2 years), followed by the United States (2.5 years), Canada (2.8 years), and EU countries (3 years). In Ukraine, the average payback period is approximately 3.5 years, which remains acceptable in the context of long-term profitability and the potential for scaling digital solutions.

The presented data confirm the high potential of digital technologies in crop production as tools for enhancing productivity, improving resource efficiency, and reducing technological risks. Building on international experience, the integration of digital solutions into Ukrainian agricultural enterprises could serve as a catalyst for transitioning toward an innovation-driven, climate-resilient, and competitive model of agricultural production. At the same time, the creation of an enabling environment for the widespread adoption of innovations remains a pressing task–particularly through state support, the development of digital infrastructure, and the establishment of public-private partnership mechanisms.

Thus, the economic efficiency of digital technologies in crop production is confirmed both globally and within the Ukrainian context. However, to fully unlock their potential, it is essential to systematically address institutional and financial barriers. A comprehensive approach to promoting digitalization should become a priority of agricultural policy in light of ongoing climate and geopolitical challenges.

CONCLUSIONS

As a result of the conducted research, it has been substantiated that the digital transformation of crop production is a necessary condition for the adaptation of the agricultural sector to climate challenges, which have already acquired a systemic and long-term nature in Ukraine. It has been established that traditional agrotechnical approaches are gradually losing their effectiveness under conditions of changing precipitation patterns, rising

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[25] Linde N., Balian A., Shabatura T., Gryshova I., Petrenko O., Shevchenko A. Agricultural Technologies as a Tool for Integrating Artificial Intelligence into the Agricultural Infrastructure of Ukraine // Grassroots Journal of Natural Resources. - 2024. - Vol. 7, № 3. - P. s30–s51. - DOI: https://doi.org/10.33002/
nr2581.6853.0703ukr02. - URL: https://grassrootsjournals.org/gjnr/nr.07-03ukr-02.lindeetal.pdf

[26] Точне землеробство дозволило скоротити витрати на 10-20% та оптимізувати продаж зерна // SuperAgronom.com, 02.12.2024. URL: https://superagronom.com/news/19943-tochne-zemlerobstvo-dozvolilo-skorotiti-vitrati-na-10-20-ta-optimizuvati-prodaj-zerna

average temperatures, increased drought frequency, and the emergence of new pests and diseases.

Based on the analysis of the functionality of digital tools – such as drones, satellites, IoT devices, artificial intelligence, and decision support platforms – it has been demonstrated that their implementation enables a shift from reactive to proactive agricultural management. This facilitates accurate risk forecasting, optimization of resource use, cost reduction, and yield improvement.

The assessment of the economic performance of digital solutions, both at the international level and using examples from Ukrainian agricultural enterprises, indicates rapid investment payback, improved production profitability, and reduced environmental impact. At the same time, the importance of creating an enabling environment for digitalization is emphasized – including the development of digital infrastructure, state incentives, adaptation of international practices, and capacity building.

Thus, digital technologies emerge not merely as tools for improving efficiency, but as the foundation for shaping a climate-resilient, adaptive, and competitive agricultural model in Ukraine. The implementation of a digital transformation strategy in crop production should become one of the key priorities of agricultural policy in the context of climate change and post-conflict recovery.

SUMMARY

This article examines the digital transformation of crop production as a strategic response to climate challenges in Ukraine. Climate change is deteriorating the conditions for cultivating agricultural crops, necessitating new approaches to agro-industrial management. The study analyzes global trends and local practices in the adoption of digital technologies–such as agrodrones, satellite monitoring, precision agriculture systems, IoT devices, and AI-based models.

Their positive impact on yields, resource savings, and the reduction of production risks is demonstrated. Ukrainian case studies are explored to highlight the economic feasibility of digitalization in agriculture.

Based on the findings, strategic approaches are proposed for scaling up digital solutions, taking into account climate, economic, and institutional factors. This article will be of interest to researchers, farmers, managers, and policymakers in the agricultural sector. It lays the groundwork for developing a climate-resilient and innovation-driven agricultural system in Ukraine.

Bibliography

1. Агродрони – Assistent Agro Group. URL: https://drone-aag.com.ua/catalog/agrodroni

2. Агропродовольчі ланцюги: систематизація науково-методичних підходів та типізація / БНАУ. URL: https://rep.btsau.edu.ua/bitstream/BNAU/1646/1/agroprodovol%60chi_lancyugy%60.pdf

3. Євген Глібовицький: «Україна експортуватиме світові культуру поєднання свободи, добробуту і безпеки» // LB.ua. 11.11.2024. URL: https://lb.ua/news/2024/11/11/643999_ievgen_glibovitskiy_ukraina.html

4. Іванюта С. П. (ред.). Зміна клімату: наслідки та заходи адаптації: аналіт. доповідь / С. П. Іванюта, О. О. Коломієць, О. А. Малиновська, Л. М. Якушенко. – Київ : НІСД, 2020. – 110 с. – URL: https://niss.gov.ua/sites/default/files/2020-10/dop-climate-final-5_sait.pdf

5. Краплинний полив: з історії Ізраїлю // Fermershop.com.ua, 2023. URL: https://fermershop.com.ua/uk/kapelnyy-poliv-iz-istorii-izrailya-u

6. Онлайн-платформа «Агро Варта»: новий етап цифрового управління небезпечними відходами // European Business Association, 2025. URL: https://eba.com.ua/zapusk-onlajn-platformy-agro-varta-novyj-etap-tsyfrovogo-upravlinnya-nebezpechnymy-vidkhodamy/

7. Перспективи розвитку аграрного сектора України в умовах кліматичних змін: аналітична доповідь / НІСД. 2024. URL: https://niss.gov.ua/sites/default/files/2024-07/ad_klimagrosektor_03_07_24_zminena.pdf

8. Перспективи розвитку аграрного сектору України в умовах кліматичних змін / Національний інститут стратегічних досліджень. URL: http://niss.gov.ua/news/komentari-ekspertiv/tsyfrova-transformatsiya-ekonomiky-ukrayiny-lyutyy-2025-roku

9. Світовий досвід використання точного землеробства // efarm.pro, 2024. URL: https://efarm.pro/dotsilnist-vykorystannia-tochnoho-zemlerobstva-ta-svitovyi-dosvid/

10. Територіальні органи Державного агентства водних ресурсів України // Державне агентство водних ресурсів України, 15.01.2025. URL: https://www.davr.gov.ua/teritorialni-organi

11. Точне землеробство в Україні: визначення та перспективи // WeAgro. 2025. URL: https://weagro.com.ua/blog/tochne-zemlerobstvo-v-ukrayini-vyznachennya-ta-perspektyvy/

12. Точне землеробство дозволило скоротити витрати на 10-20% та оптимізувати продаж зерна // SuperAgronom.com, 02.12.2024. URL: https://superagronom.com/news/19943-tochne-zemlerobstvo-dozvolilo-skorotiti-vitrati-na-10-20-ta-optimizuvati-prodaj-zerna

13. Череп О. Г., Нагайєць С. В., Веремієнко О. О., Семибратова Є. С. Впровадження сучасних цифрових технологій в аграрному секторі України // Актуальні проблеми економіки, 2024. URL: https://eco-science.net/wp-content/uploads/2024/01/1.24._topic_-Cherep-O.H.-Naha%D1%96ets-S.V.-Veremieienko-%D0%9E.%D0%9E.-Semibratova-Ye.S.-133-139.pdf

14. Ministry of Agrarian Policy of Ukraine. Analytical report on the impact of climate on agriculture. Kyiv, 2023. URL: https://minagro.gov.ua

15. World Meteorological Organization (WMO). 2024 is on track to be hottest year on record as warming temporarily hits 1.5°C. Baku, Azerbaijan, 11 November 2024. URL: https://wmo.int/media/news/2024-track-be-hottest-year-record-warming-temporarily-hits-15degc

16. Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report. Geneva, Switzerland, 2023. URL: https://www.ipcc.ch/ar6-syr/

17. Linde N., Balian A., Shabatura T., Gryshova I., Petrenko O., Shevchenko A. Agricultural Technologies as a Tool for Integrating Artificial Intelligence into the Agricultural Infrastructure of Ukraine // Grassroots Journal of Natural Resources. – 2024. – Vol. 7, № 3. – P. s30–s51. – DOI: https://doi.org/10.33002/nr2581.6853.0703ukr02. – URL: https://grassrootsjournals.org/gjnr/nr.07-03ukr-02.lindeetal.pdf

18. Linde N., Balian A., Shabatura T., Gryshova I., Yakovenko A., Hnatieva T. Artificial Intelligence in Waste Management in the Context of Implementing Circular Economy // Grassroots Journal of Natural Resources. – 2024. – Vol. 7, № 3. – P. s149–s172. – DOI: https://doi.org/10.33002/nr2581.6853.0703ukr08. – URL: https://grassrootsjournals.org/gjnr/nr.07-03ukr-08.lindeetal.pdf

19. NASA Earth Observatory. Climate Change Indicators. NASA, 2023. URL: https://earthobservatory.nasa.gov

20. Rodell, M., & Li, B. (2023). Changing intensity of hydroclimatic extreme events revealed by GRACE and GRACE-FO. Nature Water, 1(3), 241–248. https://doi.org/10.1038/s44221-023-00040-5

Information about the authors:
Shabatura Tetiana Serhiivna,
Doctor of Economics, Professor,
Chief Researcher at the Department of Geographic Information Technologies, Management and Economic Research,
Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine,
24, Maiatska doroha str., Khlibodarske, Odesa region, 67667, Ukraine

Stepanova Margarita Mykhaylivna,
Candidate of Economic Sciences,
Head of the Department of Geographic Information Technologies, Management and Economic Research,
Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine,
24, Maiatska doroha str., Khlibodarske, Odesa region, 67667, Ukraine

Yakovenko Alla Oleksiivna,
Candidate of Economic Sciences, Associate Professor,
Senior Researcher at the Department of Geographic Information Technologies, Management and Economic Research,
Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine,
24, Maiatska doroha str., Khlibodarske, Odesa region, 67667, Ukraine