

Implementation of digital forms for integrated data processing and information analysis: A factor for sustainable development of agriculture

Maria Doneva¹, Iliana B. Nacheva¹, Petya Metodieva¹, Mihaela Mihailova Mihailova², Rumena Gandeveva³, Angel Stankov Sarov² and Boryana Kozareva^{4*}

¹ *Agricultural Academy, Institute of Cryobiology and Food Technologies, 1407 Sofia, Bulgaria*

² *Agricultural Academy, Institute of Agricultural Economics, 1113 Sofia, Bulgaria*

³ *Agricultural Academy, Fruit Growing Institute – Plovdiv, 4000 Plovdiv, Bulgaria*

⁴ *Agricultural Academy, Directorate „Library and Publishing Activities“, 1113 Sofia, Bulgaria*

*Corresponding author: bkozareva@gmail.com

Abstract

Doneva, M., Nacheva, I. B., Metodieva, P., Mihailova, M. M., Gandeveva, R., Sarov, A. S. & Kozareva, B. (2026). Implementation of digital forms for integrated data processing and information analysis: A factor for sustainable development of agriculture. *Bulg. J. Agric. Sci.*, 32(3), 526–532

The article examines the role of digital databases and information systems in the development of sustainable agriculture and support for scientific research. The main goal is to analyze to what extent integrated data processing improves scientific activity and decision-making in the agricultural sector, as well as to identify existing problems and opportunities for development.

To achieve this goal, a comparative analysis of various national and European institutional databases related to agriculture was applied. Systems of Eurostat, NSI, MAF, NRA, NSSI and other institutions were studied, and their accessibility, applicability and degree of integration were assessed. Additionally, Google Trends was used to track public interest in agricultural and institutional data.

The results show that the integrated data of Eurostat and NSI have the highest degree of applicability for scientific research, especially when assessing sustainable agricultural practices. However, a number of problems were identified - fragmentation of information systems, limited access to microdata and insufficient coordination between institutions. The study highlights the need for better integration, digitalization and open access to information, which would support both the scientific community and agricultural practice.

Keywords: database; information; digitalization; Sustainable Development Goals (SDGs); agriculture

Introduction

Agriculture represents one of the fundamental pillars of socio-economic development, which assigns it a leading role in both research and practical activities across numerous scientific disciplines. As an economic sector, agriculture encompasses two principal branches: crop production and animal husbandry. These activities constitute the foundation of the raw material supply base, food security, economic

growth, and sustainability (Kabadzkhova, 2022). In this context, a key characteristic of the agricultural sector is its strong reliance on scientific research, which provides the basis for the development of best practices and serves as a catalyst for innovation aimed at enhancing efficiency and achieving sustainable development goals.

Goal 2 of the United Nations Sustainable Development Agenda (United Nations, 2025) is directed toward ending hunger, achieving food security, improving nutrition, and

promoting sustainable agriculture. Achieving these objectives is challenged by a wide range of climatic, political, social, and economic factors (FAO, 2019). Scientific research plays a critical role in addressing these challenges by generating knowledge and solutions capable of responding to complex geopolitical and socio-economic issues at both national and international levels. Goal 17, “Strengthen the Means of Implementation and Revitalize the Global Partnership for Sustainable Development,” outlines a pathway for achieving these objectives through cooperation in capacity building, financing mechanisms, trade facilitation, multi-stakeholder partnerships, science, technology, market development, and the formulation of national strategies aligned with the Sustainable Development Goals. Such collaborative efforts are essential for supporting innovation and ensuring the effective implementation of sustainable development policies.

Sustainable development in agriculture has become the subject of extensive investigation across a broad range of scientific fields (Rao et al., 2018; Kociszewski, 2018; Kalinowska et al., 2022), including both disciplines directly related to agriculture and those that define interdisciplinary research domains and collaborative scientific teams (Wanto, 2023). Examples include agroecology, agricultural biotechnology, digital agriculture, smart farming, and, importantly, the development of institutional frameworks supporting these activities (Putsenteilo et al., 2020). This raises the critical issue of information provision for agricultural research, particularly the need to overcome the information gap and ensure equitable access to scientific data and knowledge for all stakeholders involved in the research process. One potential solution lies in the development of sustainable information systems (Fisher et al., 2021) capable of providing access to verified and relevant information through comprehensive databases, and the implementation of open-access policies.

The primary objective of this study is to evaluate the significance of integrated databases and information processing for agricultural research, public governance, and the advancement of sustainable agriculture, while also identifying the main challenges, limitations, and opportunities for their further improvement. Given the increasingly important role of emerging technologies in scientific research, the study seeks to address the challenges faced by both agricultural producers and the scientific community, recognizing them as key drivers and enabling factors for the sustainable development of the agricultural sector.

Materials and Methods

The present study was developed based on a comparative analysis of existing institutional and statistical databases

related to agriculture in Bulgaria and the European Union.

The analysis encompassed data sources and information systems maintained by various institutions, including Eurostat, the Ministry of Agriculture and Food, the National Statistical Institute, the National Revenue Agency, the National Social Security Institute, the Employment Agency, the Integrated Administration and Control System (IACS), the Bulgarian Food Safety Agency, and others. For each database, the available indicators, level of accessibility, potential applications for scientific research, and existing limitations were systematically evaluated.

The methodological framework is based on a qualitative comparative analysis through which the principal categories of information were identified and systematized. Particular attention was given to the challenges associated with data collection and database integration, including system fragmentation, restricted access to microdata, and insufficient interoperability among institutional information systems. In addition, Google Trends analysis was employed to examine the dynamics of public interest in institutional and agricultural databases over time. By comparing variations in search intensity, an attempt was made to identify potential relationships between public attention, economic developments, and changes in agricultural policies.

The methodological approach is inherently interdisciplinary, combining elements of agricultural economics, statistical analysis, and information systems management. This integrated framework enables a comprehensive assessment of the availability, accessibility, and applicability of agricultural databases for scientific research and evidence-based policy development.

Results and Discussion

The role of databases in the development of agricultural research

In the context of rapidly advancing scientific progress, information technologies have assumed an increasingly important role in research activities. Among the principal tools supporting contemporary scientific investigations are databases. These constitute organized systems for the storage, processing, and management of information, enabling researchers to collect, analyze, and exchange substantial volumes of data more efficiently. The utilization of such systems creates opportunities for expanding multidisciplinary research and for accelerating the transfer of scientific findings into practical applications.

The role of databases is particularly significant across both the natural and exact sciences, as well as in social science research. Historically, the storage and processing

of information were conducted primarily through paper-based records, which considerably limited access to scientific findings and slowed the progress of research activities. Today, the development of digital technologies provides access to vast amounts of scientific information within seconds. Consequently, databases are no longer viewed solely as repositories for archiving information, but rather as fundamental components of scientific organization and knowledge management. They facilitate the systematic structuring of data and support the development of innovative ideas, methodologies, and technologies. According to Mousavi et al. (2017), modern data storage and processing systems are essential for the achievement of scientific and educational objectives.

Beyond ensuring the reliable storage of information, databases play a crucial role in fostering collaboration among researchers. Every day, a substantial number of scientific publications, experimental results, and statistical analyses are generated worldwide. Without appropriate data management systems, handling such volumes of information would be exceedingly challenging. This situation underscores the necessity of developing automated knowledge management systems capable of providing rapid and efficient access to relevant information (Figueiredo and Pereira, 2017). Through the use of the Internet and digital technologies, researchers from different countries can collaborate on common projects regardless of geographical distance. This contributes to more effective knowledge exchange and facilitates international scientific cooperation.

At the same time, the use of databases imposes important requirements related to information organization, governance, and security. Inadequate storage practices or insufficient protection mechanisms may result in the loss of valuable scientific data. Therefore, the development and maintenance of reliable information management systems are of critical importance for ensuring the integrity, accessibility, and long-term preservation of scientific knowledge (Hine, 2006).

The role of databases is particularly significant in the agricultural sector, which remains one of the most important branches of the economy and society, as it provides essential food resources and raw materials for numerous industries. The continuous growth of the global population and the increasing need for more efficient agricultural production have amplified the importance of modern technologies within the agri-food sector. In this context, databases have become a fundamental tool for both scientific research and practical agricultural management. Despite the progress achieved in digital systems, Carvalho et al. (2025) emphasize that research on database modeling in agriculture remains relative-

ly limited, particularly concerning the complex interactions among soil, water, plants, and the surrounding environment.

Agricultural research generates substantial volumes of information related to climatic conditions, soil characteristics, precipitation patterns, temperature regimes, crop yields, and plant diseases. The systematic storage and management of these data enable the long-term monitoring of agricultural processes and facilitate the assessment of climate change impacts on agricultural production systems. Consequently, more effective strategies can be developed to support the adaptation of agriculture to changing environmental conditions.

Databases also play a crucial role in plant and animal breeding programs. They facilitate the processing and analysis of information concerning the genetic characteristics of various crop varieties and livestock breeds, thereby supporting the development of more resilient crops and more productive animal populations. This function is particularly important in the context of climate change and increasing constraints on natural resources. According to Chao et al. (2023), the successful integration of such systems requires active collaboration among researchers, institutions, policymakers, and stakeholders across the agricultural sector.

Another important area of application is the development of so-called “precision agriculture.” This approach is based on the use of advanced technologies, including Global Positioning System (GPS) technologies, sensors, unmanned aerial vehicles (UAVs), and satellite imagery, which facilitate the collection of detailed information regarding soil and crop conditions. These data are processed through specialized software platforms and database systems (Ngo and Kechadi, 2020). Such technologies enable more precise resource management and support the determination of optimal quantities of water, fertilizers, and plant protection products for specific agricultural fields. In addition to improving productivity, this approach contributes to reducing production costs and minimizing adverse environmental impacts.

Databases are also widely applied in the monitoring and management of plant diseases and pests. Through the analysis of information collected from different regions, predictive models can be developed to forecast the spread of specific diseases, thereby enabling the timely implementation of mitigation measures. This capability is of considerable importance for preventing economic losses within the agricultural sector. Similar systems are employed in livestock production, where they support the management of information related to breeds, nutrition, animal health, and productivity. The analysis of these datasets facilitates more efficient farm management practices and contributes to improvements in product quality.

Despite their numerous advantages, the implementation and utilization of database systems are associated with several challenges. These include the need for reliable collection, processing, and analysis of high-quality data, as well as the provision of adequate technical and financial resources for the development of appropriate systems and analytical models (Mthembu et al., 2024). Furthermore, the management of large-scale datasets requires highly qualified specialists and advanced technological infrastructure. For this reason, many countries are investing in the development of digital technologies and capacity-building initiatives aimed at strengthening both scientific research and the practical application of modern information systems in agriculture.

The growing importance of databases in agricultural research and management extends beyond their technical applications, and is increasingly reflected in patterns of public and institutional demand for information. As digital information systems become integral to decision-making processes, understanding societal interest in these databases provides valuable insights into their practical relevance and utilization. To explore these dynamics, the present study employs Google Trends data to examine changes in public attention toward selected agricultural and institutional databases and to identify potential relationships with economic, policy, and sector-specific developments.

Google Trends data reveal significant fluctuations in public interest toward agricultural and institutional databases over

time, reflecting changing economic conditions, labor market dynamics, and policy developments. Searches related to institutions such as the National Social Security Institute (NSSI), Employment Agency, National Statistical Institute (NSI), National Revenue Agency (NRA), Ministry of Agriculture and Food, and Ministry of Finance demonstrate both long-term trends and short-term spikes associated with reforms, subsidy programs, employment crises, tax deadlines, and economic uncertainty (Fig. 1). The comparative analysis of search intensity indicates that databases connected to employment, taxation, and social security generate higher public attention during periods of economic instability, while agricultural databases show increased interest during subsidy campaigns, policy changes under the Common Agricultural Policy (CAP), and climate-related agricultural challenges. Furthermore, the observed seasonality and variability in search behavior highlight the growing dependence on digital institutional information systems and underline the importance of publicly accessible databases for researchers, policymakers, businesses, and citizens seeking timely and reliable information.

Agricultural databases are of critical importance for both research institutions and farmers, because they provide accurate, systematic, and accessible information necessary for informed decision-making, innovation, and sustainable agricultural development. For research institutions, agricultural databases serve as essential tools for conducting scientific analyses, developing econometric and forecasting models,

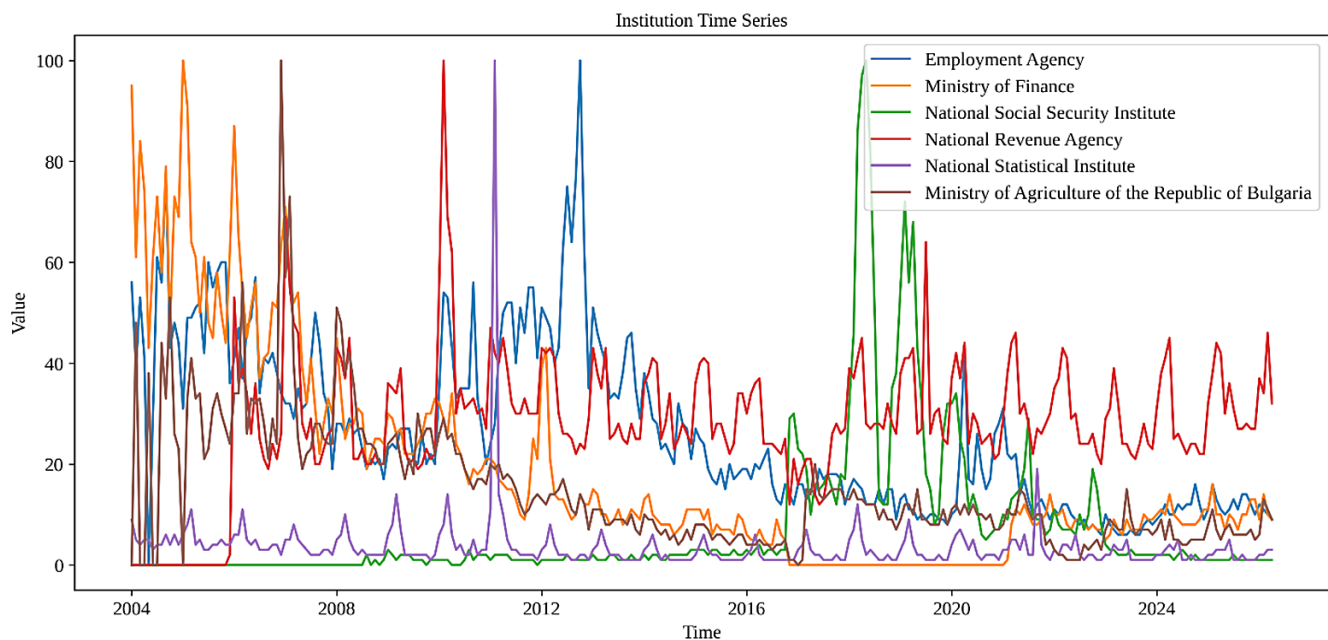


Fig. 1. Google Trends

Source: own research of Google trends for Bulgaria

monitoring market and production trends, and evaluating the impacts of agricultural policies, climate change, and technological innovations. Access to long-term and harmonized datasets improves the reliability of empirical studies and supports interdisciplinary research in areas such as food security, rural development, environmental sustainability, and

bioeconomy. At the same time, farmers benefit from agricultural databases through improved access to information on market prices, subsidies, weather conditions, land use, production technologies, and labor availability, which enhances farm management and reduces uncertainty in decision-making (Table 1). Digital agricultural information systems also

Table 1. Integration and modernization of agricultural databases

Database / Institution	Available data for agriculture	Lack / Problems with the database	Possible data that can be gathered but currently is not
Farm Structure Survey (FSS) / Eurostat	Agricultural holdings, land use, livestock, labor input, farm holder demographics, farm typology, rural development indicators, regional agricultural structure	Conducted every 3 - 4 years, limited real-time updates, insufficient environmental indicators, restricted access to micro data, weak integration with national databases	Precision agriculture adoption, greenhouse gas emissions, biodiversity indicators, soil quality, water consumption, farm digitalization, renewable energy use
Ministry of Agriculture and Food (MAF/MZH)	Subsidies, land use, crop production, livestock registers, CAP implementation data, agricultural policies	Fragmented systems, inconsistent historical datasets, limited public accessibility, weak interoperability	Farm-level profitability, irrigation efficiency, climate adaptation practices, pesticide and fertilizer intensity, smart farming technologies
National Statistical Institute (NSI)	Agricultural production statistics, employment, prices, rural demographics, economic indicators, regional statistics	Aggregated data often lack farm-level detail, delays in publication, insufficient integration with environmental data	Agricultural carbon footprint, farm innovation indicators, food waste statistics, precision farming indicators
National Revenue Agency (NRA/NAP)	Tax declarations, registered agricultural producers, business turnover, VAT information	Limited accessibility for research, confidentiality restrictions, weak linkage to agricultural production data	Informal agricultural economy estimates, farm investment behaviour, financial resilience indicators
National Social Security Institute (NOI)	Agricultural employment, insured workers, pensions, labor market dynamics	Seasonal and informal labor often underreported, limited farm-specific labor analysis	Migrant labor flows, labor shortages, workforce digital skills, occupational safety indicators
Employment Agency	Rural employment, unemployment, labor programs, workforce qualification data	Limited agricultural specialization, insufficient linkage to farm productivity and mechanization	Agricultural labor mobility, seasonal workforce forecasting, precision agriculture training participation
Ministry of Finance	Agricultural budget expenditures, CAP co-financing, fiscal indicators, public investment	Data are macroeconomic and highly aggregated, limited agricultural operational detail	Long-term agricultural investment monitoring, climate-related financial risk exposure, green finance indicators
Integrated Administration and Control System (IACS)	Subsidy applications, parcel identification, land declarations, CAP compliance	Limited researcher access, administrative focus rather than analytical design	Real-time land use monitoring, biodiversity compliance, carbon farming indicators
Bulgarian Food Safety Agency (BFSA)	Animal health, veterinary controls, food safety inspections, disease outbreaks	Limited interoperability with agricultural production and environmental databases	Traceability systems, antimicrobial usage, animal welfare indicators, food chain sustainability metrics
Cadastre and Land Registry	Land ownership, parcel boundaries, land transactions	Fragmented ownership records, inconsistencies in agricultural land categorization	Land concentration dynamics, land degradation monitoring, land market accessibility indicators
Meteorological Databases (NIMH)	Weather conditions, precipitation, temperature, drought indicators	Often insufficiently linked to agricultural productivity databases	Farm-level climate risk exposure, predictive drought impact models, crop stress monitoring
Remote Sensing / Satellite Data (Copernicus, Sentinel)	Land cover, crop monitoring, vegetation indexes, drought monitoring	Limited integration into Bulgarian agricultural statistical systems	Automated yield prediction, carbon sequestration estimates, precision irrigation management
Research Institutes and Universities	Scientific studies, experimental farm data, regional analyses	Data often fragmented, project-based, non-standardized, and not centrally integrated	National agricultural innovation databases, open-access experimental datasets, longitudinal sustainability monitoring

Source: own research

support precision agriculture practices by enabling better resource allocation, productivity optimization, and risk management. Consequently, the integration and modernization of agricultural databases contribute not only to scientific advancement but also to increased competitiveness, resilience, and sustainability within the agricultural sector.

The integration and expansion of agricultural databases in Bulgaria can create substantial opportunities for future research development, particularly in the fields of agricultural economics, sustainability, rural development, climate adaptation, and digital transformation. The combination of data from the Farm Structure Survey (FSS), Ministry of Agriculture and Food, National Statistical Institute (NSI), National Revenue Agency (NRA), National Social Security Institute (NOI), Employment Agency, environmental monitoring systems, and remote sensing technologies provides a strong foundation for interdisciplinary and evidence-based scientific analysis. By linking structural, economic, environmental, financial, and labor-related datasets, researchers can develop more advanced econometric models, predictive analytics, spatial analyses, and policy evaluation frameworks. Furthermore, the modernization and digital integration of these databases would support the development of precision agriculture research, climate risk assessment, carbon farming studies, biodiversity monitoring, and analyses related to the European Green Deal and the Common Agricultural Policy (CAP). Expanding database interoperability and improving access to anonymized microdata would significantly enhance the capacity of research institutions to conduct longitudinal and comparative studies at regional, national, and European levels. In this context, agricultural databases represent not only a statistical resource, but also a strategic infrastructure for scientific innovation, technological advancement, and sustainable agricultural development in Bulgaria and the European Union.

Conclusions

The analysis demonstrates that interest in agricultural databases is significantly influenced/correlated by the availability of public funding opportunities, measures implemented under the Common Agricultural Policy (CAP), economic uncertainty, and emerging climate-related challenges. The collection of integrated databases and their transformation into reliable and actionable information play a crucial role in the advancement of science, particularly in the field of agricultural research. Such databases facilitate the systematic collection and analysis of information, support the development of innovative technologies, enhance the efficiency of agricultural production systems, and constitute a fundamen-

tal prerequisite for sustainable development. By providing comprehensive and accessible data resources, they enable researchers to identify and address challenges related to food security, climate change adaptation, and the conservation of natural resources more effectively and efficiently.

For the purposes of this study, an analytical framework was developed in the form of a summary table encompassing the available datasets, identified limitations, and potential directions for the expansion of existing information systems. This approach enables an assessment of the opportunities for integrating economic, environmental, climatic, and technological indicators within a unified information environment capable of supporting both scientific research and practical decision-making in agricultural management. The findings obtained may serve as a foundation for future research on sustainable development, agricultural digitalization, climate adaptation, and the enhancement of the effectiveness of agricultural policies.

References

- Carvalho, H. F. De S., Bezerra, L. M. C. & Rosa, F. de F.** (2025). Database Models in Agriculture: a systematic review. *Cadernos de Ciência & Tecnologia*, 42, e27757. DOI: <https://doi.org/10.35977/01041096.cct2025.v42.27757>.
- Chao, H., Zhang, S., Hu, Y., Ni, Q., Xin, S., Zhao, L., Ivanisenko, V. A., Orlov, Y. L. & Chen, M.** (2023). "Integrating omics databases for enhanced crop breeding". *Journal of Integrative Bioinformatics*, 20(4), 20230012. <https://doi.org/10.1515/jib-2023-0012>.
- FAO.** (2019). Climate-smart agriculture and the Sustainable Development Goals: Mapping interlinkages, synergies and trade-offs and guidelines for integrated implementation. Rome.
- Figueiredo, M. S. N & Pereira, A. M.** (2017). Managing knowledge – the importance of databases in the scientific production. *Procedia Manufacturing*, 12, 166–173. International Conference on Sustainable and Intelligent Manufacturing, RESIM 2016, 14–17 December 2016, Leiria, Portugal.
- Fisher, J., Arora, P., Chen, S., Rhee, S., Blaine, T. & Simangan, D.** (2021). Four prepositions on integrated sustainability: Toward a theoretical framework to understand the environment, peace, and sustainability nexus. *Sustain. Sci.*, 16, 1125–1145.
- Hine, C.** (2006). Databases as Scientific Instruments and Their Role in the Ordering of Scientific Work. *Social Studies of Science*, 36(2), 269–298. Published By: Sage Publications, Ltd.
- Kabadzhova, M.** (2022). Attractiveness of the agricultural sector to achieving generational renewal. *Bulg. J. Agric. Sci.*, 28(1), 3–9.
- Kalinowska, B., Bórawski, P., Beldycka-Bórawska, A., Klepacki, B., Perkowska, A. & Rokicki, T.** (2022). Sustainable Development of Agriculture in Member States of the European Union. *Sustainability*, 14, 4184. <https://doi.org/10.3390/su14074184>

- Kociszewski, K.** (2018). Sustainable development of agriculture - theoretical aspects and their implications. *Economic and Environmental Studies*, 18, No. 3(47), 1119–1134, September 2018.
- Mousavi Chalak, A., Riahi, A. & Zare, A.** (2017). Students' awareness, use of and satisfaction with scientific databases and their related factors at Mazandaran University of Medical Sciences (2016-2017). *Educ. Res. Med. Sci.*, 6(2), 84–90.
- Mthembu, T. L., Kunz, R., Gokool, S. & Mabhaudhi, T.** (2024). The Use of Agricultural Databases for Crop Modeling: A Scoping Review. *Sustainability*, 16(15), 6554. <https://doi.org/10.3390/su16156554>.
- Ngo, V. M. & Kechadi, M. T.** (2020, January). Crop knowledge discovery based on agricultural big data integration. In: *Proceedings of the 4th International Conference on Machine Learning and Soft Computing*, 46–50.
- Putenteilo, P., Klapkiv, Y., Karpenko, V. & Gvozdecka, I.** (2020). The role of institutions in the development of agriculture. *Bulg. J. Agric. Sci.*, 26(1), 23–33.
- Rao, N. C., Bathla, S., Kumar, A. & Jha, G. K. (2018). Agriculture and sustainable development goals: an overview and issues. *Agricultural Economics Research Review*, 31(conf), 1. <https://doi.org/10.5958/0974-0279.2018.00016.2>.
- United Nations Department of Economic and Social Affairs** (2025). The Sustainable Development Goals Report 2025. New York. (Revision August 2025).
- Wanto, H. S.** (2023). Sustainable agricultural policy strategy through increasing food crop productivity in Indonesia. *Bulg. J. Agric. Sci.*, 29(2), 223–228.

Received: December, 02, 2025; Approved: February, 10, 2026; Published: June, 2026