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Neural network models for statistical analysis and tax planning in agrarian economy

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Abstract. Modern agricultural economy faces a number of challenges, including climate change, market volatility and the need to improve management efficiency. In the context of digitalisation, the introduction of intelligent tools, in particular neural network models for statistical analysis and tax planning, is of particular importance. This study provided an overview of current approaches to the application of artificial neural networks (ANNs) in the agricultural sector. MLP, CNN, RNN, RNN, LSTM architectures and their hybrid variants used for yield forecasting, tax burden estimation, subsidy planning and financial risk analysis were considered. The aim of this study was to identify the potential of neural network models to improve the efficiency of statistical analysis and tax planning in the agricultural economy, as well as to determine their role in the formation of digital management decision support systems. The paper systematised the main areas of application of neural networks in agrarian economy, gave examples of effective solutions and substantiated the practical significance of ANNs for decision support under uncertainty. Special attention was paid to the integration of ANNs into digital platforms of the agrarian sector and the formation of intelligent systems to support fiscal management. The

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analysis confirmed the high adaptability and forecasting accuracy of neural networks and emphasised the need to develop digital infrastructure and regulatory framework for their widespread implementation. The results of the study can be used in developing strategies for sustainable agricultural development and improving the economic sustainability of agricultural enterprises. The work is of interest to researchers, developers of digital solutions and specialists in the field of agricultural policy

Keywords: artificial intelligence; predictive modelling; fiscal policy; digital agriculture; sustainable development; yield prediction; intelligent decision support systems

Introduction

In the context of accelerating digitalisation of the economy, the agricultural sector is also undergoing a significant transformation due to the need to adapt to new challenges: climate change, growing global competition, fluctuations in prices for products and resources, increasing requirements for efficiency and transparency of management. One of the key tasks of modern agricultural economy is to ensure sustainable development of agricultural enterprises by optimising production, financial and tax processes on the basis of objective data and modern analytical tools. In this context, intelligent methods of data analysis, including artificial intelligence technologies and, in particular, neural networks, are becoming increasingly relevant (Bassine *et al.*, 2023). As noted by M. Al-Adhaileh & T. Aldhyani (2022), the agricultural economy is inherently characterised by a high degree of uncertainty and seasonality, which makes traditional economic modelling and forecasting difficult. Parameters such as crop yields, subsidy levels, tax burden, market prices and logistics costs are subject to numerous fluctuations and depend on a variety of factors, from weather conditions to public policy decisions. In this situation, neural network models become a reliable decision support tool both at the individual farm level and in public fiscal policy formulation (Mansoor *et al.*, 2025). As pointed out by Y. Adhitya *et al.* (2023), the use of neural network models that can identify hidden non-linear dependencies in data and learn from historical information is becoming a powerful tool for analysing and making management decisions.

Effective tax planning is of particular importance in the management of agricultural enterprises. According to A. Berguiga *et al.* (2023), with limited access to financial resources and instability of tax laws, agricultural producers need a reliable mechanism for estimating current and future tax liabilities. Traditional tax calculation methods often fail to account for industry specificity, seasonality and subsidies, leading to unreliable forecasts and risks of fiscal instability (Garg *et al.,* 2021). Neural networks allow to form individualised forecasts of tax burden taking into account multidimensional parameters: profitability level, asset structure, volume of benefits, regional coefficients, price fluctuations, etc. As pointed out in their work F. Huber *et al.* (2022), the application of artificial neural networks (ANN) in agricultural economics opens new opportunities for processing a large amount of statistical information. Unlike classical econometric models, which are limited by linear dependencies and require prior assumptions, ANNs are able to learn from incomplete and noisy data, identify complex relationships and adapt to new input conditions (Islam *et al.,* 2024). According to J. Logeshwaran *et al.* (2024), this is particularly important for analysing economic indicators from various sources – accounting records, tax returns, agricultural statistics, subsidy and credit programmes.

In recent years, there has been a growing interest in the use of artificial intelligence in the agribusiness sector. Pilot projects are being implemented in many countries to introduce digital solutions in agribusiness: from monitoring crop yields using drones to managing finances using intelligent systems. An important area of digitalisation is the automation of accounting processes, which is confirmed by the successful experience of implementing modern information systems in the public sector in Albania, where automation has significantly improved the efficiency of financial information processing (Hoxha *et al.,* 2025). However, as noted by Z. Sbai (2025), most of such projects in the agricultural sector focus on technological aspects – field automation, precision farming and crop health monitoring. At the same time, financial and economic instruments, including tax planning models, remain underdeveloped.

Thus, the generalised analysis confirms that the use of neural network models (MLP, CNN, as well as LSTM) in agrarian economics contributes to improving the quality of forecasts and forming more informed decisions in the field of tax planning and financial flow management. The aim of this paper was to conduct an analytical review and systematisation of existing approaches to the application of neural network models for statistical analysis and tax planning in agrarian economy. The objectives of the study were: to systematise the main areas of application of neural network models in the agricultural sector, including yield forecasting, tax burden estimation and subsidy planning; to describe and classify the most common neural network architectures (MLP, CNN, RNN, LSTM) and their hybrid variants used in agricultural economics; to analyse the key advantages of neural network models, such as improved forecast accuracy, ability to detect non-linear dependencies and adaptability to regional conditions; to justify the use of neural network models in statistical analysis and tax planning in the agricultural economy; to analyse the key advantages of neural network models, such as improved forecasting accuracy, ability to detect non-linear dependencies and adaptability to regional conditions.

Materials and Methods

The present study is an analytical review of modern approaches to the application of neural network models in the tasks of statistical analysis and tax planning in agrarian economy. The methodological basis of the work included system and comparative analysis, as well as a substantial review of publications in the leading scientific databases Scopus, Web of Science and Google Scholar. The following keywords were used for the search: "neural networks in agriculture", "tax planning using AI", "crop yield prediction with deep learning", "agricultural economics and machine learning". The criteria for selecting sources were: publication in peer-reviewed journals in the last 5-10 years, availability of practical examples or empirical validation of models, as well as the relationship of the work to tax planning, financial analysis or risk management in agriculture. Special attention was paid to publications containing the results of applying neural network architectures to solve applied problems in the agricultural sector. Comparative analysis was carried out in the following areas: yield forecasting – models for analysing data on climate, soil, agrotechnics; tax planning – use of neural network algorithms for modelling tax burden and subsidies; financial analysis – profitability assessment, forecasting revenues and expenses; risk management – identification of uncertainty factors and reduction of fiscal instability. When systematising the publications, the type of neural network architecture was taken into account:

- MLP (Multi-Layer Perceptron) – most effective for analysing tabular economic data, including income, expenditure and tax payment indicators;
- CNN (Convolutional Neural Networks) – applicable for processing spatial and visual data, such as satellite images of fields for yield estimation;
- RNN and LSTM (Recurrent Neural Networks, Long Short-Term Memory) – allow to work with time series, which is important for forecasting price dynamics, seasonality of crops and tax revenues;
- hybrid models – combine the advantages of neural networks (NN) and traditional methods (regression, decision trees), increasing the accuracy of forecasts and interpretability of results, especially in models of complex analysis of taxes and subsidies.

In addition, the study took into account the criteria of applicability of the models at different levels of management – from individual farms to state structures. Both experimental prototypes and tested solutions already implemented in digital agribusiness platforms were analysed. The work also considered the integration of neural network algorithms with accounting, financial forecasting and tax administration systems, which allowed for assessing their potential not only in the technological but also in the institutional context. Thus, the methodological approach of the study was based on the integration of modern scientific data, systematic comparison of different architectures and their applicability to the key tasks of agrarian economy.

Results and Discussion

The analysis of publications devoted to the application of neural network models in agrarian economics allows for identifying several key areas of their use that have the greatest potential for statistical analysis and tax planning. First of all, neural network models are successfully used for forecasting financial indicators of agricultural enterprises, including revenue, profit, cost structure and tax burden. The most popular in this area are multilayer perseptrons (MLP) and convolutional neural networks (CNN), which are able to efficiently process multivariate data and identify complex relationships between economic variables. For example, R. Manogna *et al.* (2025) proved the effectiveness of MLPs in predicting agricultural commodity prices, while the study of I. Attri *et al.* (2023) showed many examples of successful application of CNNs and RNNs to accelerate economic growth. At the same time, the study by T. Saranya *et al.* (2020) and M. Bhavana & K. Rao (2025) confirm that the application of neural network architectures improves the accuracy of forecasting yields and financial outcomes in highly variable environments.

Comparison with classical econometric models also demonstrates the advantages of neural networks. A. Chlingaryan *et al.* (2018) and A. Mahin (2025) note that the prediction accuracy of neural network algorithms is higher when working with non-linear dependencies and incomplete data. This is especially true in highly variable agricultural markets and climatic factors, where linear models are often not sufficiently reliable. In addition, the use of neural networks in management decision support systems (MDSS) is an important trend (Albanese *et al.,* 2021). Such systems allow to automate the assessment of tax risks, analyse the consequences of different tax policy options and form recommendations on tax optimisation in agrarian farms. Integration of neural network models into management decision support systems provides adaptation to regional conditions, tax incentives, asset structure and seasonal features of agricultural production (Adkisson *et al.,* 2021). This makes it possible to form individualised forecasts and improve the accuracy of economic calculations taking into account territorial specifics.

A separate group consists of studies that use neural network algorithms to assess the impact of climate and weather factors on the economic performance of agribusinesses. I. Malashin (2024) demonstrated the potential of deep learning for predicting crop yields under climate variability, which is directly related to the estimation of future income and tax base of enterprises. Similarly, A. Chlingaryan *et al.* (2018) showed that the use of machine learning to analyse agro-climatic data can significantly improve the accuracy of yield forecasts compared to classical models. Moreover, the studies of G. Kamilaris & F. Prenafeta-Boldú (2018) confirmed that the application of convolutional and recurrent neural networks is effective when dealing with spatial and temporal data (e.g., satellite images and meteorological series), which makes it possible to take into account seasonal and climatic risks when developing agroeconomic strategies. In turn, R. de Oliveira & R. de Souza e Silva (2023) addressed crop management and forecasting, as well as disease and pest management.

Neural network models not only improve forecasting of economic indicators, but also contribute to the comprehensive consideration of climate risks, making tax planning more accurate and resilient to external fluctuations. This approach is particularly relevant for calculating taxes that depend on production, yields or natural conditions, and can be used to justify the application of tax exemptions in times of force majeure (Pérez-Pérez *et al.,* 2024). The review showed that one of the most promising tasks is the modelling of tax burden taking into account subsidies and state support, especially in countries with a developed system of agricultural regulation. Thus, M. Yakubov *et al.* (2023) proposed to use neural networks to forecast regional tax revenues in the agricultural sector, emphasising the importance of including the parameters of subsidies and benefits in the model. In turn, P. Adekemi (2025) showed that artificial intelligence methods can identify tax risks and prevent unfair practices. The practical effectiveness of digital innovations in the financial accounting of agricultural enterprises is confirmed by concrete results: the introduction of automated systems for processing financial data and the use of machine learning technologies allow not only to increase the accuracy of accounting operations, but also significantly improve economic performance (Hnatyshyn *et al.,* 2025). Additionally, A. Alawode *et al.* (2024) point out that the integration of artificial intelligence (AI) in agricultural economic forecasting allows regional subsidies, price fluctuations and institutional regulatory mechanisms to be taken into account, making tax models more adaptive and practically meaningful. Thus, modelling tax burden using neural network algorithms opens new perspectives for the development of financial planning tools capable of taking into account the impact of public policies, subsidies and benefits on the sustainability of the agricultural sector. Under these conditions, neural networks allow taking into account not only direct tax payments, but also indirect fiscal impacts associated with subsidy mechanisms, compensations, as well as tax deductions and deferrals (Chlingaryan *et al.,* 2018). It has also been established that the efficiency of neural network models significantly depends on the quality and volume of available data, which makes relevant issues of information preprocessing, feature normalisation, handling missing values and class imbalance. Thus, K. Liakos *et al.* (2018) in their review emphasise that the correct processing of raw data and their harmonisation to common formats is a key condition for the successful application of machine learning in agriculture.

The problem of dealing with missing values and limited datasets is analysed in detail in the study by A. Chlingaryan *et al.* (2018), where it is shown that the use of data reconstruction techniques and hybrid algorithms can improve the reliability of predictions under agrarian uncertainty. In addition, G. Kamilaris & F. Prenafeta-Boldú (2018) emphasise the need for class balancing in agricultural object classification tasks (e.g. soil types or crop classes), as sampling imbalance can distort the training results of neural networks. Scientific works confirm that data preprocessing and preparation play no less important role than the model architecture itself and largely determine its accuracy and stability. The use of modern approaches to data preparation (feature engineering) and regularisation methods makes it possible to increase the models' resistance to overtraining and improve the interpretability of the results. Comparative analysis has shown that hybrid models combining neural network architecture with traditional analytical tools such as linear regression, principal component methods and decision trees provide maximum accuracy of tax burden forecasting. M. Abedin *et al.* (2022) in their review note that the combination of machine learning methods and classical statistical tools allows for more accurate modelling of tax planning and consideration of state support factors. Similar results are obtained in the study of P. Sharma *et al.* (2023), where the integration of deep learning and regression methods demonstrated high efficiency in the development of models of agrarian economy management.

R. de Oliveira & R. de Souza e Silva (2023) emphasise that the integration of neural network algorithms with decision trees and factor analysis methods significantly increases the interpretability of results and the adaptability of models to regional conditions, which is especially important in the tasks of financial forecasting and tax planning. In addition, the review of K. Liakos *et al.* (2018) confirms that hybrid approaches in the agricultural sector have an advantage by combining the ability of neural networks to detect non-linear dependencies and the robustness of traditional econometric methods to noise and omissions in the data. This confirms the effectiveness of a combined approach that combines the capabilities of artificial intelligence and economic logic.

The results of the review show that neural network models are an effective tool for analysing and forecasting economic and fiscal processes in the agrarian economy. They are highly adaptive, robust to noise in the data and capable of modelling complex relationships, which makes them particularly valuable in the uncertainty characteristic of agriculture (Kamilaris & Prenafeta-Boldú, 2018). However, the full integration of such models into practice requires further development of digital infrastructure, improvement of data quality and the formation of normative approaches to the use of AI in the management of agricultural systems. Table 1 summarises the main neural network architectures and their functions to illustrate their potential in agricultural economics and tax planning tasks.

Table 1. Overview of neural network models and their application in agricultural economics

Type of model	Functions	Application in agrarian economy
MLN (Multilayer Perseptron)	Suitable for forecasting based on structured tabular data, easy to implement	Forecasting of revenues, expenditures, tax burden
CNN (Convolutional Neural Networks)	Effective for analysing spatial and visual data (e.g. satellite images, yield maps)	Crop image analysis, biomass estimation
RNN (Recurrent Neural Networks)	Applied to sequential data, modelling temporal dependencies	Prediction of prices, resource consumption, yields by seasons
LSTM (Long Short-Term Memory)	Improved version of RNN, stores information over long time intervals	Modelling the impact of climate cycles on production
Hybrid models (NN + decision tree, etc.)	Combining neural networks with other algorithms to improve accuracy and interpretability	Integrated modelling of taxes, subsidies, production decisions

Source: compiled by the authors based on the analysis of scientific publications

Table 1 is a classification of the main types of neural network models used in agricultural economics, indicating their key features and areas of practical use. The table includes both basic architectures (multilayer perseptron – MLP, convolutional neural networks – CNN, recurrent neural networks – RNN, modifications of LSTM type) and hybrid models that combine the capabilities of neural networks with other machine learning algorithms. The peculiarities of each architecture in terms of structure and analytical capabilities are considered, as well as examples of tasks in which these models have shown high efficiency. These include tax forecasting, satellite image analysis, modelling of seasonal and climatic factors, integrated planning based on production and fiscal data. The presented review demonstrates the broad potential of neural network approaches within the digital transformation of the agricultural sector, especially in the context of developing decision support systems and tax modelling. As an illustration, Figure 1 presents the structure of a neural network model applicable to statistical analysis and tax planning in the agrarian economy.

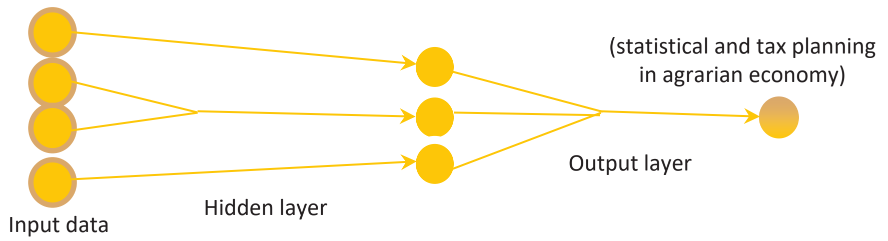

Figure 1. Structure of neural network model for statistical analysis and tax planning in agrarian economy
Source: compiled by the authors

Figure 1 shows the basic architecture of a feed forward neural network model consisting of three layers: input layer, hidden layer and output layer. The input layer accepts input data such as economic indicators, taxes, subsidies, climate and agricultural resources. The latent layer processes the input information using internal weights and activation functions, revealing non-linear relationships between variables. The output layer generates predicted values that are interpreted as results of statistical analyses and fiscal planning in the agricultural economy. The framework is used for decision support, tax burden modelling, subsidy optimisation and economic efficiency assessment of agricultural production. The presented review demonstrates the broad possibilities of applying neural network approaches within the digital transformation of the agricultural sector, especially in the context of developing decision support systems and tax modelling. As can be seen in Figure 1, the structure of the neural network model reflects the main stages of data processing, and Table 2 summarises the directions of practical application of neural networks in the agricultural economy.

Table 2. Applications of neural networks in agrarian economics

Field from application	Type of model	Problem description
Yield forecast	RNN / LSTM	Forecasting of yields by season, taking into account weather conditions
Tax burden estimation	MLP / Decision Tree	Calculation of taxes and levies based on historical financial data
Subsidy planning	CNN + MLP	Determining optimal allocation of government support
Cost management	MLP	Forecasting resource costs (seeds, fuel, machinery, etc.)
Climate risk modelling	RNN LSTM +	Analysing the impact of droughts, rainfall and temperature on crop yields
Assessment of agribusiness performance	Hybrid modelling (NN + econometrics)	Profitability and efficiency analytics based on AI algorithms

Source: compiled by the authors based on analytical synthesis of scientific publications

Table 2 presents a summarised list of key benefits of using neural network models in agricultural economics. Six main areas in which neural networks demonstrate their effectiveness are presented: improvement of forecasting accuracy, processing of complex and hidden dependencies between data, adaptation to regional conditions of agricultural production, automation of analytical processes and reporting, the possibility of integration into digital agricultural platforms, as well as support for strategic planning and management of tax and investment decisions. Each benefit is accompanied by a brief description of its relevance for digitalisation and sustainability of the agricultural sector. The presented characteristics emphasise the relevance of implementing artificial intelligence in the management of agricultural systems and the development of intelligent decision support tools.

The review confirms that neural networks have significant advantages for the agricultural economy: they allow more accurate forecasting of crop yields and tax burden, identify hidden dependencies in data, take into account regional peculiarities and integrate into the digital infrastructure of "smart agriculture". The main benefits of using neural network models are summarised in Table 3.

Table 3. Advantages of using neural networks in the agricultural economy

Advantage	Description
Increase in the accuracy of forecasts	Neural networks provide more accurate predictions than classical models, especially in the case of complex dependencies between parameters
Processing of non-linear and hidden dependencies	Ability to identify hidden patterns in economic and climate data
Adaptation to regional conditions	Models take into account local agricultural specificities and can be trained on regional data
Automate analytics and reporting	Reduce reporting time and human error in analyses
Integration into digital platforms	Compatible with smart agriculture platforms and AI infrastructure
Support strategic planning	Support tax, investment and risk management solutions

Source: compiled by the authors based on an analysis of the academic literature

Table 3 summarises the key benefits of implementing neural network technologies in the practice of agricultural management and economic analysis. The most significant areas in which artificial neural networks provide added value are presented: from improving the accuracy of forecast calculations to adapting models to local conditions and automating reporting procedures. Each benefit is accompanied by an explanation of its practical significance – whether it is the processing of complex multivariate dependencies, reducing the burden on economic specialists or extending the functionality of digital platforms in the agro-industrial complex. The systematisation of these advantages highlights the relevance and prospects of using neural networks as a tool for digital transformation of the agrarian economy, aimed at improving the efficiency and sustainability of management in changing conditions.

Neural network models such as MLP, CNN, RNN, LSTM and their hybrid combinations with econometric algorithms have been effectively applied for yield forecasting, calculating tax burden, modelling the impact of climate risks and assessing agribusiness performance (Khan & Yairi, 2018). These models are able to account for non-linear and hidden dependencies between economic, climatic and fiscal indicators, making them more accurate and adaptive than traditional analytical tools. Thus, neural network technologies can significantly improve the quality of management decisions in the agricultural economy, provide adaptation to regional conditions, increase the transparency of tax planning and the sustainability of agricultural enterprises. However, for the successful integration of AI in the agricultural sector, further efforts are needed to develop digital infrastructure, improve the quality of source data and form a regulatory and legal framework governing the application of intelligent technologies in the agricultural sector.

The results of the review confirm the growing interest of the scientific community in the application of neural network models in the agricultural economy, especially in the context of statistical forecasting and tax planning. However, despite the obvious effectiveness of such approaches, there are a number of theoretical and practical issues that require more in-depth study. Firstly, neural network models demonstrate high accuracy in the presence of large datasets, but the agricultural sector in a number of regions, especially in developing countries, suffers from a lack of quality and structured data. This limits the ability to train models and requires the implementation of better data processing techniques, including mechanisms for missing value immunisation, normalisation and class balancing.

Secondly, there is a significant difference in the performance of neural networks depending on the choice of architecture and training parameters. A number of studies emphasise that MLP and RNN models are susceptible to overtraining, especially when the amount of data is small and the number of training samples is limited. For example, A. Chlingaryan *et al.* (2018) note that simple neural network architectures can lose generalisability when analysing agrarian data with high variability. Similar conclusions are drawn in a study by G. Kamilaris & F. Prenafeta-Boldú (2018), where it is stated that when dealing with small volume agricultural datasets, MLP and RNN networks show a decrease in accuracy and the need for regularisation techniques. In a study by K. Liakos *et al.* (2018) also emphasises that the choice of architecture and training parameters has a critical impact on the accuracy of predictions, and the use of LSTMs and hybrid models capable of accounting for complex temporal dependencies is recommended to reduce the risk of overtraining. At the same time, hybrid approaches combining neural networks with econometric methods produce more stable and interpretable results. This raises the question of the need for further development of explainable AI, which is particularly important for fiscal and tax decisions, where validity and transparency of models are required.

A third important aspect is the integration of neural networks into real-world decision support systems in agricultural policy and economic management. Despite the development of prototypes and conceptual solutions, their practical application is hampered by the lack of a regulatory framework, IT infrastructure limitations and a shortage of qualified specialists in the field of agricultural digitalisation. This is especially true for tax modelling tasks, where it is necessary to take into account dynamic changes in the regulatory framework, subsidy system and economic specifics of regions. In addition, an ethical and legal aspect arises when discussing the implementation of AI in tax planning. The use of models that make decisions based on historical data may lead to implicit discrimination of certain categories of households. Consequently, when building neural network systems, it is necessary to take into account the principles of fairness, transparency and accountability, which requires the participation of not only technical specialists, but also lawyers, economists and representatives of government agencies. Thus, despite the obvious prospects, the application of neural network models in agrarian economics requires an interdisciplinary approach that combines technical accuracy with economic logic and regulatory expediency.

Conclusions

This review has shown that neural network models have significant potential in the tasks of statistical analysis and tax planning in agrarian economy. Their ability to process large volumes of multidimensional data, to identify hidden and non-linear relationships between economic, climatic and fiscal parameters makes them an effective tool in conditions of uncertainty characteristic of agricultural production. The analysis of publications has confirmed that the use of neural networks can significantly improve the accuracy of forecasting yields, tax burden and financial indicators compared to classical econometric methods. The most promising for the agricultural sector are MLP, RNN, LSTM architectures, as well as hybrid models, which combine the capabilities of neural networks with classical methods of analysis (regression, decision trees, principal component methods). These approaches have been successfully applied to solve problems of yield forecasting, tax burden assessment, optimisation of subsidy allocation and strategic planning in agriculture. Special attention in the analysed studies is paid to the problems of quality of initial data. It is revealed that correct preprocessing, normalisation of attributes and dealing with missing values have a decisive influence on the accuracy of models. The development of digital infrastructure, the creation of specialised databases for agriculture and the formation of a regulatory framework for the application of AI in the agricultural sector are also important areas. It is necessary to take into account the issues of interpretability, transparency and reliability of AI systems, especially in the context of fiscal decision-making and public resource management.

Prospects for further research are related to the development of more interpretable hybrid models, the integration of neural network algorithms into "smart agriculture" platforms, as well as the creation of tools to take into account climate risks and regional specifics. An important direction will be the development of intelligent decision support systems capable not only of forecasting economic indicators, but also of offering optimal scenarios for tax planning, subsidy distribution and risk management. Of additional interest is the integration of neural network models with big data, blockchain and Internet of Things technologies, which will enable the formation of more sustainable and transparent value chains in the agricultural sector.

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Conflict of Interest
The authors declare no conflict of interest.

References
[1] Abedin, M.Z., Chi, G., Uddin, M.M., Satu, M.S., Khan, M.I., & Hajek, P. (2021). Tax default prediction using feature transformation-based machine learning. *IEEE Access*, 9, 19864-19881. doi: 10.1109/ACCESS.2020.3048018.
[2] Adekemi, P. (2025). Leveraging artificial intelligence to promote international tax compliance. *Journal of Advanced Public International Law*. doi: 10.2139/ssrn.5245928.
[3] Adhitya, Y., Mulyani, G.S., Köppen, M., & Leu, J.-S. (2023). IoT and deep learning-based farmer safety system. *Sensors*, 23(6), article number 2951. doi: 10.3390/s23062951.
[4] Adkisson, M., Kimmel, J.C., Gupta, M., & Abdelsalam, M. (2021). Autoencoder-based anomaly detection in smart farming ecosystem. *arXiv:2111.00099*. doi: 10.48550/arXiv.2111.00099.
[5] Al-Adhaileh, M.H., & Aldhyani, T.H.H. (2022). Artificial intelligence framework for modeling and predicting crop yield to enhance food security in Saudi Arabia. *PeerJ Computer Science*, 8, article number e1104. doi: 10.7717/peerj-cs.1104.
[6] Alawode, A., Blessing, A.O., & Chiamaka, O.T. (2024). Integrating IoT and AI in sustainable agriculture to mitigate environmental risk and financial misuse. *International Journal of Research Publication and Reviews*, 5(12), 2810-2828. doi: 10.55248/gengpi.6.0625.2187.
[7] Albanese, A., Nardello, M., & Brunelli, D. (2021). Automated pest detection with DNN on the edge for precision agriculture. *IEEE Journal on Emerging and Selected Topics in Circuits and Systems*, 11(3), 458-467. doi: 10.1109/JETCAS.2021.3101740.
[8] Attri, I., Awasthi, L.K., Sharma, T.P., & Rathee, P. (2023). A review of deep learning techniques used in agriculture. *Ecological Informatics*, 77, article number 102217. doi: 10.1016/j.ecoinf.2023.102217.
[9] Bassine, F.Z., Epule, T.E., Kechchour, A., & Chehbouni, A. (2023). Recent applications of machine learning, remote sensing, and IoT approaches in yield prediction: A critical review. *arXiv:2306.04566*. doi: 10.48550/arXiv.2306.04566.
[10] Berguiga, A., Harchay, A., Massaoudi, A., Ayed, M.B., & Belmabrouk, H. (2023). GMLP-IDS: A novel deep learning-based intrusion detection system for smart agriculture. *Computers, Materials & Continua*, 77(1), 379-402. doi: 10.32604/cmc.2023.041667.
[11] Bhavana, M., & Rao, K.S. (2025). Deep learning models for crop yield prediction in South India based on climate change. *International Journal of System Assurance Engineering and Management*. doi: 10.1007/s13198-025-02929-8.
[12] Chlingaryan, A., Sukkarieh, S., & Whelan, B. (2018). Machine learning approaches for crop yield prediction and nitrogen status estimation in precision agriculture: A review. *Computers and Electronics in Agriculture*, 151, 61-69. doi: 10.1016/j.compag.2018.05.012.
[13] de Oliveira, R.C., & de Souza e Silva, R.D. (2023). Artificial intelligence in agriculture: Benefits, challenges, and trends. *Applied Sciences*, 13(13), article number 7405. doi: 10.3390/app13137405.
[14] Garg, S., Pundir, P., Jindal, H., Saini, H., & Garg, S. (2021). Towards a multimodal system for precision agriculture using IoT and machine learning. *arXiv:2107.04895*. doi: 10.48550/arXiv.2107.04895.
[15] Hnatyshyn, L., Prokopyshyn, O., Maletska, O., Keleberda, T., & Pylypenko, K. (2025). Digital innovations in accounting as economic growth factors of an enterprise. *Scientific Bulletin of Mukachevo State University. Series "Economics"*, 12(1), 75-89. doi: 10.52566/msu-econ1.2025.75.
[16] Hoxha, E., Angjeli, A., & Bombaj, F. (2025). Implementation of modern information systems for automating accounting processes in the public sector: The experience of Albania. *Scientific Bulletin of Mukachevo State University. Series "Economics"*, 12(1), 61-74. doi: 10.52566/msu-econ1.2025.61.
[17] Huber, F., Yushchenko, A., Stratmann, B., & Steinhage, V. (2022). Extreme gradient boosting for yield estimation compared with deep learning approaches. *arXiv:2208.12633*. doi: 10.48550/arXiv.2208.12633.
[18] Islam, M.M., Alharthi, M., Alkadi, R.S., Islam, R., & Masum, A.K.M. (2024). Crop yield prediction through machine learning: A path towards sustainable agriculture and climate resilience in Saudi Arabia. *AIMS Agriculture and Food*, 9(4), 980-1003. doi: 10.3934/agrfood.2024053.
[19] Kamilaris, G., & Prenafeta-Boldú, F.X. (2018). Deep learning in agriculture: A survey. *Computers and Electronics in Agriculture*, 147, 70-90. doi: 10.1016/j.compag.2018.02.016.
[20] Khan, M.A., & Yairi, N. (2018). A review on the application of deep learning in system health management. *Mechanical Systems and Signal Processing*, 107, 241-265. doi: 10.1016/j.ymssp.2017.11.024.
[21] Liakos, K.G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors*, 18(8), article number 2674. doi: 10.3390/s18082674.

[22] Logeshwaran, J., Srivastava, D., Kumar, K.S., Rex, M.J., Al-Rasheed, A., Getahun, M., & Soufiene, B.O. (2024). Improving crop production using an agro-deep learning framework. *BMC Bioinformatics*, 25, article number 341. doi: 10.1186/s12859-024-05970-9.
[23] Mahin, A.N., Adnan, N., & Khondoker, R. (2025). Precision agriculture using machine learning and deep learning algorithms: A comprehensive study. *Research Square*, preprint. doi: 10.21203/rs.3.rs-6589718/v1.
[24] Malashin, I., Tynchenko, V., Gantimurov, A., Nelyub, V., Borodulin, A., & Tynchenko, Y. (2024). Predicting sustainable crop yields: Deep learning and explainable AI tools. *Sustainability*, 16(21), article number 9437. doi: 10.3390/su16219437.
[25] Manogna, R.L., Dharmaji, V. & Sarang, S. (2025). Enhancing agricultural commodity price forecasting with deep learning. *Scientific Reports*, 15, article number 20903. doi: 10.1038/s41598-025-05103-z.
[26] Mansoor, S., Iqbal, S., Popescu, S.M., Kim, S.L., Chung, Y.S., & Baek, J.-H. (2025). Integration of smart sensors and IoT in precision agriculture: Trends, challenges and future prospectives. *Frontiers in Plant Science*, 16, article number 1587869. doi: 10.3389/fpls.2025.1587869.
[27] Pérez-Pérez, J.F., Bonet, I., Sánchez-Pinzón, M.S., Caraffini, F., & Lochmuller, C. (2024). Using artificial intelligence to predict the financial impact of climate transition risks within organisations. *International Journal of Intelligent Systems*, 2024, article number 3334263. doi: 10.1155/int/3334263.
[28] Saranya, T., Deisy, C., Sridevi, S., & Anbananthen, K.S.M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. *Engineering Applications of Artificial Intelligence*, 122, article number 106034. doi: 10.1016/j.engappai.2023.106034.
[29] Sbai, Z. (2025). Deep learning models and their ensembles for robust agricultural yield prediction in Saudi Arabia. *Sustainability*, 17(13), article number 5807. doi: 10.3390/su17135807.
[30] Sharma, P., Dadheech, P., Aneja, N., & Aneja, S. (2023). Predicting agriculture yields based on machine learning using regression and deep learning. *IEEE Access*, 11, 111255-111264. doi: 10.1109/ACCESS.2023.3321861.
[31] Yakubov, M., Turgunov, A., & Jamalova, G. (2023). Use of mathematical model of artificial neural network for current forecasting of tax base of region. *E3S Web of Conferences*, 401, article number 02062. doi: 10.1051/e3sconf/202340102062.

Агрардык экономикадагы статистикалык талдоо жана салыктык пландаштыруу үчүн нейротармактык моделдер

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Аннотация. Азыркы агрардык экономика климаттын өзгөрүшү, рыноктун туруксуздугу жана башкаруунун эффективдүүлүгүн жогорулатуу зарылчылыгы сыяктуу бир катар чакырыктарга туш болууда. Санариптештирүү шартында интеллектуалдык куралдарды, айрыкча статистикалык талдоо жана салыктык пландаштыруу үчүн нейротармактык моделдерди киргизүүнүн мааниси өзгөчө чоң. Бул изилдөөдө агрардык сектордо жасалма нейрондук тармактарды (ЖНТ) колдонуу боюнча заманбап ыкмаларга сереп берилет. MLP, CNN, RNN, LSTM архитектуралары жана алардын гибриддик варианттары түшүмдүүлүктү божомолдоодо, салыктык жүктү баалоодо, субсидияларды пландаштырууда жана каржылык тобокелчиликтерди талдоодо колдонулушу каралат. Изилдөөнүн максаты – агрардык экономикадагы статистикалык талдоону жана салыктык пландаштырууну натыйжалуу жүргүзүүдө нейротармактык моделдердин потенциалын аныктоо жана башкаруу чечимдерин колдогон санариптик системаларды түзүүдөгү алардын ролун белгилөө. Иште агрардык экономикада нейрондук тармактарды колдонуу негизги багыттары системалаштырылган, натыйжалуу чечимдердин мисалдары келтирилген жана белгисиздик шартында чечим кабыл алууну колдоо үчүн ЖНТнын практикалык мааниси негизделген. Айрыкча ЖНТны агрардык сектордун санариптик платформаларына интеграциялоо жана фискалдык башкарууну колдогон интеллектуалдык системаларды түзүү маселесине көңүл бурулган. Жүргүзүлгөн талдоо нейрондук тармактардын жогорку адаптивдүүлүгүн жана божомолдорунун тактыгын ырастап, аларды кеңири колдонуу үчүн санариптик инфраструктураны жана нормативдик-укуктук базаны өнүктүрүүнүн зарылдыгын баса белгилейт. Изилдөөнүн жыйынтыктары айыл чарбасын туруктуу өнүктүрүү стратегияларын иштеп чыгууда жана айыл чарба ишканаларынын экономикалык туруктуулугун жогорулатууда пайдаланылышы мүмкүн. Иш изилдөөчүлөр, санариптик чечимдерди иштеп чыгуучулар жана агрардык саясат чөйрөсүндөгү адистер үчүн кызыктуу болуп саналат

Негизги сөздөр: жасалма интеллект; предиктивдик моделдөө; фискалдык саясат; санариптик айыл чарба; туруктуу өнүгүү; түшүмдүүлүктү божомолдоо; чечим кабыл алууну колдогон интеллектуалдык системалар

Нейросетевые модели для статистического анализа и налогового планирования в аграрной экономике

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Аннотация. Современная аграрная экономика сталкивается с рядом вызовов, включая изменение климата, волатильность рынка и необходимость повышения эффективности управления. В условиях цифровизации особое значение приобретает внедрение интеллектуальных инструментов, в частности нейросетевых моделей для статистического анализа и налогового планирования. В данном исследовании представлен обзор современных подходов к применению искусственных нейронных сетей (ИНС) в аграрном секторе. Рассматривались архитектуры MLP, CNN, RNN, LSTM, а также их гибридные варианты, используемые для прогнозирования урожайности, оценки налоговой нагрузки, планирования субсидий и анализа финансовых рисков. Целью данного исследования было выявление потенциала нейросетевых моделей для повышения эффективности статистического анализа и налогового планирования в аграрной экономике, а также определение их роли в формировании цифровых систем поддержки управленческих решений. В работе систематизированы основные области применения нейронных сетей в аграрной экономике, приведены примеры эффективных решений и обоснована практическая значимость ИНС для поддержки принятия решений в условиях неопределенности. Особое внимание уделено интеграции ИНС в цифровые платформы аграрного сектора и формированию интеллектуальных систем поддержки фискального управления. Проведенный анализ подтвердил высокую адаптивность и точность прогнозирования нейронных сетей и подчеркнул необходимость развития цифровой инфраструктуры и нормативно-правовой базы для их повсеместного внедрения. Результаты исследования могут быть использованы при разработке стратегий устойчивого развития сельского хозяйства и повышения экономической устойчивости сельскохозяйственных предприятий. Работа представляет интерес для исследователей, разработчиков цифровых решений и специалистов в области аграрной политики

Ключевые слова: искусственный интеллект; предиктивное моделирование; фискальная политика; цифровое сельское хозяйство; устойчивое развитие; прогнозирование урожайности; интеллектуальные системы поддержки решений