International Journal for Quality Research 19(1) 211-222
ISSN 1800-6450

Tatiana N. Litvinova
Davit N. Hakhverdyan
Elena G. Popkova[1]
Angelina I. Litvinova

Article info:
Received 15.05.2024.
Accepted 18.11.2024.

DOI – 10.24874/IJQR19.01-14

MANAGEMENT OF THE QUALITY OF AGRICULTURAL PRODUCTS IN THE AGRARIAN AI ECONOMY IN SUPPORT OF FOOD SECURITY

Abstract: *Climate change, challenges in the sphere of environmental pollution, and socioeconomic and technological changes predetermined transformations of requirements for the quality of agricultural products. The vector of quality indicators shifted from the focus on the achievement of consumer qualities and support for production, export of products, and achievement of food security to eco-friendliness and accessibility. Leading countries in the sphere of agricultural production have to be also leaders in the development and implementation of the tools of the agrarian AI economy, for this allows ensuring the quality and support for food security at the national and international levels.*

In this paper, we demonstrated the directions for the use of the main tools of this category and determined their advantages and influence on the achievement of the quality of agricultural products. We revealed the indicators of the effectiveness of the agrarian AI economy at the level of the leading countries and regions in this sphere.

The scientific novelty of this research lies in the systematisation of the directions of development of the agrarian AI economy in the leading countries and the possibilities for its transformations at the level of new players in this sector.

Keywords: *Agrarian AI economy, Quality of agricultural products, Requirements, Food security, ICT, Digital tools, Consumer values,Aaccessibility*

1. Introduction

Food security is one of the benchmarks of the UN programme in the sphere of sustainable development. Striving towards its achievement and prevention of famine in underdeveloped countries are the priorities of these countries' governments and countries which main type of economic activity is agriculture. Despite the necessity of solving tasks in the sphere of ensuring high productiveness of agricultural production, it is important to manage the quality of this sector's products. Traditionally, agricultural products were assessed in the context of aesthetic (correspondence to the requirements for the external appearance of a certain sort or type

[1] Corresponding author: Elena G. Popkova
Email: 210471@mail.ru

of product), physiological (influence on consumers' health), and technological (compliance with norms and standards of production, processing, transportation, and storing) requirements (Qaxxorov, 2024). Supporting the level of the quality of agricultural products is a rather complex task in the modern conditions of unpredictable climate change, which influences crop yield (drought, reduction of water resources, floods, hurricanes, etc.). The notion of quality at this stage is formed given the focus on consumer values (Niewczas-Dobrowolska, 2022), accessibility of products, and pricing parameters (Polukhin et al., 2021).

Given the above, there appears a necessity of creating stimuli to raise the productiveness and quality of the studied sector's products. Achievement of this task is connected with the use of the tools of the agrarian AI economy, which facilitate the management of the quality of this category of products at all life cycles of production and turnover. At the current stage in world practice, the use of the tools of the agrarian AI economy is accessible for developed and quickly developing countries. Assessment of their experience and specifics of the implementation of the high indicators of management of the quality and efficiency of agricultural products, which ensure protection from challenges and threats in the sphere of food security, is the relevant direction for the research.

The purpose of this paper was to find the features of the management of the quality of agricultural products in the agrarian AI economy in support of food security in the leading countries in this sphere. To reach this purpose, we determined the leading countries in the sphere of agricultural production, assessed their participation in supporting food security in the world, and revealed directions for the management of the quality of agricultural products in the agrarian AI economy in these countries.

2. Materials and method

The main requirements and formation of progress in the sphere of implementing the achievements of the management of the quality of agricultural products in the agrarian AI economy were studied in a range of scholarly works.

Qaxxorov (2024) presented a list and characteristics of the requirements for the quality of agricultural products, the focus on which is the framework basis for consideration of the influence of artificial intelligence on its indicators. Taneja (2023) systematised and characterised the main digital tools of artificial intelligence, which is used in the agrarian sphere, and distinguished the spheres of the AI economy in the studied sector. Shah (2022) elaborated on the features of implementing the main ICT tools in the formation of the agrarian sector of India. Polukhin et al. (2021) considered the specifics of the phenomenon of product quality and its transformation in the context of socioeconomic, technological, and climate features. Sofiina and Dyachkov (2021) dwelt on the assessment of the need for the tools of the agrarian AI economy in countries with favourable conditions for agriculture and countries that have problems with water resources and good soil.

Though there is a sufficient number of scholarly works on the problems and characteristics of the use of artificial intelligence in the improvement and support of the quality of agricultural products, there is a need to systematise positive trends and approaches.

We used a range of methods in this research. Statistical analysis was used to determine the data on productiveness and quality of agricultural products in the leading countries in this sphere. The method of systematisation was used to reveal key approaches of these countries to quality management of agricultural products in the agrarian AI economy. The method of comparison was utilised to find the results of the leading

countries in agricultural production in ensuring food security in the world.

3. Results

Let us determine the leading countries in agricultural production in the world and distinguish their contribution to food security (% of world export and agricultural production).

According to FAOSTAT (FAOSTAT, 2022), as of year-end 2021, the leading agricultural producers in the world were the following:

1) Corn production: USA (31 % of the world total); China (24 %); Brazil (6 %); other countries (39 %);
2) Rice production: China (28 %); India (23 %); Bangladesh (9 %); other countries (40 %);
3) Wheat production: China (19 %); India (13 %); Russian Federation (10 %); other countries (58 %);
4) Barley production: Russian Federation (12 %); Australia (10 %); France (8 %); other countries (70 %);
5) Sorghum production: USA (19 %); Nigeria (11 %); India (8 %); other countries (62 %);
6) Sugar production from sugar cane: USA (40 %); India (20 %); China (5 %); Pakistan (5 %); Thailand (4 %); other countries (26 %);
7) Beet sugar production: Russian Federation (15 %); France (14 %); USA (11 %); Germany (11 %); Turkey (9 %); other countries (40 %);
8) Production of oilseeds: palm oil (Indonesia (61 %); Malaysia (24 %); Thailand (4 %); other countries (11 %)); soybean oil (Brazil (35 %); USA (34 %); Argentina (12 %); other countries (19 %)); rapeseed oil (China (20 %); Canada (20 %); India (14 %); other countries (46 %)); coconut oil (Indonesia (28 %); Philippines (22 %); India (22 %); other countries (8 %));
9) Greens and microgreens production: USA (1st position), Canada, Israel, and the UAE (2nd position) (Imarcgroup, 2024).

The above types of agricultural products are the basis for food security in the world. Given the above, the commodity and geographical structure of vegetable, fruit, meat, and dairy production is not considered here.

Based on the above production structure, we can state that the key world agricultural producers are China, the USA, India, and the Russian Federation – by assortment, and China, Canada, and the USA – by volume. Let us consider to which level producers of this category of products are integrated into the international market. The international integration as to the level of export is the indicator of the level of participation in ensuring food security. Table 1 shows the volumes of agricultural exports of the leading countries for all commodity groups in 2022.

Table 1. Export of agricultural products by the leading countries in 2022

	Country	Export, billions of USD	GDP, billions of USD	% of exports in the volume of GDP
1	USA	199.9	25,461	0.79
2	China	69.37	17,963	0.39
3	Canada	66.14	2,137	3.09
4	Indonesia	57.2	1,186	4.82
5	Australia	51.1	1,702	3
6	Mexico	48.1	1,465.8	3.28
7	India	47	3,416	1.38

Source: Formed by the authors based on (Trading Economics, 2023a; Trading Economics, 2023b; Statista, 2023a; Statista, 2023b; Statista, 2023c; Statista, 2023d; WTO, 2022; WorldEconomics, 2023)

As shown in Table 1, Indonesia, Mexico, and Canada have the largest share of agricultural exports in GDP, which is a sign of the higher dependence of these economies on exports. Accordingly, though these three countries are not among the leaders in the export of agricultural products, they are deeply involved with ensuring the food security of the world.

Let us determine the main directions for the management of the quality of agricultural products in the agrarian AI economy in the leading countries by assortment and volumes of export.

The agrarian AI economy is connected with the use of the tools of artificial intelligence, which helps achieve managerial goals, including growth and support of the quality of agricultural products. Assessment of the studies shows that its main sectors are as follows: 1) system of computer vision (identification of the taste characteristics of products (neural networks and modelling are used); quality control (the use of magnetic resonance technologies and X-ray imaging, which allow finding defects)); 2) tools of forecast analytics (used for forecasting of the change in the quality of products in the course of the products natural and artificial changes; management of the sphere of quality and safety of fruits (use of smart refrigerators, based on digital sensors, models of product division, etc.); packaging and sorting of products (use of the systems equipped with digital sensors); 3) tools of machine and deep learning (integration of information flows on the quality of products supply chain; sphere of smart agriculture (technologies and equipment for monitoring of soil (including remote, with the help of robots); digital apps with the data on processes, technologies, and managerial solutions that can be realised in the given conditions); algorithms of machine learning and modelling; other types of digital tools based on artificial intelligence)) (Taneja, 2023).

Artificial intelligence in agriculture is very widespread in the USA in Canada (Precedence Research, 2023) (Table 2).

Table 2. Indicators of the implementation of artificial intelligence in agriculture

	Indicators	Characteristics
1	Investments in the purchase (development) of the tools of artificial intelligence in agriculture	2022 (factual data) – 1,370 million USD, 2026 (forecast data) – 3,170 million USD, 2028 (forecast data) – 4,810 million USD, 2030 (forecast data) – 7,320 million USD, 2032 (forecast data) – 11,130 million USD
2	Structure of the tools of artificial intelligence that are used in the management of the quality of agricultural products	Systems of computer vision (15 % in the total volume of implementing the tools of artificial intelligence in the agrarian AI economy); tools of forecast analytics (47 %); tools of machine and deep learning (38 %)
3	Reasons for prospective growth of the use of the tools of artificial intelligence in the agrarian sphere by regions	1. Countries of the Asia-Pacific region, countries of Africa and the Middle East, and countries of Latin America: reduction of water reserves used for irrigation; processes connected with climate change and reduction of fertile soil; growth of population, which involves improvement of food security. 2. Countries of North America and Europe: focus on sustainable development (including environmental protection and food security); emergencies that lead to the need for providing regions with agricultural products (reduction of the dependence on import)
4	Level of implementation of tools of artificial intelligence, used in the management of the quality of agricultural products, % (in regions)	Countries of Latin America – 3 %. Countries of Africa and the Middle East – 5 %. Countries of Europe – 28 %. Countries of the Asia-Pacific region – 25 %. Countries of North America – 39 %.

Source: Formed by the authors based on (Precedence Research, 2023)

An important and the most widespread direction for the management of the quality of agricultural products in the agrarian AI economy is smart farms (or smart agriculture), created within the category of the components of machine and deep learning and computer vision.

The development of this direction in Canada by the example of smart farms deserves special attention. The leading company in the sphere of smart farms that produce and sell greens and microgreens is GoodLeaf Farms, a subsidiary of TReLeaf (GoodLeaf Farms, 2024). Table 3 presents the main indicators of implementing smart farms by GoodLeaf Farms.

Table 3. Indicators of smart agriculture of GoodLeaf Farms (Canada)

	Indicator	Characteristics
1	Type of farms	Vertical with the use of the tools of artificial intelligence. They include the possibility of sustaining the level of CO2, humidity, air and water temperature; ensuring the required concentration and structure of substances necessary for the growth of greens and microgreens; systems of the management of the duration and intensity of lighting (imitation of solar rays); irrigation regime that is controlled with the help of digital sensors.
2	Indicators of activities	Number of production cites as of early 2022: 8 objects; after investments in 2022-2023: 10 objects. Production capacities of each site: 2 million pounds of greens and microgreens. Personnel: 2,400. Export: 160 countries.
3	Transformation of integration and an increase in production	150 million CAD in 2022, 78 million CAD in 2022 – investments in the creation of new productions. Expected growth of production and turnover – 25%
4	Indicators of product quality	Freshness during harvesting, packaging, and transportation is ensured with the help of robotised technologies and systems with sensors. The absence of hazardous substances (pesticides, etc.) is confirmed by certificates of conformity.
5	Indicators of food security (prevention of contamination in the process of harvesting, packaging, and transportation; information on the absence of hazardous substances)	Quality and preservation of useful substances are ensured with the help of vacuum packaging made of biomaterials. Information about natural allergens is given on the packaging, as well as information about possible side effects

Source: Formed by the authors based on (GoodLeaf Farms, 2024; Achard, 2023)

The direction of smart agriculture implemented by GoodLeaf Farms is connected with the support for the UN Sustainable Development Goal on the protection of land from intense use. The use of vertical farms allows achieving such tasks. Forecasting and control over irrigation allow saving water resources. Achievement of the minimisation of damage to ecology and achievement of the main indicators of quality are sought within comprehensive managerial systems based on the above tools of artificial intelligence, which allow supporting food security due to the promotion of the company's products.

Specific features of implementing smart agriculture in the USA could be viewed in the example of Carbon Robotics (Table 4).

Table 4. Characteristics of smart agriculture in Carbon Robotics

	Indicator	Characteristics
1	Smart agriculture technology	Laserweeding (multicomplex of precise laser weeding – a tool for fighting weeds in crop research)
2	Indicators of the quality of agricultural products	Technological capabilities of Laserweeding allow preventing the violations in microbiological indicators of soil. Period of return of Laserweeding: 1-3 years. Possibility of 24/7 work. Precision of laser weeding, down to 1 millimetre. Technological features: - Graphic processor Nvidia; - System of computer vision, based on the capabilities of machine learning; - 42 high-definition video cameras, which allow identifying the main types of weed under different view angles, in different lighting and weather conditions; - Autonomous modules of laser weeding; - With the speed of work of 1 mile per hour, 2 acres are covered; - Destruction of up to 99 % of pests and weeds; - Technical capability of dealing with 200,000 pests and weeds per hour; - Sensor user interface with remote control.
3	Effectiveness of using Laserweeding technology in the management of the quality of agricultural products	1. Prevention of the use of fertilisers and herbicides – indicator of chemical safety of products. Laser technologies help ensure eco-friendly products of the agrarian AI economy. This allows saving the health of the consumers of agricultural products (humans and animals). 2. Price/quality indicator. This technology allows reducing expenses for the workforce and wages. Workforce expenses account for 28.2% of the total volume of expenses. Their reduction by two times ensures additional economic effect and the growth of demand for agricultural products. 3. High-quality products are received due to the absence of weeds and pests, eliminated at the initial stages of crop development.
4	Using the multicomplex Laserweeding in sectors and countries	This complex is used in the USA and Canada in the activities of large agrarian companies.

Source: Formed by the authors based on (Carbon Robotics, 2024; Precedence Research, 2023)

Carbon Robotics implemented an effective project in the creation, mass production, promotion, and service maintenance of a digital multicomplex, which allows receiving quality crops and ensuring food security due to the absence of negative impact of crops on consumers' health. Integration of the digital tool (the system of smart agriculture) into the crop research sector of the agrarian AI economy in the USA and Canada, made by Carbon Robotics, allows the key manufacturers in this sphere to raise and sustain the quality of agricultural products despite the negative external influences.

We should also dwell on the features of the influence of the Project FarmVibes complex, developed by Microsoft (USA) for the market of agrarian AI economy at the end of 2022. This complex is a synthesis of technologies of machine learning and big data analysis in the sphere of management of the quality of agricultural products (Microsoft, 2024). The key features of this complex are as follows (Microsoft, 2024; Precedence Research, 2023):

1) Main functional directions: gathering information on the characteristics of smart farms, indicators of the management of the quality of agricultural products through open

cases of agricultural equipment sensors (in case it is digital), drones (automatically, without involvement of human resources); autonomous robotized processing of smart farms' data, received within the first functional direction (systematization of data on the growth of crops, level and presence of negative external effects of weeds, pests, and climate change; indicators of external environment; indicators of crop handling)); receipt of data on the results of management of the quality based on autonomous processing of data (key indicators of growth and changes in quality, threats and possible problems as to the state of crops); using the capabilities of chatbots to ensure the interaction of farmers and managers of the agrarian AI economy companies with the representatives of Microsoft to implement corrections in the system's work according to individual needs, provision of additional user opportunities, and creation of new options;

2) Constant consultation support for continuous work of Project FarmVibes software at the scientific and technological level; the level of environmental specialists (increase in the quality of ecologization of agricultural products due to comprehensive inspection, analysis and processing of obtained data on the state of smart farms, indicators of management of the quality of products at different levels); economic level; innovative level; level of training of the personnel of the companies of the agrarian AI economy (remote and individual training);

3) Goals of the use of Project FarmVibes complex:

- Constant assessment of agricultural production waste at different stages of the life cycle, management decision-making on its minimisation and/or prevention with the help of digital tools of implementing the circular economy in the agrarian sphere. The focus on this goal raises the quality of agricultural products due to the minimisation of waste and facilitates the achievement of a good price/quality ratio. It is also possible to ensure food security due to the reduction of the level of waste and defects in production, all logistics processes and during storing and transportation of products;

- Improving the level of the quality of agricultural products due to adapting the activities of farms and process management to the influences of the external environment (precision weather forecasting). For this, Project FarmVibes uses such digital tools as machine learning and modelling of forecast situations and indicators of the company's development;

- Formation of a large set of typical models of the management of the quality of agricultural products, which is created due to the processing of the indicators of customers' functioning (companies of the agrarian AI economy of various categories) and forecasting of possible solutions. Implementation of this goal is based on forecast analytics, based on non-linear and linear forecasting of the transformations of the indicators of economic and technological activities and data on the processes of the management of agricultural product quality.

Countries of the Asia-Pacific region account for 25 % of the market of tools of artificial intelligence, used in the management of the quality of agricultural products (Table 2). China is the leader in this market. In the process of quick implementation of the digital economy, China developed many new ICTs in various spheres. Agriculture, which, in the past, was one of the key sectors of the Chinese economy, also demonstrates growth due to the application of AI economy tools. Smart agriculture and systemic collection and analysis of big data are the key directions for the management of agricultural products' quality in the agrarian AI economy of China.

Let us analyse the features of implementing the tools of the agrarian AI economy in China on the example of SZ DJI Technology Co., Ltd. (DJI) (Table 5).

Table 5. Features of the participation of DJI (China) in the improvement of the management of agricultural products' quality

	Indicator	Description
1	Technology of the management of agricultural products' quality	Mavic 3 Multispectral is a multifunctional drone with a multispectral camera, which allows for quality aerial surveys in hard-to-reach places and difficult weather conditions. Purposes: 1) Assessment of the state of soil and crops; 2) Collection of data for their further entry in territorial, regional, and national databases for soil, crops, weeds, and pests.
2	Influence of the technology on the indicators of quality of the agrarian sectors' products	Quality aerial survey allows scanning of crops, which provides the possibility of the following actions: - Control over the quality of their growth, presence of pests, and influence of weeds at all stages of the life cycle; - Assessment of the state of soil, air temperatures, humidity level, and presence of pollutants in the air; - Control over the tests on the use of fertilisers. This technology (Mavic 3 Multispectral) helps determine the quality of agricultural products.
3	Technological and technical features of Mavic 3 Multispectral	1. Possibility of avoiding obstacles on the designated course. 2. High-resolution camera. 3. Data transfer and remote control (up to 15 km). 4. Work efficiency of Mavic 3 Multispectral: 200 hectares per flight (2-2.5 hours).
4	Using digital tools in the sectors of the economy and countries	In 2024, Mavic 3 Multispectral is widely used in most countries of the world by the subjects of the agrarian AI economy.

Source: Formed by the authors based on (Dji, 2024; Precedence Research, 2023)

The use of the multifunctional drone Mavic 3 Multispectral from the company DJI (China) ensures an increase and support of the quality of agricultural products due to technological features and the use of large databases on the work of this equipment within the target tasks (survey, scanning of data, identification, data transfer to the centre of decision-making). The use of Mavic 3 Multispectral allows companies of the agrarian AI economy to reduce expenses for the installation and maintenance of video cameras, sensors of climate indicators, and the work of specialists on individual and systemic collection of data on crops. Reduction of this category of expenses allows raising the price/quality indicator of agricultural products, which is a sign of competitiveness in the national and international markets. High precision of scanning and processing of information and quick forecasting of the models of managerial decision-making allow achieving the required levels of product quality.

4. Discussion

The described directions for the management of agricultural products' quality in the agrarian AI economy formed under the influence of transformations in the sphere of ICT, due to the appearance of new knowledge and technologies in agriculture and under the influence of the growing need to ensure food security (in the achievement of requirements and standards of compliance and the achievement of the UN goal of fighting hunger). Each of the considered directions (collection and analysis of big data) and smart farms (or smart agriculture) became very widespread in countries that are leaders in agricultural production. Given the above, their striving towards the achievement of high parameters of

agricultural products' quality is explained by the focus on the growth of sales revenues at the national and international markets. High quality of this category of products in the conditions of the use of the agrarian AI economy tools is achieved in the leading countries with a simultaneous focus on the socioeconomic and environmental components. As was shown in this work, the leaders in this sphere are the USA, Canada, and China. These countries also have large GDP, play the leading roles in the world food security, and strive towards the achievement of high standards in the reduction of climate change.

The experience of these countries and ICT (tools of the agrarian AI economy), which they promote in the international market, facilitates the resolution of many tasks of the socioeconomic and environmental character. Digital tools of agrarian AI economy, manufactured in China, the USA, and Canada, are widely used in other countries that strive towards the implementation of ICT in the activities of agrarian companies. The transition to mass digitalization led to the emergence of threats in employment, which is especially relevant for countries that cannot ensure the corresponding support for the unemployed. Many companies started using robots and specialised software with a simultaneous reduction of personnel who were responsible for routine mechanical work. Accordingly, the use of the modern digital tools of the agrarian AI economy can increase this threat. However, large companies in the leading countries successfully cope with this problem by training personnel to work with ICT. Further studies in this sphere should be focused on the issue of the mass involvement of labour resources in the mastering of new skills and knowledge in the management of agricultural products' quality with the use of modern digital tools. It is possible to create public-private partnerships for teaching new professions, which will be competitive and will allow employees to raise their professional development. An interested party here is the government, for the problem of employment will be solved. Another interested party is entrepreneurship, which, due to an increase in the quality of training of labour resources, will improve the quality of agricultural production and reduce losses from defects and waste. Another interested party is local communities, which promote the idea of environmental protection from the destructive influence of various sectors of the economy, including the agricultural sector. The latter is achieved due to the use of modern ICT in the tools of the agrarian AI economy, which reduces the destructive effect on the environment.

Accordingly, the government and business environment's participation in the achievement of the tasks of digitalization of the agrarian sector and improvement of the quality of agricultural products in certain countries is the necessary condition for success.

Achievement of the UN goals in the sphere of food security in the context of the production of affordable agricultural products cannot be implemented without a focus on its quality. This is a precondition for supporting the health of the current and future generations. Agricultural products that are exported to other countries, including underdeveloped countries, must conform to the existing standards and norms of quality. This is the benchmark of the world's leading producers of agricultural products, which use new tools of the agrarian AI economy. The USA, Canada, and China are leaders in the sphere of development, production, and promotion of these tools.

There might appear new leaders in this sphere. Countries of South-East Asia, especially India, have a large perspective. India demonstrates significant growth in the sphere of implementing ICT in this sphere and achievement of price/quality indicators (Shah, 2022). It is also possible to expect interest and effort from countries that do not have favourable conditions as to the environment and that have problems with

food security (Sofiina and Dyachkov, 2021). Further development in such countries is possible in the conditions of interactions with international financial organisations, which can ensure the purchase and implementation of innovative tools for the agrarian AI economy.

5. Conclusion

This research allowed identifying the specific features of the management of the quality of agricultural products in the agrarian AI economy in support of food security at the level of the key participants of this sector. It is possible to state that the described directions for quality management might be transformed in the future, due to the emergence of new ICT and requirements for agricultural products. Analysis showed that modern tools of the agrarian AI economy allow achieving the indicators of quality and influence the price/quality indicator, which positively influences the growth of the competitiveness of agricultural products at the national and international markets.

Improving the quality of agricultural products with the use of ICT allows supporting the achievement of the UN goals in ensuring food security. The possibilities of dealing with challenges in the sphere of prevention of hunger might influence the transfer of technologies that help raise quality and crop yield in the countries of South-East Asia. The emergence of new leaders in this sphere could positively influence the achievement of tasks in the sphere of food security and an increase in ecologization of agricultural management.

References:

Achard, S. (2023). GoodLeaf Farms Secures $78M For Expansion of Indoor Vertical Farms. Retrieved from https://igrownews.com/goodleaf-farms-secures-78m-for-expansion-of-indoor-vertical-farms/

Carbon Robotics (2024). What is Laserweeding? Retrieved from https://carbonrobotics.com/laserweeding?gclid=CjwKCAiAibeuBhAAEiwAiXBoJCa6egphVD31uZnF1clNjjLQF-VeoK_VgurKkBgnRDeb2QdvBs4UkRoC13EQAvD_BwE

Dji (2024). About us. Retrieved from https://ag.dji.com/about-us?site=ag&from=footer

FAOSTAT (2022). Agricultural production statistics 2000–2021. Retrieved from https://www.fao.org/3/cc3751en/cc3751en.pdf

GoodLeaf Farms (2024). Vertically Farmed, Straight up good™. Retrieved from https://www.goodleaffarms.com/

Imarcgroup (2024). Top 11 Microgreens Companies in the World. Retrieved from https://www.imarcgroup.com/microgreens-manufacturing-companies

Microsoft (2024). Project FarmVibes. Democratizing digital tools for sustainable agriculture. Retrieved from https://www.microsoft.com/en-us/research/project/project-farmvibes/

Niewczas-Dobrowolska, M. (2022). Food safety by consumers importance, attitude, self assuring. *International Journal for Quality Research*, *17*(1), 13–26, 2023, doi: 10.24874/IJQR17.01-02.

Qaxxorov, F. (2024). Product Quality control when storing Agricultural Products fruit and vegetables. *Universum: technical sciences: online scientific journal. 2024. 1*(118). Retrieved from https://7universum.com/ru/tech/archive/item/16706

Polukhin, A. A., Panarina, V. I., & Klimov, S. P. (2021). Quality Management in the Food Market for Sustainable Development based on Industrial and Manufacturing Engineering in the Age of Digital Economy. *International Journal for Quality Research*, *15*(4), 1159-1178. doi: 10.24874/IJQR15.04-09

Precedence Research (2023). Artificial Intelligence In Agriculture Market. Retrieved from https://www.precedenceresearch.com/artificial-intelligence-in-agriculture-market

Shah, D. (2022). Role of Information and Communication Technology in Agricultural Development of India. *Review of Market Integration*, *14*(2-3), 113-132. https://doi.org/10.1177/09749292221119286

Sofiina, E. V., & Dyachkov, V. P. (2021). Digitalization: interconnection with the scientific and research sphere - one of the main strategic directions of quality management by agricultural land users. *International Journal for Quality Research*, *16*(1), 35–54. doi: 10.24874/IJQR16.01-03

Statista (2023a). Australia: Gross domestic product in current prices from 1987 to 2028 (in billion U.S. dollars). Retrieved from https://www.statista.com/statistics/263573/gross-domestic-product-gdp-of-australia/

Statista (2023b). Canada: Gross domestic product in current prices from 1987 to 2028 (in billion U.S. dollars). Retrieved from https://www.statista.com/statistics/263574/gross-domestic-product-gdp-in-canada/

Statista (2023c). Gross domestic product of the United States from 1990 to 2022 (in billion current U.S. dollars). Retrieved from https://www.statista.com/statistics/188105/annual-gdp-of-the-united-states-since-1990/?gclid=Cj0KCQiA5rGuBhCnARIsAN11vgRR2725d28f5O0Pyam7EnxThAde79FfgMSL1f7O9OvaXct7XLzvCEMaAuIfEALw_wcB Accessed: 12.02.2024

Statista (2023d). Mexico: Gross domestic product in current prices from 1987 to 2028 (in billion U.S. dollars). Retrieved from https://www.statista.com/statistics/263580/gross-domestic-product-gdp-in-mexico/

Taneja, A., Nair, G., Joshi, M., Sharma, S., Sharma, S., Jambrak, A.R., Roselló-Soto, E., Barba, F.J., Castagnini, J.M., Leksawasdi, N., et al. (2023). Artificial Intelligence: Implications for the Agri-Food Sector. *Agronomy*, *13*(5):1397. https://doi.org/10.3390/agronomy13051397

Tradingeconomics (2023a). China GDP. Retrieved from https://tradingeconomics.com/china/gdp

Tradingeconomics (2023b). India GDP. Retrieved from https://tradingeconomics.com/india/gdp

WorldEconomics (2023). Indonesia GDP: $1.186 Trillion. Retrieved from https://www.worldeconomics.com/GrossDomesticProduct/Current-GDP/Indonesia.aspx

WTO (2022). Charts - World trade in agricultural products. Retrieved from https://www.wto.org/english/tratop_e/agric_e/ag_imp_exp_charts_e.htm6

Tatiana N. Litvinova
Volgograd State Agricultural University, Volgograd, Russia
litvinova1358@yandex.ru
ORCID 0000-0003-3101-2621

Angelina I. Litvinova
RUDN University, Moscow, Russia
ang1358@yandex.ru
ORCID 0000-0001-8945-2334

Davit N. Hakhverdyan
Armenian State University of Economics, Yerevan, Armenia
dhakhverdyan@yahoo.com
ORCID 0000-0003-3224-2461

Elena G. Popkova
Armenian State University of Economics, Yerevan, Armenia
210471@mail.ru
ORCID 0000-0003-2136-2767