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GLOBAL EXPERIENCE OF USING CRYPTOCURRENCIES AS A FINANCIAL INSTRUMENT IN AGRICULTURE

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This article explores the integration of cryptocurrencies into the global agribusiness sector, positioning them as a new financial instrument. The study examines the main advantages of cryptocurrencies in agriculture, including the simplification of financial operations, reduction of transaction costs, increased transparency in supply chains, and access to alternative sources of financing. Based on the analysis of international cases, the research reviews key projects and platforms implementing blockchain solutions in the agricultural sector. Special attention is given to the challenges and risks associated with cryptocurrency adoption, such as regulatory restrictions, the volatility of digital assets, and the need for technological adaptation within agricultural operations. The study provides an assessment of the potential of cryptocurrencies in agricultural financial systems and offers recommendations for their effective implementation. The stages of cryptocurrency development and their adaptation within the agricultural sector are analyzed. The main areas of digital currency application in agriculture are identified, including financing of farming enterprises through crowdfunding platforms, conducting international settlements for agricultural products, crop insurance, and optimization of logistics chains. Particular attention is devoted to examining regulatory approaches to the implementation of cryptocurrencies in the agricultural sector and analyzing risks related to market volatility, cybersecurity threats, and legal uncertainty. The international experience of digital technology integration into the agricultural sector, along with the challenges and prospects for the integration of cryptocurrencies into agri-financial systems, is explored. The article emphasizes the importance of developing state policies that stimulate innovation in agriculture and ensure the financial stability of farming enterprises. It concludes that the use of cryptocurrencies in the agricultural sector holds significant potential for improving access to financing, enhancing transaction transparency, and increasing agricultural production efficiency.

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СВІТОВИЙ ДОСВІД ВИКОРИСТАННЯ КРИПТОВАЛЮТ ЯК ФІНАНСОВОГО ІНСТРУМЕНТУ В СІЛЬСЬКОМУ ГОСПОДАРСТВІ

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Ключові слова:
блокчейн, криптовалюта, агробізнес, сільське господарство, агро-стартап.

У цій статті досліджується інтеграція криптовалют у світовий агробізнес, позиціонуючи їх як новий фінансовий інструмент. У дослідженні розглядаються основні переваги криптовалют у сільському господарстві, включаючи спрощення фінансових операцій, зниження транзакційних витрат, підвищення прозорості ланцюгів поставок і доступ до альтернативних джерел фінансування. Спираючись на аналіз міжнародних кейсів, у дослідженні розглядаються ключові проекти та платформи, які впроваджують блокчейн-рішення в аграрному секторі. Особливу увагу приділено викликам і ризикам, пов'язаним із впровадженням криптовалют, таким як регуляторні обмеження, волатильність цифрових активів і необхідність технологічної адаптації в рамках сільськогосподарських операцій. Дослідження надає оцінку потенціалу криптовалют у фінансових системах сільського господарства та рекомендаціями щодо їх ефективного впровадження. Проаналізовано етапи розвитку криптовалют та їх адаптацію в аграрному секторі. Визначено основні напрями застосування цифрових валют у сільському господарстві, зокрема фінансування фермерських господарств через краудфандингові платформи, здійснення міжнародних розрахунків за сільськогосподарську продукцію, страхування врожаїв та оптимізацію логістичних ланцюгів. Окрему увагу приділено вивченню регуляторних підходів до впровадження криптовалют у аграрному секторі, аналізу ризиків, пов'язаних з волатильністю ринку, кіберзагрозами та правовою невизначеністю. Досліджено міжнародний досвід, який активно впроваджується через цифрові технології в аграрну галузь, а також проблеми і перспективи інтеграції криптовалют в аграрні фінансові системи. В статті підкреслюється важливість розвитку державної політики, яка стимулює впровадження інновацій у сільському господарстві та забезпечує фінансову стабільність фермерських господарств. Зроблено висновок про те, що використання криптовалют в агросекторі має значний потенціал для підвищення доступу до фінансування, прозорості операцій та підвищення ефективності аграрного виробництва.

Statement of the problem

Agriculture is a cornerstone of the global economy, playing a vital role in ensuring food security and promoting societal resilience. However, the sector faces numerous challenges, including access to financing, supply chain opacity, and significant reliance on traditional financial instruments. Against this backdrop, the use of cryptocurrencies as a financial instrument in the agricultural sector is gaining increasing popularity.

Blockchain technology and cryptocurrencies open up new opportunities for agribusiness by facilitating rapid transactions, reducing financial operating costs, and increasing the transparency of market participants' interactions. They also contribute to farmers' access to alternative sources of financing, in particular through decentralized finance (DeFi) platforms, crowdfunding, and asset tokenization. An analysis of global experience in integrating cryptocurrencies into agriculture allows for the identification of key advantages, challenges, and prospects for the development of this financial technology. The article examines current practices of cryptocurrency use in various countries, their impact on agricultural production efficiency, and the risks associated with their implementation. Special attention is paid to regulatory issues, adaptation of agricultural businesses to new technologies, and future trends in the digital transformation of the agricultural sector.

Analysis of recent studied publications

In modern scientific literature and reports of international organizations, considerable attention is paid to the implementation of blockchain technology and cryptocurrencies in agriculture. Studies show that the use of cryptocurrencies contributes to reducing transaction costs, increasing transparency in the supply chains of agricultural products, and expanding farmers' access to financial resources. Among the main authors who have dedicated their time to studying cryptocurrencies in general and in specific sectors of the economy are: Kunishnikova O. (cryptocurrency as a financial market instrument), Bezverkhyi K. (the essence of cryptocurrencies), Ryadinska V. (financial and legal analysis of cryptocurrencies), Dyachuk M., Oginok S. (risks and opportunities of cryptocurrencies), Mazur V. (use of cryptocurrency as a financial instrument). Among foreign experts, the works of the following authors were studied: Kumar K., Lahza H.

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(cluster-based agriculture using blockchain), Bhat S., Huang N. (development of precision agriculture through artificial intelligence and big data), Sivaganesan D. (smart farming through blockchain technologies), and Neeta M., Sushila Sh. (use of cryptocurrencies in agriculture).

Research by AgriDigital demonstrates the effectiveness of blockchain solutions in grain logistics, while GrainChain offers smart contracts for automating settlements in the farming business. Other studies emphasize risks such as cryptocurrency volatility, regulatory restrictions, and technological barriers to implementation in agricultural practices..

Objectives of the article

Is to examine the global experience of using cryptocurrencies as a financial instrument in agriculture, to determine their impact on the financial stability of agribusiness, and to assess the prospects for their implementation in the context of the digital transformation of the agricultural sector. The goal of the study is to analyze the advantages, limitations, and potential risks of cryptocurrency application in agribusiness, as well as to develop recommendations for the effective integration of these technologies into the financial system of agricultural enterprises in Ukraine, based on global experience.

The main material of the research

Despite the significant spread of crypto technologies across various industries, they remain relatively new to most users. The foundation for introducing cryptocurrencies and blockchain technologies is the digital literacy of potential beneficiaries in this field. According to the general economic approach, cryptocurrencies are decentralized digital (virtual) assets, also referred to as "currency," protected by cryptographic methods (mathematical methods ensuring confidentiality). Kuvshinnikova O. defines cryptocurrency as a public digital asset created using cryptography to ensure transaction confidentiality and control over the issuance of virtual units [1].

The key functional features of cryptocurrencies are their anonymity and lack of regulation by state authorities. At the same time, this anonymity has attracted interest from regulatory bodies worldwide, as cryptocurrencies are unfortunately known for their potential to evade taxes and mandatory fees, be invested in dubious projects, and sometimes even finance terrorist groups. Similar to more conservative financial instruments, cryptocurrencies face the problem of high volatility in the digital asset market and dependence on global financial and trade policies. The creation of cryptocurrency is not subordinated to any state or government authority, since the principle behind the creation of these virtual currencies lies in the operation of a system known as "blockchain" (from English – "a chain of blocks") [2]. Interestingly, the name "blockchain" itself immediately reflects the principle of its operation: distributed across thousands of points around the world (the so-called "nodes"), the system looks like a long chain with computing machines – “miners” – connected to it, whose task, via electronic calculations, is to process existing blocks and write new ones. The data is thus represented in the system only once, i.e., as a unique entry, which automatically prevents duplication and protects it from forgery. An additional advantage of the blockchain system is equal access for all its participants, with the ability to validate data. It is appropriate to analyze the schematic principle of a cryptocurrency transaction through the lens of the blockchain system’s operation (Fig. 1).

Thus, the following conclusion can be drawn: the main advantages of cryptocurrencies are their security, decentralization, transaction irreversibility, and the ability to operate without intermediaries, based on the peer-to-peer (P2P) principle.

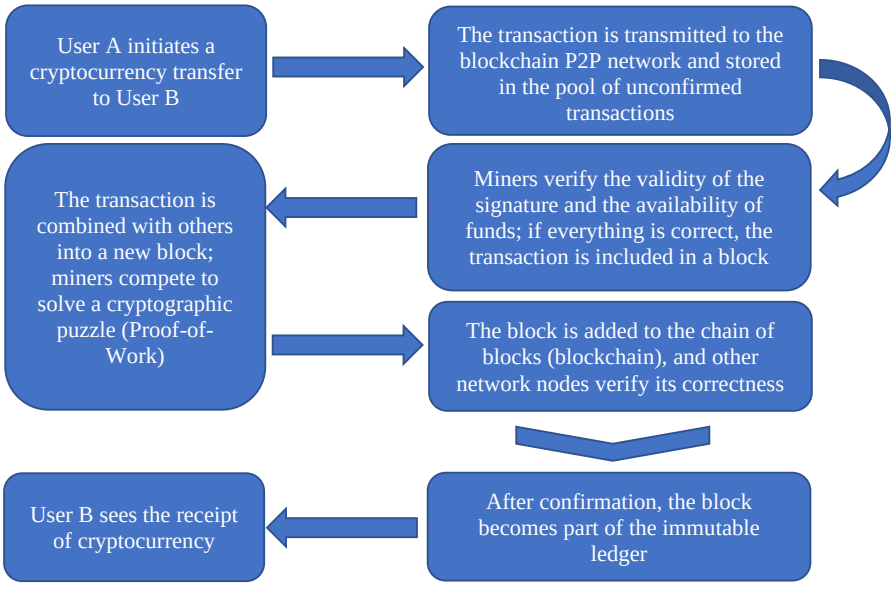

Fig. 1. – Cryptocurrency Transaction System in the Blockchain (created by the authors)

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The aforementioned approaches, specifically their economic advantages, have found application in various sectors of product manufacturing and service provision, mainly in the IT sector. However, in our opinion, given such a secure, transparent, and advanced system of data exchange and storage, limiting blockchain and cryptocurrency transactions solely to the digital sphere is a waste of their high potential.

One of the most stable and conservative branches of the economy has been and remains agriculture. Global experience in the use of cryptocurrencies in agriculture (and the agro-industrial complex in general) shows that there is demand for revolutionary approaches to attracting financial instruments, and that this demand is actively developing. Entrepreneurs seek to automate production and trade processes, as well as to conclude more transparent and fair transactions.

If we turn to the statistical indicators of the capitalization of the sustainable agricultural market that utilizes blockchain technology and actively employs cryptocurrency transactions in its operations, we can observe that in 2023 the global blockchain market in sustainable agriculture was valued at $188.90 million. It is expected to reach $294.97 million by 2031, with a compound annual growth rate (CAGR) of 5.9% during the forecast period (Figure 2) [3].

Given this data and the growth rate of market capitalization, we can conclude that the driving factors behind such indicators include the growing demand for transparent and traceable supply chains, the desire to reduce operational costs, and the increasing investment in agricultural startups worldwide.

Among the main drawbacks and "barriers" to conducting agricultural activities on the blockchain are, of course, the high entry threshold for the average farmer or producer, the cost of implementing blockchain technologies, and transitioning to cryptocurrency-based payments.

A significant challenge for those seeking to shift their agricultural business to cryptocurrency transactions and smart contracts is the dependency of producers on existing digital literacy skills and the geographical location of farms and production facilities, especially considering the availability of high-speed digital telecommunications in remote rural areas.

Over the past ten years, there has been a significant growth in the world of crypto assets – from a niche financial instrument to a massive global market. Bitcoin and Ethereum are vivid examples of digital currencies that represent the revolution of decentralization in finance, radically transforming key concepts related to transactions, value protection, and the engagement of economic players.

These digital currencies are based on blockchain technology, which ensures decentralization, enhanced transparency, immutability of data, and security. The existence of cryptocurrencies on financial markets is now undeniable; however, the range of opportunities that this technology offers is far broader. According to researcher Kumar K. R., rural enterprises powered by blockchain combined with intelligent systems can bring significant benefits and also reshape how governments manage rural territories [4].

Despite the key role agriculture plays in food security, the rural economy remains one of the least developed sectors in the global economic system. A strong infrastructure, a large base of smallholder farms, and access

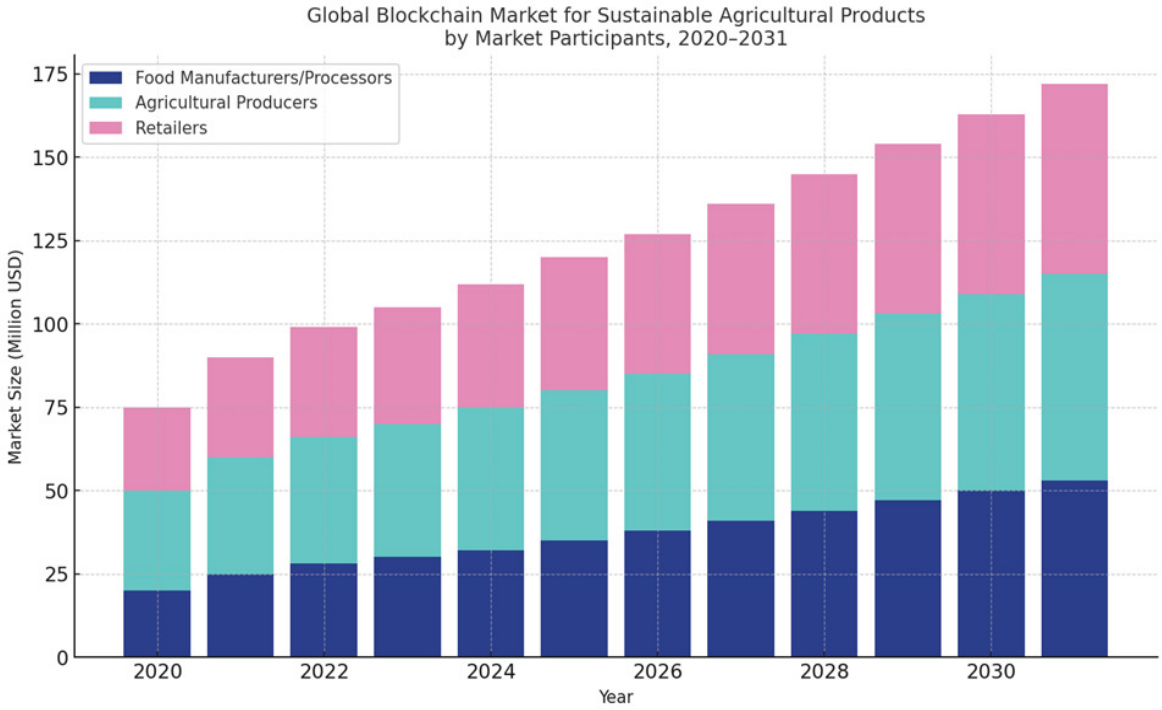

Fig. 2. – Global blockchain market for sustainable agricultural products by market participants, 2020–2031 (based on [3])

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to financial assets – in combination with technological advancement – complement each other in enhancing digital capacities within the innovation sphere. These factors also hold the potential for large-scale transformations [4].

Blockchain, digital tokens, the Internet of Things (IoT), and the progressive development of artificial intelligence (AI) are all examples of tools that can support the advancement of rural economies.

A key component in the development of blockchain technologies may be the chain-based structural approach. The majority of the global population is unable to fully verify the variety of products they purchase. This creates uncertainty, especially in cases of organic products, compliance with environmental regulations, and decision-making processes.

The use of blockchain technology allows for the creation of a permanent, open ledger (a connected chain of records) that covers all stages of production – from farm to retail [4]. Every step – from harvest dates, storage conditions, transportation methods, certification procedures – can be recorded on the blockchain and made accessible for verification by all interested parties.

This fosters mutual trust among all participants in the supply chain: from farmers to postal workers, distributors, and business partners in general. Moreover, it significantly reduces the risk of fraud or manipulation by unscrupulous market players. Farmers thus go beyond traditional ethical standards while remaining competitive in the market [5].

A core feature of the cryptocurrency system is smart contracts – computer programs programmed to autonomously manage transactions linked to corresponding legal actions by new parties [5, 8]. For example, after signing a contract between a farmer and a postal service provider, the parties can agree on a deferred payment that occurs only after the receipt of goods is confirmed. A smart contract formalizes this agreement without human intervention, and the payment is automatically executed once all terms are fulfilled. This system reduces the role of intermediaries, simplifies transaction processes, and lowers the risk of breach of contract or misconduct.

Such contracts can be useful not only for financial operations but also for risk management. For instance, insurance payouts to farmers can be tied to meteorological data from weather stations or sensors (using Internet of Things – IoT technology) [5, 7]. Upon submitting a claim, the smart contract automatically initiates an insurance payout without the need for additional claim verification.

Technological advancements in systems based on the Internet of Things are increasingly transforming the agricultural sector. Sensors can track a wide range of variables, such as air temperature, soil moisture, air humidity, crop growth rates, and even sunflower activity.

All of this data can be easily entered into the blockchain, ensuring its preservation, analysis, and use in decision-making processes [5, 7].

For example, artificial intelligence-based algorithms driven by this data can:

- determine the optimal time for sowing or harvesting;
- signal the need for intervention or irrigation;
- detect risks or plant diseases.

This process allows for the efficient use of resources, reduces losses, increases productivity, and mitigates the negative impact on profits.

The use of cryptocurrencies and blockchain in the agro-industrial sector contributes to environmental sustainability. Through efficient monitoring and automation, farmers can maximize water use efficiency, ensure healthy yields, and save energy. This not only helps minimize waste but also conserves natural resources, reduces greenhouse gas emissions, and prevents pollution of soil and aquatic ecosystems.

Additionally, there is significant potential for implementing incentive schemes. For example, farmers who support sustainable agricultural technologies – such as crop rotation, organic farming, and lawful use of chemicals – may receive rewards from local authorities in the form of tokens or cryptocurrencies [5]. If implemented, this trend creates substantial added value in the agricultural sector, promoting the development of sustainable production.

One of the main obstacles faced by farmers, especially in developing countries, is limited access to financial services. Banks are often reluctant to lend to small agricultural enterprises due to high risks and lack of collateral. In this context, decentralized finance (DeFi) platforms based on blockchain may become a viable alternative to traditional banking systems [6].

Agricultural producers can receive loans, insurance, and investments without intermediaries. It is expected that data about their activities – yields, contracts, environmental responsibility – recorded in a blockchain-based digital portfolio, will improve their creditworthiness.

Overall, the aforementioned areas of crypto-economy development are transforming its internal nature, which has made it vulnerable to marginalization within the traditional financial system due to the internal unpreparedness of economic actors to adopt new and more rational rules of the game.

Another advantage of cryptocurrencies is their ability to facilitate access to international markets. Small-scale farmers have faced numerous difficulties when trying to enter global markets due to intermediaries, high transaction fees, and complicated logistics [7, 8]. Cryptocurrencies allow such farmers to receive payments directly from consumers around the world with minimal fees and high liquidity. This contributes to the growth of the local economy, the farmer's income, stimulates employment, and increases the level of innovation.

Despite its enormous potential, the development of cryptocurrencies in rural areas is accompanied by a number of challenges:

- A significant portion of rural territories lacks permanent access to the Internet, complicating the implementation of digital technologies.
- Most farmers lack sufficient knowledge about cryptocurrencies, blockchain, or IoT, which slows the adoption of new technologies.
- The protection of data and digital assets is critically important to building trust in new systems.
- The crypto economy has medium-level legal recognition, but only in developed countries, which still complicates its use in official business operations [8].

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All of this requires the involvement of the private sector, the state, and the international community. Investment is needed in infrastructure, educational projects, the development of regulatory systems, and support for innovative initiatives.

Conclusions

The integration of blockchain and cryptocurrencies into rural communities represents a unique opportunity to transform these vital components. Enhanced awareness, operational efficiency, sustainability, access to finance, and automation of procedures have the potential to significantly improve the functioning of the rural economy while ensuring environmental sustainability and resilience of the agricultural sector itself.

Research into overcoming the barriers shows that the advantages far outweigh the risks. The future development of agriculture depends on the proper implementation of innovative principles, where cryptocurrencies will play a key role.

The future of rural entrepreneurship is not only in traditional agriculture, but also in smart contracts, the development and accumulation of personal crypto-assets for proper investment in one's own enterprise, decentralized financial structures, and a global virtual network based on trust.

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