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### Blockchain and sustainable finance: Enhancing transparency and efficiency in green investments

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**Abstract.** The study aimed to analyse the possibilities of using blockchain technology to increase transparency and efficiency in sustainable finance. The application of blockchain technologies and environmental and social practices in the context of sustainable finance was analysed, emphasising implementation and prospects in Kyrgyzstan. Blockchain, as an innovative decentralised data recording technology, provides a high level of security, transparency and immutability, which renders it particularly valuable for the financial sector. The study highlighted how blockchain can improve international transfer processes, increase the transparency of financial transactions and simplify the management of smart contracts, and noted existing challenges such as scalability and legal issues. The role of blockchain technologies in sustainable finance, especially in the field of green investments, was highlighted as an important aspect of the study. The introduction of blockchain in areas such as green project financing and social initiative management can help increase investor confidence and improve investment performance. Financial technology is also central in shaping new approaches to finance and investment, facilitating access to capital through crowdfunding and person-to-person (P2P) lending platforms. The introduction of environmental and social practices in financial institutions of the Kyrgyz Republic demonstrates the growing attention to corporate responsibility and sustainable development, despite the initial stage of their implementation. On international stage, successful projects such as the use of blockchain to track supply chains, green bonds and carbon credit management demonstrate the potential of technology to improve the transparency and efficiency of sustainable finance. These examples can be used by Kyrgyzstan in developing and implementing domestic blockchain and environmental and social initiatives, contributing to more sustainable economic growth and attracting international investment

**Keywords:** environmental factors; environmental and social practices; technology integration; digital transformation; risk management

## Introduction

Blockchain technology is rapidly gaining popularity in various sectors of the economy, and one of the most promising areas of its application is sustainable financial activities. In the face of global environmental challenges such as climate change, environmental degradation and the depletion of natural resources, sustainable finance is becoming a way to support projects aimed at reducing carbon footprints, developing renewable energy sources and ensuring greener business practices. However, effective investment in such projects faces several barriers, including insufficient transparency of financial flows, difficulties in assessing risks and doubts about the integrity of the funds.

Trust between market participants remains one of the key challenges in green investment. It is often difficult to verify the extent to which investments are aimed at achieving environmental goals, which reduces the appeal of such projects for investors. Greenwashing issues, where companies and projects claim to be environmentally friendly but fail to achieve significant results in practice, also undermine trust and slow down the pace of sustainable finance.

Blockchain, as a decentralised and immutable record-keeping technology, can offer a solution to these problems. Given the possibility for transparency, accountability and traceability of transactions, blockchain can be used to monitor in real time how and where investments in sustainable projects are used. This not only increases the credibility of such investments but also reduces administration and control costs.

Blockchain can be used to create global sustainable finance platforms where information about projects and their environmental impacts can be made available to all stakeholders (Furmanchuk, 2023). Thus, investors can better assess risks and make more informed decisions based on transparent data. In addition, the automation of processes through smart contracts can significantly simplify the

implementation of projects and ensure their compliance with environmental standards.

An important step in the definition of the role of blockchain in sustainable finance is an analysis of the results of research conducted in this area by various authors. K.J. Lee & H. Jeong (2022) emphasised that blockchain can eliminate the issue of asymmetry of information between investors and recipients of funds. The study demonstrates that the decentralised structure of the blockchain allows each participant to access immutable project data. K. Schulz & M. Feist (2021) investigated the effectiveness of smart contracts in sustainable finance. They concluded that automating processes using blockchain could not only speed up contract execution but also ensure that the project meets environmental and financial standards. Q. Li *et al.* (2022), in turn, addressed the use of blockchain in the supply chain tracking system for green investments. Their study demonstrated that blockchain can be used to monitor every stage of project implementation. S. Anvar kyzy *et al.* (2022) conducted research confirming that the use of blockchain in the financial sector can reduce transaction costs. Their findings show that decentralised systems can replace traditional intermediary structures. J. Woo *et al.* (2021) analysed the issue of improving the mechanism for verifying environmental projects through blockchain. This technology can significantly reduce the time required to verify the compliance of projects with environmental standards based on open and publicly available data. S. Guo *et al.* (2023) also addressed the potential of blockchain to combat greenwashing. Following the authors, blockchain makes it impossible to change or conceal data on funds usage. R. Almadadha (2024) analysed the use of blockchain to increase the transparency of environmental, social and corporate governance (ESG) reporting of corporations. Blockchain can help companies provide more accurate and timely

information about their environmental impact, which increases their reputation among investors. N. Alsharari (2021), in turn, analysed the integration of blockchain with other technologies, such as the Internet of Things (IoT), to improve the monitoring of sustainable projects. Y.-S. Ren *et al.* (2023) analysed the role of blockchain in creating global sustainable finance platforms. Their findings showed that such a platform could provide global access to investment opportunities. M.R.H. Polas *et al.* (2022) concluded that blockchain can facilitate democratic access to green investment by allowing small and medium-sized investors to participate in financing environmental projects that were previously only available to large institutional investors.

Many authors confirm that blockchain has significant potential to address key issues related to sustainable finance, including transparency, efficiency and reduced transaction costs. Despite a significant amount of research on the use of blockchain in sustainable finance, several important topics remain under-researched. In particular, the aspects of blockchain use in the context of green investment management in the Kyrgyz Republic, as well as the impact of blockchain on transparency and risk mitigation in the sustainable finance ecosystem in an emerging economy, are not sufficiently studied.

The study aimed to analyse the impact of blockchain technology on sustainable finance in the context of green investments and ESG practices. The objectives of the study were to assess the impact of blockchain on the transparency and efficiency of sustainable finance in the Kyrgyz Republic, to explore opportunities and challenges of implementing blockchain to improve green investment management and to analyse ESG approaches in the financial sector.

## Materials and Methods

A complex approach was employed to analyse the role of blockchain technologies, financial technologies and ESG practices in financial institutions in the Kyrgyz Republic. The effect of innovations on the sustainability of business and the development of the country's financial sector, as well as the implementation of the Sustainable Development Goals, was prioritised.

A detailed analysis of the topic of blockchain, financial technologies and ESG practices was initially conducted. Areas of sustainable development and the inclusion of ESG factors in the investment decision-making process were prioritised. In addition, the use of blockchain in green finance was analysed. To better define the specific features and opportunities for using blockchain, financial technologies and ESG practices in the financial sector of the Kyrgyz Republic, an analysis related to financial innovation and sustainable development in the country was conducted.

One of the key research methods was a comparative analysis of the ESG practices of financial institutions in the Kyrgyz Republic with international experience. Examples of implementation of ESG standards by such organisations as Optima Bank (n.d.), Eldik Bank (n.d.), Aiyl Bank (n.d.), Commercial Bank Kyrgyzstan (n.d.), Bai-Tushum Bank (n.d.), Bank of Asia (n.d.) and DosCredoBank (n.d.) were

used to identify the most effective models and methods that can be used to increase business sustainability and improve financial performance. This data was used to assess the impact of ESG factors on the reputation, customer confidence and long-term business sustainability of financial institutions in the country.

The study of real cases of blockchain and financial technologies in the Kyrgyz Republic was an important part of the study. For this purpose, examples of financial technologies, such as person-to-person (P2P) lending and crowdfunding, which were already introduced into the national financial sector, were analysed. An analysis of successful initiatives to use blockchain to increase transparency and reduce risks in the process of allocating credit resources and managing public tenders was conducted.

Key initiatives that use blockchain in green investments were selected to analyse international projects. These initiatives include initiatives such as the IBM Food Trust, which is used to track food supply chains, ensuring transparency and sustainability of products. Another important example is SolarCoin, a global project that rewards solar energy production in the form of tokens, which helps to increase clean energy production. The WePower project and the Power Ledger, demonstrate the use of blockchain for green energy trading and decentralised energy, simplifying access to finance and reducing the carbon footprint. Initiatives analysed included Energy Web, which uses blockchain to manage distributed energy resources, Poseidon Foundation, which has developed a platform to track and reduce the carbon footprint of commodity purchases, Hongkong & Shanghai Banking Corporation, which applies blockchain to track and manage green bonds, Santander Bank, which also actively employs blockchain to provide transparency and speed up international transactions within its green bonds. These projects were selected for detailed analysis to identify their role and impact on sustainable finance and green investment.

## Results

Blockchain is an innovative decentralised record-keeping technology that allows data to be stored and transmitted securely, transparently and permanently. It is based on a distributed network consisting of nodes, each of which stores a copy of the data. Blockchain technology was created as a basis for the bitcoin cryptocurrency, but since then its application has expanded to many other areas, including the financial sector. One of the key advantages of blockchain is its decentralised nature. Unlike traditional databases that are managed by central organisations, blockchain does not require trust in one party. All network participants have access to a single version of the data, and any changes are made only after a consensus is reached among all network nodes. This renders blockchain highly protected against fraud and manipulation, which is highly relevant for the financial sector, where data accuracy and security are crucial (Zheng *et al.*, 2018).

In the financial sector, blockchain is already actively used to address an array of tasks. One of the most prominent

applications is the improvement of cross-border payments. Traditional international transfer systems require the involvement of intermediaries and often face delays and high fees. The blockchain, due to its decentralised structure, can be used for quick international transfers at minimal cost (Collomb *et al.*, 2016). An example is Ripple, which uses blockchain for instant and low-cost transactions between financial institutions around the world.

Another important area of blockchain application in the financial sector is ensuring transparency and traceability of financial transactions. This is particularly relevant in the context of the fight against fraud and money laundering. Blockchain can be used to create an immutable record of all transactions, which simplifies auditing and monitoring. As a result, banks and other financial institutions can more effectively comply with anti-money laundering requirements and know their customers.

In addition, the blockchain can be used to create smart contracts - automated digital agreements that are executed only if pre-agreed conditions are met. This simplifies financial transactions, reduces the cost of legal support and minimises the risk of non-compliance with contract terms.

Despite all the advantages, the introduction of blockchain in the financial sector has certain challenges. First, it is scalability. Currently, many blockchain systems cannot process the same volume of transactions as traditional financial systems. Second, legal and regulatory issues are also significant aspects. Most states and financial regulators do not yet have set rules for the use of blockchain, which makes its implementation difficult (Mishra and Kaushik, 2023). With the development of technology and the emergence of new solutions to increase scalability and efficiency, blockchain can become the basis of the future financial infrastructure, ensuring the security, transparency and accessibility of financial services for all market participants.

Blockchain technology can radically transform the process of sustainable finance, in particular green investments, thanks to its potential transparency and reduced risks. In the context of global environmental challenges, attracting investment in projects aimed at reducing carbon emissions and protecting the environment is becoming highly relevant (Macchiavello and Siri, 2022). However, this process involves several challenges, such as a lack of trust between investors and projects, as well as difficulties in assessing and verifying the environmental performance of projects. This is where blockchain can be used.

Transparency is one of the main advantages of blockchain. In the context of green investments, this technology can be used to create immutable, decentralised records of all transactions and project stages. This renders the financing and monitoring process accessible to all stakeholders in real-time. For instance, if a company or government agency receives funds to implement an environmental project, blockchain can be used to track how these funds are used, what resources are purchased, and what results are achieved. This transparency prevents misuse or mismanagement of resources, which is one of the key issues in green investments. Another problem investors face is the risk of

“greenwashing”, when companies claim to be environmentally friendly but fail to achieve real environmental results. Blockchain helps combat this phenomenon by recording all stages of project implementation and its environmental impact (de Freitas Netto *et al.*, 2020). For instance, information on carbon emissions or the use of renewable energy sources can be automatically recorded on the blockchain through smart contracts and IoT sensors, which is in line with the principles of the green taxonomy. The green taxonomy aims to create a unified approach to defining environmentally sustainable economic activities, and the use of blockchain technologies allows for transparency, accuracy and reliability of data related to environmental indicators (Ministry of Economy..., 2024). This, in turn, contributes to more efficient management of green investments and monitoring of projects' compliance with sustainability criteria.

In addition to increasing transparency, blockchain can reduce risks for investors. Firstly, due to the immutability of data, blockchain minimises the possibility of fraud and manipulation of financial statements. This ensures that information, including that for investors, is correct. Secondly, the decentralised structure of the blockchain reduces dependence on intermediaries, which lowers transaction costs and minimises the risks associated with delays and inaccuracies in data transmission. Moreover, blockchain can be used for global investment at minimal cost. This is especially relevant for green projects that may be located in remote regions with limited access to traditional financial institutions. Blockchain enables direct interaction between investors and recipients of funds, bypassing complex and expensive banking structures.

Financial technologies are becoming primary in sustainable development, shaping new approaches to financing and investment. It includes a wide range of innovative solutions such as mobile payments, crowdfunding, algorithmic investing and digital currencies. These technologies can simplify and speed up financial transactions, which is especially relevant for sustainable finance (Gomber *et al.*, 2017). Traditional financial systems often prove to be complex and expensive for SMEs involved in green projects. Financial technologies are facilitating access to capital through crowdfunding platforms and direct P2P loans, where investors can finance projects directly, without the need for intermediaries. This opens new opportunities for financing environmentally friendly projects, especially in developing countries where access to traditional finance is limited.

In addition, financial technologies such as algorithmic investing and artificial intelligence are enabling a more accurate assessment of the risks and potential benefits of green investments. Big data and machine learning in financial technologies can be used to analyse the sustainability of projects, predict their environmental impact and suggest optimal investment strategies (Zelisko *et al.*, 2024). This not only increases investment efficiency but also reduces the likelihood of investing in inefficient or unreliable projects, making the sustainable finance market more reliable.

ESG approaches are significant in the development of corporate responsibility and sustainability standards. ESG

metrics are used to evaluate companies and projects in terms of their environmental impact, social responsibility and management quality. For investors and financial organisations, integrating ESG factors into the decision-making process can be used to assess not only financial performance but also long-term sustainability. Studies show that companies with high ESG scores are more resilient to risks, including environmental disasters, social conflicts and changes in the regulatory environment, making such investments more attractive to long-term investors (Schramade, 2016).

An important aspect of ESG is its role in building a culture of corporate responsibility. For instance, companies that actively implement ESG principles strive to minimise carbon emissions, use renewable resources, ensure decent working conditions and support gender equality. For financial organisations, this means accounting for these factors when assessing investment projects and credit risks, which contributes to a more sustainable and ethical business.

The economy of the Kyrgyz Republic is characterised by a combination of factors that determine the specifics of its development as a post-Soviet republic in transition. The main national economic sectors include agriculture, mining and services, with agriculture remaining the key source of employment for a large proportion of the population. The country is also a major transit hub for trade between China and Central Asia, which strengthens its role in regional economic ties. The financial system of the Kyrgyz Republic is developing under conditions of limited resources and dependence on external capital inflows. Remittances from labour migrants working abroad remain an important source of external financing. These remittances play a significant role in maintaining the national balance of payments and ensuring household income (Hasanova, 2018).

The Kyrgyz Republic faces institutional and infrastructural challenges, such as limited development of the financial sector, weak financial regulation, and low financial literacy. The national central bank is seeking to improve control over financial flows, but access to credit for small and medium enterprises remains difficult due to high interest rates and tight conditions. This slows down the development of entrepreneurship and reduces employment.

On the other hand, the impact of financial technologies on the banking sector and financial organisations of the Kyrgyz Republic is becoming more and more noticeable every year. One of the key areas of financial technology development in the Kyrgyz Republic is mobile banking. With a significant part of the population not having access to traditional bank branches, the use of mobile phones for financial transactions has become a popular solution. Mobile payment services, such as Elcard and Mbank, have

become widespread and are actively supported by commercial banks. These platforms allow users to pay bills, send money transfers, and purchase goods and services online, making financial services more accessible to the population, including those in remote areas.

One of the significant achievements of financial technology in the Kyrgyz Republic has been the simplification of access to credit. Traditional banks often impose strict requirements on borrowers, which limits the opportunities for small and medium-sized businesses. At the same time, financial technologies offer alternative lending mechanisms, such as P2P (person-to-person) loans and crowdfunding. These platforms help small businesses and individual entrepreneurs raise capital bypassing traditional banking structures. This provides businesses with flexible access to finance, which fosters entrepreneurship and stimulates economic growth.

The introduction of ESG practices in financial institutions in the Kyrgyz Republic is a relatively new but rapidly developing process. This trend is dictated by both global changes in the financial sector and the need to address local economic and social problems facing the country. Given the growing importance of sustainable development and environmental challenges, financial institutions in the Kyrgyz Republic are gradually realising the importance of implementing ESG principles to ensure long-term economic growth, business sustainability and attracting foreign investment. First, the implementation of ESG practices is closely linked to the growing requirements of international financial organisations, investors and partners, who are increasingly paying attention to sustainable development. Banks and financial institutions in the Kyrgyz Republic should adapt to these new standards to remain competitive in the international arena and to have access to global investment and capital. This implies the need to comply with international standards of corporate responsibility, which includes environmental, social and governance aspects.

On the one hand, financial institutions need to implement initiatives aimed at minimising the environmental impact of their operations and assets, for instance, by supporting green projects and refusing to finance environmentally harmful enterprises. On the other hand, respect for human rights, including within supply chains, and safe and inclusive working conditions are becoming mandatory elements of their strategy. Another key factor is ensuring transparent and ethical management, which is reflected in the openness of data, financial reports and management decisions that build investor and partner confidence. Table 1 presents examples of ESG practices in financial institutions in the Kyrgyz Republic.

**Table 1.** ESG practices in financial institutions of the Kyrgyz Republic

Financial organisation	Type of ESG practice implementation	Implementation goal	Impact on business	Impact on sustainable development
Optima Bank	Social responsibility (support for local communities)	Improving the social climate and increasing customer loyalty	Improving reputation and customer confidence	Creating jobs, supporting small businesses

Table 1, Continued

Financial organisation	Type of ESG practice implementation	Implementation goal	Impact on business	Impact on sustainable development
Eldik Bank	Risk management (sustainable investment and risk monitoring)	Reducing investment risks and increasing portfolio stability	Minimising financial losses due to changes in legislation	Financing green projects, increasing responsibility in lending
Aiyl Bank	Social programmes (support for rural areas)	Promoting rural development and inclusion	Expanding the customer base, improving the business reputation	Increasing financial inclusion in rural areas
Commercial Bank Kyrgyzstan	Persistent corporate management	Improved transparency and compliance with international standards	Increasing investor confidence	Improving corporate governance and reporting standards
Bai-Tushum Bank	Financing of renewable energy sources	Promoting the development of a green economy	Expanding the product line, attracting green investors	Financing of solar and wind energy projects
Bank of Asia	Environmental management (carbon footprint reporting)	Increasing transparency of environmental aspects of operations	Strengthening market positions and attracting new customers	Reducing our carbon footprint and supporting sustainable development
DosCredoBank	Investments in social and environmental projects	Supporting educational and healthcare initiatives	Improving customer reputation and loyalty	Improving the quality of life and social security in the regions

**Source:** compiled by the author based on Optima Bank (n.d.), Eldik Bank (n.d.), Aiyl Bank (n.d.), Commercial Bank Kyrgyzstan (n.d.), Bai-Tushum Bank (n.d.), Bank of Asia (n.d.) и DosCredoBank (n.d.)

These practices not only contribute to the improvement of social and environmental responsibility but also have a positive impact on the business performance and financial stability of organisations, reflecting the growing interest in sustainable development in the Kyrgyz Republic. Blockchain technology in sustainable finance in the Kyrgyz Republic is at an early stage of development but shows significant potential. Blockchain, as a decentralised and transparent system, has unique properties that can significantly improve sustainable finance processes, especially in areas such as green investments, social project management and transparency in financial decision-making.

For the Kyrgyz Republic, where the level of trust in financial institutions is often low, the introduction of blockchain into sustainable finance processes could be an important step towards increasing transparency and confidence among investors and the public. One area where blockchain could be particularly useful is in the financing of green projects. In the Kyrgyz Republic, as in other Central Asian countries, environmental issues are becoming increasingly relevant, given the impact of climate change and problems with access to clean water and renewable energy.

In 2022, the Kyrgyz Republic started attracting the attention of international investors to cryptocurrency mining using hydropower, which is one example of a combination of blockchain and ESG practices. The country has

a significant potential for clean energy, and some mining companies have started investing in projects aimed at sustainable cryptocurrency mining, minimising the carbon footprint (Final Report of..., 2022). Such initiatives can contribute to economic development without worsening the environmental situation.

The Kyrgyz Republic has microfinance institutions that play an important role in providing access to finance for small businesses and rural communities. Some of these organisations have begun to consider the use of blockchain to improve transparency in the distribution of credit resources and reduce fraud risks. An example is the discussed introduction of blockchain technology in microfinance to track transactions and confirm the reliability of borrowers, which helps to build trust in the system and ensure transparency of operations (Kyrgyz Republic Development..., 2023).

In Kyrgyzstan, the Ministry of Finance, with the support of the World Bank, is launching a system of labelling green budget expenditures to increase transparency and efficiency in the use of public funds for environmental programmes (Mambetalieva, 2024). This initiative aims to track funding related to environmental protection and climate change adaptation, which is in line with the United Nations (UN) Sustainable Development Goals and the Paris Agreement. As part of the pilot project, the labelling will be introduced in the Ministry of Natural Resources and

Ecology and the Ministry of Emergency Situations, which will allow for the classification of green finance flows and improved resource management. This, in turn, will open new opportunities for attracting international financing, which will create conditions for the implementation of environmental projects and the introduction of innovative solutions to protect the environment.

In 2024, a project to introduce digital identification using blockchain technology was presented in the Kyrgyz Republic. This provides secure and transparent identity verification, which can be used in the financial sector, including for providing financial services to remote and rural communities (Alabi & Telukdarie, 2021). This area contributes to social inclusion, which is an important element of ESG. So far, projects in the Kyrgyz Republic using blockchain and ESG are at the stage of experimental and pilot initiatives. However, their successful implementation can open up new opportunities for sustainable economic growth, improve confidence in financial institutions and attract international investment in environmental and socially oriented projects.

Many countries and companies have begun to actively use blockchain to increase the transparency, efficiency and sustainability of their operations, especially in the context of green finance and socially responsible investment initiatives. On the international stage, one of the most successful examples of blockchain use is its implementation for tracking supply chains in the framework of sustainable development. Large corporations such as Walmart and Unilever use blockchain to monitor the supply of products, including agricultural and low-carbon products (Maleki, 2023). This not only increased transparency but also ensured that products meet high environmental standards, which is part of ESG practices. For instance, the IBM Food Trust's blockchain platform traces the origin of products and confirms that they meet sustainability requirements.

Some countries, such as Sweden, are experimenting with issuing green bonds based on blockchain technologies (Jahankhani et al., 2021). These bonds aim to finance environmentally sustainable projects, such as renewable energy or energy-efficient buildings. Blockchain ensures transparency at every stage of the bond's life cycle and simplifies the reporting process for investors, who can track where the funds were allocated. As a result, green bonds are becoming more attractive to investors, as blockchain provides assurances that funds are being used in line with the stated ESG goals. International experience shows that blockchain can be successfully used to solve social problems that also fall within the ESG context. The World Bank and the United Nations use blockchain to provide financial services to refugees and people who do not have access to traditional banking systems. In this context, blockchain becomes a financial inclusion method, which is one of the key elements of ESG. For instance, Jordan has implemented a blockchain project that allows refugees to receive assistance in the form of vouchers used to buy food, making the processes more transparent and protected from corruption (Juskalian, 2018).

In European countries, such as Germany and the Netherlands, blockchain is being actively used in energy projects related to the distribution of renewable energy. Blockchain-based platforms allow households and businesses to trade energy directly with each other, bypassing traditional energy companies. This approach contributes to sustainable development by increasing energy efficiency and encouraging the use of renewable sources. One such project is the Power Ledger in Australia, which successfully uses blockchain to trade solar energy, enabling buyers to track the source of energy and its environmental footprint. Table 2 shows the most famous international projects using blockchain in green investments.

**Table 2.** International projects using blockchain in green investments

Project	Project description	Application of blockchain	Role in sustainable finance	Results
IBM Food Trust	Food supply chain tracking platform	Usage of blockchain for transparent tracking of product supplies	Guarantee of sustainable food origin	Increasing transparency and trust in the food supply chain
SolarCoin	Remuneration for solar energy production in the form of tokens	Blockchain is used to track produced solar energy	Stimulating clean energy production	More than 10 GWh of renewable energy was registered
WePower	A platform for green energy trading	Tokenisation of energy supply contracts	Attracting investment in renewable energy	Simplified access to financing for green energy projects
Power Ledger	Solar energy trading between consumers directly via a blockchain platform	Decentralised platform based on blockchain	Supporting distributed energy and reducing our carbon footprint	Successful implementation of decentralised energy trading
Energy We	Blockchain for managing distributed energy resources	Decentralised energy management	Improving the efficiency of renewable energy sources	Attracting new market participants and increasing transparency of operational data

Table 2, Continued

Project	Project description	Application of blockchain	Role in sustainable finance	Results
Poseidon Foundation	A platform for tracking and reducing the carbon footprint of goods purchases	Blockchain integration to track the carbon footprint of transactions	Reducing carbon footprint and attracting customers to sustainable projects	The programme was introduced into retail to offset customers' carbon footprint
Santander Bank	A platform for financing environmentally friendly projects	Employment of blockchain for transparent finance tracking	Simplifying the process of obtaining financing for green projects	Supporting the funding of multiple sustainable initiatives around the world
Hongkong & Shanghai Banking Corporation	Green bond tokenisation programme	Usage of blockchain to create tokenised assets	Attracting investment in sustainable development projects	Successful issue of green bonds on a blockchain platform

**Source:** compiled by the author

International experience with blockchain and ESG practices in the financial sector shows that the combination of these two areas can lead to significant changes in the management of sustainable projects, investment attraction and transparency. The Kyrgyz Republic can use these examples to accelerate the implementation of domestic blockchain and ESG projects, creating conditions for more sustainable economic growth and attracting international investment.

The successful implementation of blockchain and ESG practices in the financial sector of the Kyrgyz Republic requires more active cooperation between the government, financial institutions and international organisations aimed at creating a comprehensive legal framework and technological infrastructure. The government should develop regulatory standards that will ensure transparency and security of the use of blockchain technologies in sustainable finance, as well as create incentives for green investments. These standards should include reporting requirements on ESG criteria and mechanisms for monitoring the fulfilment of environmental and social obligations.

In addition, it is necessary to strengthen the development of local digital infrastructure, which implies the introduction of secure digital platforms and data management systems for the effective use of blockchain. At the same time, educational programmes and training for financial institutions that will cover not only the basics of ESG practices but also the practical use of blockchain for investment management should be emphasised. This will help raise awareness of the benefits of blockchain and ESG, as well as improve the skills of employees.

The integration of blockchain technologies into investment management will significantly reduce operational risks, improve the transparency of financial transactions and increase investor confidence in environmental projects. The introduction of ESG practices will ensure the long-term sustainability of the financial sector, making the Kyrgyz Republic more attractive to global investors interested in responsible and sustainable financial instruments. The synergy of blockchain and ESG will create conditions for

modernising the financial system, increasing its competitiveness and developing new areas of sustainable finance.

## Discussion

The study demonstrated that blockchain has significant potential to transform the financial sector, including sustainable finance and green investment management. One of the main advantages of this technology is its decentralised structure, which ensures a high degree of transparency and data security. This is especially relevant in the context of sustainable development and implementation of ESG practices in financial institutions in the Kyrgyz Republic. O. Juszczak & K. Shahzad (2022) investigated the use of blockchain technologies in the financing of renewable energy projects. The authors concluded that the use of smart contracts significantly increases transparency and reduces transaction costs for green investments. These findings are similar to the current results, especially in terms of increasing transparency and efficiency of transactions. However, in contrast to current data, the authors did not address the challenges of implementing blockchain in countries with a low level of digitalisation.

F. Kalfaoglou (2020) highlighted a significant reduction of financial risks for banks that actively apply ESG practices. The author noted that the implementation of these standards helps to increase investor confidence and strengthen reputation. B. Torre Olmo *et al.* (2021) demonstrated that investments in sustainable development directly increase banks' profitability. In the current results, ESG practices also show a positive impact on the image.

The experience of implementing blockchain in the financial sector of Kyrgyzstan identified several key areas of its application. Firstly, the technology is used to increase the transparency of financial transactions and control over the distribution of funds, which is relevant for government tenders and international grants. In the context of a low level of trust in national financial institutions, blockchain can help reduce corruption and increase transparency. T. Jiang *et al.* (2022) addressed blockchain integration into

the carbon trading system. Authors noted that blockchain reduced fraud and increased investor confidence. These findings are in line with current findings on improving data security and transparency for investors. However, unlike the current study, the authors did not address the impact of blockchain on small and medium-sized enterprises, which is an important aspect.

In addition, the use of blockchain can significantly improve access to finance for small and medium-sized businesses, especially in rural areas (Tsapova *et al.*, 2024). Notably, microfinance institutions in Kyrgyzstan are already showing interest in using blockchain to increase the transparency of lending operations and minimise fraud risks. This also contributes to building trust in the system and developing small businesses, which is an important element of national socio-economic growth. M. Kumara-thunga *et al.* (2022) studied the impact of blockchain on microfinance for sustainable agricultural projects. They emphasised that blockchain promotes transparency and the elimination of intermediaries, which is consistent with current findings. H.O. Bello *et al.* (2024) noted that the use of financial technologies simplifies the implementation of ESG practices in small and medium-sized companies by increasing transparency of operations and automating reporting. However, they stressed that for smaller organisations, the main barrier is the lack of financial resources to invest in modern digital solutions. The current study also determined a positive correlation between financial technology and ESG practices, especially in terms of transparency.

One of the most promising areas of blockchain use is the support of green projects, such as the sustainable use of water resources for cryptocurrency mining (Spytska, 2023). This is an example of how technology can help attract foreign investment while minimising the negative impact on the environment. In Kyrgyzstan, there are already initiatives to develop cryptocurrency mining based on hydropower, which contributes to a more environmentally friendly use of energy. H. Kalaiarasi & S. Kirubahari (2023) addressed the introduction of blockchain in companies specialising in green bonds. They noted that blockchain helps improve reporting and control over environmental projects, which coincides with current results. However, their study demonstrated that the introduction of blockchain has not yet provided a significant increase in green investments.

International experience also confirms that blockchain can be effectively used to ensure the sustainability and transparency of supply chains (Smutchak *et al.*, 2023). Large corporations such as Walmart and Unilever are already using blockchain to track product deliveries, which helps not only to increase transparency but also to ensure that products meet high environmental standards. The implementation of such solutions could be useful for the Kyrgyz Republic, especially in the context of developing the agricultural sector and improving product quality. B. Georgescu *et al.* (2022) addressed the use of blockchain to track the supply of organic food in the EU. Their study

noted that blockchain ensures transparency and traceability of the entire supply chain, ensuring that products truly meet environmental standards. This is in line with current findings on blockchain transparency, but the author emphasised an increase in consumer confidence from blockchain usage. In contrast to the current data, which focuses on direct green investments, the authors focus on the role of consumer confidence.

M. Nour *et al.* (2022), in turn, investigated the use of blockchain technologies to track the supply of products within large-scale renewable energy projects. They noted that blockchain provided better control over the supply of equipment for solar and wind farms, which reduced logistics costs and minimised delays. These findings support the current results in terms of improving the efficiency of supply chain management through blockchain. However, unlike the current study, which focuses on the impact of these technologies on attracting green investments, the authors emphasise their role in improving the operational efficiency of projects.

Despite its considerable potential, blockchain implementation faces certain challenges. First, it is scalability. Many blockchain systems are not yet able to process the same transaction volumes as traditional financial systems, which limits their use in large financial institutions (Vazov *et al.*, 2022). Second, legal and regulatory aspects remain challenging. In the Kyrgyz Republic, as in many other countries, there are no clear rules and standards governing the use of blockchain in the financial sector, which creates uncertainty for its implementation. In analysing the impact of blockchain on the banking sector, A. Ahl *et al.* (2022) highlighted negative aspects such as the high energy footprint of blockchain and regulatory issues. This partly contradicts the current findings, which focus on the potential of blockchain to stimulate green investment. Unlike the authors, the current study emphasises the desire to reduce the carbon footprint by switching to more energy-efficient technologies.

Overall, blockchain could become substantial in the development of sustainable finance in the Kyrgyz Republic, but scalability and regulation issues need to be addressed for successful implementation. Given the growing interest of international investors in sustainable development projects, blockchain can become central in attracting capital to green projects and increasing the transparency of financial processes.

An analysis of studies by various authors demonstrated that blockchain technologies are central both in the financial sector and in stimulating green investments. Nevertheless, approaches to assessing the impact of these technologies on sustainable finance vary and may differ depending on the context and the aspects under investigation. The overlap between the research findings includes aspects such as increased transparency and traceability of supply chains, improved operational efficiency and stimulating green investments through the introduction of blockchain.

## Conclusions

Blockchain technology is an innovative means of record-keeping that provides secure, transparent and immutable data storage. This technology, originally developed for cryptocurrencies such as Bitcoin, can be effectively used in the financial sector to improve transactions, transparency and fight fraud. The main advantages of blockchain include its decentralised nature and the ability to provide reliable and fast international transfers, such as Ripple. It also increases transparency and traceability of financial transactions, which is critical for compliance with anti-money laundering and customer due diligence standards.

The introduction of smart contracts also greatly simplifies financial transactions, reducing the cost of legal support and minimising the risk of non-compliance with contractual terms. Nevertheless, there are scalability, legal and regulatory issues that are slowing down the adoption of blockchain in the financial sector. Nevertheless, blockchain has the potential to become the foundation of the future financial infrastructure, offering improvements in the security, transparency and accessibility of financial services. In the context of sustainable finance and green investment, blockchain can significantly increase transparency and reduce risks. It can be used to create immutable and decentralised records of all transactions and project milestones, which is relevant for preventing abuse and combating green marketing. It also reduces dependence on intermediaries and reduces transaction costs, which is particularly useful for projects in remote areas.

Financial technologies are also substantial in sustainable development, providing new approaches to financing and investment through mobile payments, crowdfunding and digital currencies. These technologies facilitate access to capital and allow for a more accurate assessment of the risks and potential of green investments, improving the efficiency and reliability of the sustainable finance market.

ESG approaches are substantial in the development of corporate responsibility and sustainability standards. In the Kyrgyz Republic, the implementation of ESG practices in financial institutions and the use of blockchain are at an early stage but show significant potential. Optima Bank, RSK Bank, Aiyl Bank and many others demonstrate the growing interest in sustainability in the Kyrgyz Republic and show how financial institutions can implement ESG approaches to improve their social and environmental responsibility, as well as to increase financial stability.

Examples of successful blockchain applications include attracting international investors to clean mining and using blockchain to track transactions and improve transparency. International projects such as the IBM Food Trust Power Ledger, SolarCoin and Veridium demonstrate the successful use of blockchain to improve transparency and sustainability of transactions, which can serve as an example for the Kyrgyz Republic in creating a more sustainable and transparent financial sector. Thus, international experience and research show that blockchain can significantly improve the management of sustainable projects, attract investment and ensure transparency.

The study limitations include a lack of data on the long-term results of blockchain implementation in financial institutions of the Kyrgyz Republic, which renders the definition of their impact on sustainable development difficult. For further research, it is advisable to study the impact of blockchain on financial performance and social development in the long term, as well as to compare it with the practices of other developing countries.

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## Conflict of Interest

None.

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## **Блокчейн та стале фінансування: Підвищення прозорості та ефективності зелених інвестицій**

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**Анотація.** Метою дослідження був аналіз можливостей використання технології блокчейн для підвищення прозорості та ефективності у сфері сталого фінансування. Проаналізовано застосування блокчейн-технологій та екологічних і соціальних практик в контексті сталого фінансування, з акцентом на впровадження та перспективи в Киргизстані. Блокчейн, як інноваційна технологія децентралізованого запису даних, забезпечує високий рівень безпеки, прозорості та незмінності, що робить його особливо цінним для фінансового сектору. У дослідженні підкреслюється, як блокчейн може поліпшити процеси міжнародних переказів, підвищити прозорість фінансових операцій і спростити управління смарт-контрактами, а також відзначаються існуючі виклики, такі як масштабованість і правові питання. Важливим аспектом дослідження стала роль технологій блокчейн у сталому фінансуванні, особливо у сфері зелених інвестицій. Впровадження блокчейну в таких сферах, як фінансування зелених проектів та управління соціальними ініціативами, може сприяти підвищенню довіри інвесторів та покращенню ефективності інвестицій. Фінансові технології також відіграють центральну роль у формуванні нових підходів до фінансів та інвестицій, полегшуючи доступ до капіталу за допомогою краудфандингу та платформ кредитування від людини до людини (P2P). Впровадження екологічних та соціальних практик у фінансових установах Киргизької Республіки демонструє зростаючу увагу до корпоративної відповідальності та сталого розвитку, незважаючи на початковий етап їх впровадження. На міжнародній арені такі успішні проекти, як використання блокчейну для відстеження ланцюгів поставок, зелені облігації та управління вуглецевими кредитами, демонструють потенціал технологій для підвищення прозорості та ефективності сталого фінансування. Ці приклади можуть бути використані Киргизстаном при розробці та впровадженні внутрішніх блокчейн- та еколого-соціальних ініціатив, що сприятиме більш сталому економічному зростанню та залученню міжнародних інвестицій

**Ключові слова:** екологічні фактори; екологічні та соціальні практики; інтеграція технологій; цифрова трансформація; управління ризиками