APPLICATION OF GREEN BLOCKCHAIN AND ALGORAND ALGORITHM IN AGRICULTURAL PRODUCT TRACEABILITY: THE CASE STUDY OF COFFEE SUPPLY CHAIN IN VIETNAM

ỨNG DỤNG CÔNG NGHỆ GREEN BLOCKCHAIN VÀ THUẬT TOÁN ALGORAND TRUY XUẤT NGUỒN GỐC SẢN PHẨM NÔNG SẢN: TRƯỜNG HỢP ỨNG DỤNG TRONG CHUỖI CUNG ỨNG CÀ PHÊ VIỆT NAM

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Tóm tắt

Traceability has increasingly become a mandatory requirement in the export of agricultural products. Efforts in developing IoT and traditional software solutions, however, have not adequately met the growing demand for transparency and sustainability in supply chain. This study proposes the application of green blockchain technology for agricultural product traceability, with a case study focusing on the Vietnamese coffee supply chain. By employing the Proof of Stake (PoS) consensus mechanism and Algorand algorithm, the proposed model enables real-time data collection and ensures data immutability, transparency, and efficiency in information exchange among stakeholders. Additionally, this solution contributes to the digitization of the entire agricultural supply chain with minimal environmental impact, representing a significant development toward promoting the sustainability and competitiveness of Vietnamese agricultural products in the global market.

Từ khóa: *Green blockchain, Algorand, traceability, coffee supply chain.*

Abstract

Truy xuất nguồn gốc ngày càng trở thành một yêu cầu bắt buộc trong hoạt động xuất khẩu nông sản. Tuy nhiên các nỗ lực trong phát triển IoT và các phần mềm truyền thống chưa đáp ứng được yêu cầu ngày càng tăng về tính minh bạch và bền vững của chuỗi. Nghiên cứu này đề xuất ứng dụng công nghệ Green Blockchain để truy xuất nguồn gốc nông sản với trường hợp ứng dụng điển hình trong chuỗi cung ứng cà phê Việt Nam. Bằng việc sử dụng cơ chế đồng thuận PoS cùng thuật toán Algorand, mô hình đề xuất cho phép thu thập dữ liệu theo thời gian thực, đảm bảo tính bất biến của dữ liệu, đồng thời cải thiện tính minh bạch và hiệu quả trong trao đổi thông tin giữa các bên liên quan. Bên cạnh đó, giải pháp này còn góp phần số hóa toàn bộ chuỗi cung ứng nông sản với tác động tối thiểu đến môi trường, là một bước tiến quan trọng trong việc thúc đẩy tính bền vững và khả năng cạnh tranh của nông sản Việt Nam trên thị trường quốc tế.

Keywords: *Green blockchain, Algorand, truy xuất nguồn gốc, chuỗi cung ứng cà phê.*

1. Introduction

The agricultural sector plays a crucial role in economic development, particularly in developing countries. It drives income growth, reduces poverty, and provides employment while ensuring food security (Dether, 2011). Given its significance, food safety, quality assurance, and traceability remain major challenges (Zhang & Zhao, 2021). The lack of standardization across processes creates information gaps, reducing transparency and increasing risks of poor-quality products (Voora et al., 2022). This affects consumers and complicates manufacturers' and exporters' efforts to maintain competitiveness and supply chain stability (Alamsyah et al., 2023).

Blockchain technology, with its decentralized and immutable data storage, enhances supply chain transparency from farm to consumer (Xu et al., 2020). By creating a secure, trust-based system without intermediaries, blockchain improves traceability and quality management (Li et al., 2021). Its adoption in agriculture, as seen in IBM Food Trust and Walmart, highlights its transformative potential.

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For Vietnam, a top global coffee exporter, supply chain transparency is critical (Nguyen & Sarker, 2018). The industry faces challenges due to complex stakeholder involvement and strict international traceability standards, especially from the EU and the US. Vietnam struggles with export rejections due to non-compliance with quality and transparency regulations (UNIDO, 2023). From June 2025, the EU will require proof that Vietnamese coffee is not grown on deforested land, posing significant challenges.

Blockchain adoption in Vietnam's coffee supply chain can enhance traceability, ensuring compliance with stringent import regulations (Yacoub & Castillo, 2022). While solutions like Te-Food and Vn-Check exist, they remain fragmented. A unified blockchain system is needed to address industry-wide challenges. However, its implementation demands high investment and raises concerns about energy consumption and carbon emissions (Alzoubi & Mishra, 2023). This study explores blockchain's potential in creating a sustainable and transparent coffee supply chain while incorporating green solutions to minimize environmental impact.

The paper is structured as follows: Section 2 reviews the literature, Section 3 outlines the research methodology, Section 4 presents findings and discussion, and Section 5 is concludes the study.

2. Literature Review

2.1. Coffee industry processing

The coffee industry supply chain consists of many stakeholders, where the leading actor commonly is the coffee processor, responsible for treating harvested products into refined coffee beans. Several steps are needed to process coffee from the farmers to the final product. The coffee industry begins with coffee beans grown and harvested on farms, then goes through stages of processing, packaging, and distribution to consumers around the world (Fairtrade Foundation, 2023). Based on previous research, the coffee supply chain consists of two main sectors: (1) Production Sector: This sector focuses on the core production network and involves coffee farming, innovation, and advancements in agricultural technology (Shanker et al., 2022). (2) Logistics Sector: This sector is responsible for logistics functions, which are generally carried out by government agencies and third-party logistics providers (Shanker et al., 2022).

2.2. Green Blockchain

Blockchain can be defined as an immutable ledger with an ordered list of blocks that records transactions (Arena et al., 2019). Consensus operates as a mechanism for block verification, such as Proof of Work (PoW) or Proof of Stake (PoS). These attributes define the core characteristics of blockchain: immutable data records, tamper resistance, traceability, cryptographic security, and decentralization (Wang et al., 2023). Blockchain technology has been researched and successfully applied across various domains, from finance (Nakamoto, 2008) and smart contracts (Christidis & Devetsikiotis, 2016) to healthcare (Azaria et al., 2016).

However, in recent years, blockchain has faced criticism due to its high energy consumption, particularly associated with global warming caused by the PoW consensus algorithms widely used to maintain network consensus. This has drawn harsh criticism from academia, businesses, and the media (Platt et al., 2021).

To address this issue, a new paradigm of green blockchain has emerged. Green blockchain emphasizes environmentally sustainable use of blockchain technology, prioritizing reduced carbon emissions and energy consumption (Oudani et al., 2023). Green blockchain employs validation mechanisms such as Proof of Stake, Delegated Proof of Stake, Proof of Luck, Proof of Elapsed Time, and others. These novel consensus processes are energy-efficient, requiring minimal computational power, and are highly scalable (Saad et al., 2020). In the financial sector, for instance, green blockchain simplifies transactions, eliminates intermediaries, and consumes less energy, contributing to cost savings and environmental sustainability (Qin et al., 2023).

2.3. Blockchain traceability and supply chain management

Traceability has become increasingly important for companies and exporters as it represents compliance with rules and regulations. It is not merely about ensuring product origin or optimizing logistics (Thakur et al., 2020). Traceability systems enable product tracking by providing information such as origin, composition, or location during production and distribution processes (Lu & Xu, 2017). Similar conditions apply to coffee businesses, where traceability is essential for making process information throughout the supply chain more transparent to stakeholders. Enterprises are required to provide detailed information to governments (upstream) and end consumers regarding the plantations where coffee beans were grown and harvested, the roasting companies that processed them, and the retailers that sold them.

Blockchain technology has also been applied to supply chain management, drawing academic attention due to its notable successes. In the pharmaceutical supply chain, Musamih et al. (2021) proposed an Ethereum-based approach utilizing smart contracts and decentralized off-chain storage for efficient drug traceability. Baygin et al. (2022) developed a shipment management system addressing payment and traceability challenges using blockchain-based smart contracts, yielding significant financial and workforce benefits.

Blockchain solutions have also been applied for agricultural supply chain traceability to enhance transparency and trust among participants. Alamsyah et al. (2022) designed a blockchain-based traceability system for the halal meat industry in Indonesia, improving chain transparency, tracking asset movements within the chain, and integrating data across the supply chain-minimizing information asymmetry and strengthening trust among producers, distributors, and retailers. Similarly, Alamsyah et al. (2023) successfully developed a blockchain-enabled traceability model for the coffee supply chain, allowing data collection on activities and statuses of coffee batches from farmers to end consumers.

2.4. Research gap

Most of the current research focuses on developing solutions to serve end consumers in the supply chain. However, there is still a gap in researching solutions to optimize the supply chain specifically for export activities, especially in the context of the new EU regulations that coffee exported from Vietnam to the EU must clearly meet the origin. In addition, although there have been studies related to the application of "green" criteria in agricultural product traceability, there is still a lack of specific studies on sustainability and "green" factors in coffee traceability. This is especially important because the supply chain and stakeholders of coffee have different characteristics compared to other agricultural products. Research and development of a "green" coffee traceability system not only helps to increase product value but also meets the increasing requirements of the international market.

3. Methodology

The research process is divided into four stages: understanding business processes and data collection, model development, application creation, and system evaluation.

Stage 1: Researching Business Processes and Data Collection

In this stage, the research team synthesized and analyzed previous scientific literature related to the coffee supply chain ecosystem. These ecosystems are typically dominated by producers and processors, who participate in activities ranging from roasting to product packaging. Business concepts within the supply chain often stem from market demand, encompassing retailers, large supermarket chains, restaurants, coffee shops, and exporters.

A notable finding is the lack of market understanding among farmers, which has led to the emergence of intermediaries. Furthermore, coffee products fail to meet the requirements for verifying the origins of the land used for cultivation, posing challenges for export to markets like the EU. If these issues persist, the sustainability of the supply chain will be severely compromised.

Stage 2: Developing a Green Blockchain Model for the Coffee Supply Chain

Based on the information gathered regarding the supply chain and its specific requirements, the research team designed a Green Blockchain model tailored to the Vietnamese coffee industry. After comparing various consensus mechanisms, Proof of Stake (PoS) mechanism with Algorand algorithm was selected due to its energy efficiency and sustainability features. The proposed model is outlined as follows:

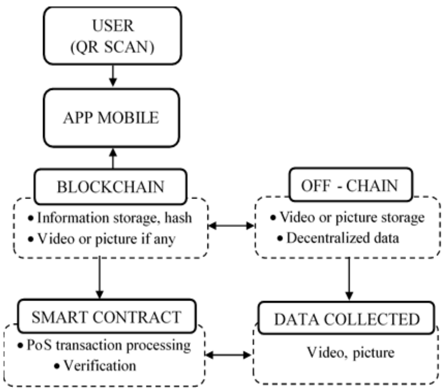

Figure 1. Blockchain operations using the PoS consensus mechanism and Algorand algorithm

The system collects data and processes it through Smart Contracts, which handle the verification and execution of transactions using PoS consensus mechanism. Critical data is stored directly on the blockchain, while large data files such as videos and

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images that do not require high immutability are stored off-chain using the Inter Planetary File System (IPFS) model. In such cases, only the hash of the data (IPFS hash) is stored on the blockchain to optimize cost and storage capacity. Users can scan QR codes via the application to retrieve product information from the blockchain. If the information is related to off-chain data, the system uses the IPFS hash stored on the blockchain to access and retrieve the corresponding off-chain data from IPFS (Figure 1).

Stage 3: Developing a Traceability Application

In this stage, the research team developed an application based on Green Blockchain technology. This application was built from a customized version of the general traceability model designed in the previous stage. Through the application, stakeholders in the supply chain can record information or access data transparently, ensuring that the entire process is monitored and supervised.

Stage 4: System Evaluation

The coffee traceability system was evaluated against a set of criteria identified from the literature review and technical considerations. These criteria, presented in Table 1, include detailed descriptions and specific measurement methods. They serve as the basis for assessing the effectiveness of Green Blockchain model compared to traditional blockchain platforms.

4. Results

4.1. Build a data model

The data model in the traceability system is designed in a layered structure to ensure clarity and logic in information management. This structure includes five main blocks, corresponding to five stages of the coffee supply chain: farm, processing facility, distribution unit, legal agency, and retail point (Figure 2).

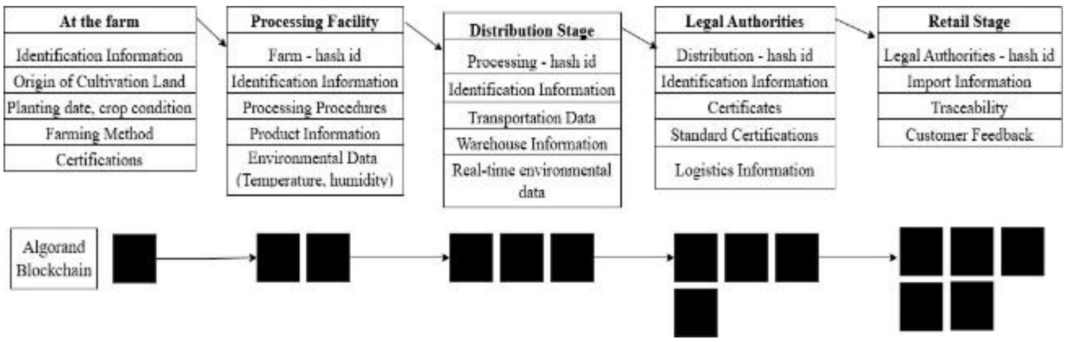

Figure 2. Blocks and connections between blocks

Table 1. Criteria for assessing the effectiveness of Blockchain models

Criterion	Description	Measurement
Data Integrity	Ensure data remains unchanged and tamper-proof.	Verify data using cryptographic hash comparisons.
Energy Efficiency	Minimize energy consumption in system operations.	Calculate average energy use per transaction (kWh) and compare with benchmarks.
Transaction Cost	Ensure cost-effectiveness of blockchain transactions.	Determine average transaction fees (USD) over various scenarios.
Transparency	Enable stakeholders to trace supply chain processes.	Survey stakeholder satisfaction and calculate the percentage of traceable records.
Sustainability Impact	Reduce environmental footprint of the traceability process.	Measure carbon emissions per transaction (grams CO2 equivalent) and compare with traditional methods.
Export Compliance	Meet international standards for product traceability.	Test compliance against export regulations (e.g., EU standards).
Stakeholder Satisfaction	Assess acceptance and satisfaction levels among all system users.	Collect survey data and calculate average satisfaction scores from stakeholders.

Each block represents a specific stage and acts as a transaction node on the blockchain. After being censored, cross-verified, and approved between organizations and individuals participating in the chain, the data will be uploaded to the blocks. Data from each block is encrypted and stored in the form of blocks, forming a linked chain that ensures immutability and transparency. Each transaction is assigned a unique hash code, closely connected to the previous transaction, thereby creating a reliable and unchangeable data system. New data will continue to be entered into the system without replacing or deleting old data. Therefore, this model helps to optimize the storage and retrieval of information and enhance the connectivity between stages in the supply chain, from the beginning to the end, from the farm to the consumer.

4.2. Specific blocks in the coffee supply chain

At the farm, data is collected to ensure transparency right from the beginning of the supply chain. Identification information includes the farm name, address, GPS coordinates, and owner name. In addition, data to verify the origin of the land, including the land plot number and land classification (residential land, agricultural land, forest land) based on the land use right certificate database, will be recorded. Data on the type of crop, such as Robusta, Arabica, or improved varieties such as Catimor, are also recorded. Cultivation methods such as organic, traditional, or combined with environmental parameters such as temperature, humidity, and rainfall are entered into the system. Planting date and crop status, time, volume of fertilizer, and fumigation are updated periodically. Harvest time, harvest yield, coffee quality of each batch, process, and results after processing at the farm. Certifications such as Fair Trade, Rainforest Alliance, and illustrative photos or videos from the farm are also stored to increase reliability.

At the processing facility, the production process and product quality improvement are focused on. Recorded information includes roasting temperature, roasting time, and type of machine used. Blending ingredients, if any, are also entered into the system. Data on production date, packaging type, and batch identification ensure that all products can be traced. IoT applications are integrated with the factory to record environmental parameters such as temperature and humidity in real-time and are also synchronized to the blockchain.

During the distribution stage, transportation and storage data are collected to ensure product quality throughout the journey. IoT sensors on vehicles record temperature and humidity during transportation. This is especially important in coffee exports, as according to Vietnamese Standard TCVN 6602:2013 (ISO 8455:2011), storage temperature should be around 22°C, and relative humidity should not exceed 60%. Information on warehouse status, including temperature, humidity, storage time, and inventory quantity, is updated in real-time. For exported coffee, this data helps exporters ensure that products are not affected by storage conditions, especially when transported over long distances by sea. The system ensures that all information is transmitted directly to the blockchain, minimizing the risk of loss and damage.

Legal authorities play a key role in promoting transparency and traceability in the export coffee supply chain through green blockchain applications. On this platform, the data that needs to be recorded includes detailed information about the origin of the product and important legal documents, such as a Phytosanitary Certificate, Certificate of Quality, Certificate of Food Safety, and Certificate of Origin (C/O). At the same time, special standard certificates such as Rainforest Alliance, UTZ, Fairtrade, Environmental Certificate, etc., also need to be integrated to confirm that the product meets international standards. In addition, logistics-related information such as bills of lading, quantity, shipment weight, and export licenses must be fully recorded. Synchronizing this data on the blockchain not only ensures legal compliance but also increases the level of trust from import partners and consumers, thereby meeting the increasing demand for transparency and responsibility in global trade. At the point of sale, import data, including the date of receipt and suggested retail price, are stored on the system. Consumers can look up the entire product journey through the QR code on the packaging. In addition, the system also integrates a function that allows customers to provide feedback and reviews on products, thereby improving the quality and customer experience consumers.

4.3. Steps to import data into the blockchain

First, users log into the system through a unique identifier. This helps control access and facilitates tracking and recording the history of each individual's activities in the system.

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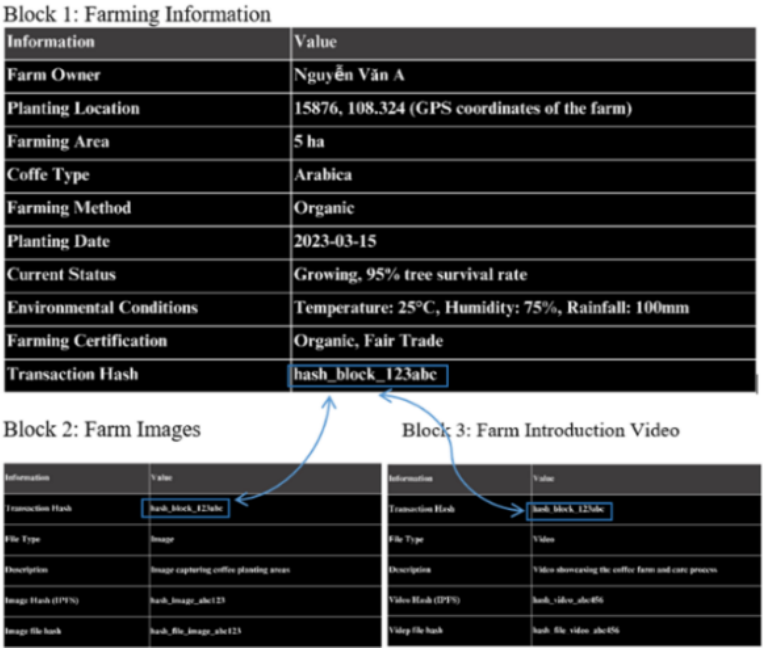

Block 1: Farming Information

Information	Value
Farm Owner	Nguyễn Văn A
Planting Location	15876, 108.324 (GPS coordinates of the farm)
Farming Area	5 ha
Coffe Type	Arabica
Farming Method	Organic
Planting Date	2023-03-15
Current Status	Growing, 95% tree survival rate
Environmental Conditions	Temperature: 25°C, Humidity: 75%, Rainfall: 100mm
Farming Certification	Organic, Fair Trade
Transaction Hash	hash_block_123abc

Block 2: Farm Images

Information	Value
Transaction Hash	hash_block_123abc
File Type	Image
Description	Image capturing coffee planting areas
Image Hash (IPFS)	hash_image_abc123
Image file hash	hash_file_image_abc123

Block 3: Farm Introduction Video

Information	Value
Transaction Hash	hash_block_123abc
File Type	Video
Description	Video showcasing the coffee farm and care process
Video Hash (IPFS)	hash_video_abc456
Videp file hash	hash_file_video_abc456

Figure 3. Example of farm off-chain storage model

Next, users enter the necessary information into online forms. These forms are standardized to suit each stage of the supply chain, such as harvesting information from farmers or processing parameters from roasters. This process helps collect data systematically and in detail while ensuring that all important information, such as the origin of raw materials and production date, is fully recorded.

For large data, such as images or videos, the system uses an off-chain storage model through the IPFS protocol as shown in Figure 3. Only the hash code of this data is stored on the blockchain, optimizing costs and storage capacity. When retrieval is needed, the system uses hash codes to load data from IPFS, ensuring consistency and accuracy.

After data is entered, the system automatically performs validity checks to detect missing or inconsistent information. Errors will be clearly notified so users can correct them promptly. And the editing history will also be saved in the data network. This helps increase data accuracy right from the early stages.

After being entered, data will be sent to network nodes in the system for authentication through a consensus mechanism POS by Algorand. Once the transaction is confirmed, the information is added to the blockchain. This not only ensures that data cannot be altered or deleted but also helps increase transparency throughout the system.

Once the information has been verified, the system encrypts the data to protect against unauthorized access. At the same time, a unique hash code is generated to represent that data. This hash code acts as a digital "fingerprint," ensuring immutability and future retrieval of data. End users or stakeholders can easily access the data by scanning the QR code via the mobile application as shown in Figure 4 to be able to see the entire supply chain of the product. Therefore, this software helps save time as well as enhance the ability to verify product origin.

Figure 4. Interface when users use the app to trace the origin of a coffee shipment

5. Conclusion

Although there has been a study applying Green Blockchain technology to traceability in the dairy supply chain, no research in Vietnam has yet addressed the implementation of this technology in the traceability of agricultural supply chains. It is imperative to emphasize that the adoption of this technology is crucial, particularly in the context of the new EU regulations requiring agricultural products, including coffee exported from Vietnam to the EU, to meet transparent and sustainable traceability standards.

This study introduced a traceability solution based on the Algorand Blockchain platform, specifically designed to support the traceability of the Vietnamese coffee supply chain with low energy consumption and cost. With its proposed system architecture, design, and interaction model, this solution has the potential for widespread adoption across other agricultural supply chains in Vietnam due to operational similarities.

The Blockchain-based traceability system provides real-time information throughout the supply chain, enhancing transparency and efficiency in data exchange among stakeholders. Furthermore, Blockchain technology ensures data integrity and immutability-key factors in meeting the requirements for exporting Vietnamese agricultural products to international markets.

The use of Green Blockchain with an energy-efficient consensus mechanism offers significant benefits in promoting sustainability and enhancing the "Made in Vietnam" brand value among consumers and regulators. Additionally, optimizing the process by reducing the number of transactions through staged data collection and transmitting information only after the completion of the entire supply chain presents a critical solution to minimizing transaction costs associated with Blockchain technology.

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REFERENCES

[1] Alamsyah, A., Hakim, N., Hendayani, R. (2022). *Blockchain-based traceability system to support the Indonesian halal supply chain ecosystem*. Economies, Vol.10, pp.134-152.

[2] Alamsyah, A., Widiyanesti, S., Wulansari, P., Nurhazizah, E., Dewi, A. S., Rahadian, D., & Tyasamesi, P. (2023). *Blockchain traceability model in the coffee industry*. Journal of Open Innovation: Technology, Market, and Complexity, Vol.9(1), 100008.

[3] Alzoubi, Y. I., & Mishra, A. (2023). *Green blockchain-A move towards sustainability*. Journal of Cleaner Production, Vol.430, 139541.

[4] Arena, A., Bianchini, A., Perazzo, P., Vallati, C., & Dini, G. (2019). *BRUSCHETTA: An IoT blockchain-based framework for certifying extra virgin olive oil supply chain*. In 2019 IEEE international conference on smart computing (SMARTCOMP) (pp.173-179). IEEE.

[5] Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2016, August). *Medrec: Using blockchain for medical data access and permission management*. In 2016 2nd international conference on open and big data (OBD) (pp. 25-30). IEEE.

[6] Baygin, M., Yaman, O., Baygin, N., Karakose, M. (2022). *A blockchain-based approach to smart cargo transportation using UHF RFID*. Expert Syst. Appl. Vol.188.

[7] Christidis, K., & Devetsikiotis, M. (2016). *Blockchains and smart contracts for the internet of things*. IEEE.

[8] Dether, J. (2011). *Agriculture and economic development*. Springer.

[9] Fairtrade Foundation. (2023). *Coffee farmers - Fairtrade Foundation*. Retrieved February 4, 2023, from https://www.fairtrade.org.uk/farmers-and-workers/coffee/

[10] GSO (no date) General Statistics Office of Vietnam.

Available at:
https://www.gso.gov.vn/en/homepage/

[11] Li, K., Lee, Y. J., & Gharehgozli, A. (2021). *Blockchain in food supply chains: A literature review and synthesis analysis of platforms, benefits, and challenges*. International Journal of Production Research.

[12] Lu, Q., Xu, X. (2017). *Adaptable blockchain-based systems: a case study for product traceability*. IEEE Softw. Vol.34, pp.21-27.

[13] Musamih, A., Salah, K., Jayaraman, R., Arshad, J., Debe, M., Al-Hammadi, Y., & Ellahham, S. (2021). *A blockchain-based approach for drug traceability in healthcare supply chain*. IEEE.

[14] Nakamoto, S. (2008). *Bitcoin: A peer-to-peer electronic cash system*. Decentralized Business Review

[15] Nguyen, G. N., & Sarker, T. (2018). *Sustainable coffee supply chain management: A case study in Buon Me Thuot City, Daklak, Vietnam*. International Journal of Corporate Social Responsibility, Vol.3, pp.1-17.

TẠP CHÍ KHOA HỌC CÔNG NGHỆ HÀNG HẢI ISSN: 1859-316X
JOURNAL OF MARINE SCIENCE AND TECHNOLOGY

[16] Oudani, M., Adib, A., Zahidi, A., & El Hallaoui, A. (2023). *Green blockchain technology: The move towards sustainable energy*. Journal of Cleaner Production, Vol.430, 139541.

[17] Platt, M., Sedlmeir, J., Platt, D., Xu, J., Tasca, P., Vadgama, N., & Ibañez, J. I. (2021, December). *The energy footprint of blockchain consensus mechanisms beyond proof-of-work*. In 2021 IEEE 21st International Conference on Software Quality, Reliability and Security Companion (QRS-C) (pp.1135-1144). IEEE.

[18] Qin, M., Zhang, X., Li, Y., Badarcea, R.M., (2023). *Blockchain market and green finance: the enablers of carbon neutrality in China*. Energy Econ. Vol.118, 106501.

[19] Saad, S. M. S., & Radzi, R. Z. R. M. (2020). *Comparative review of the blockchain consensus algorithm between proof of stake (pos) and delegated proof of stake (dpos)*. International Journal of Innovative Computing, Vol.10(2).

[20] Shanker, S., Sharma, H., & Barve, A. (2022). *Analysing the critical success factors and the risks associated with third-party logistics in the food supply chain: a case of coffee industry*. Journal of Advances in Management Research, Vol.19(2), pp.161-197.

[21] Statista. (2022). *Blockchain technology market size worldwide from 2017 to 2027*. https://www.statista.com/statistics/1015362/worldwide-blockchain-technology-market-size/. (Accessed 1 April 2023)

[22] Thakur, M., Tveit, G.M., Vevle, G., Yurt, T. (2020). *A framework for traceability of hides for improved supply chain*. Comput. Electron. Agric. Vol.174.

[23] The Evolution of the Crypto Economy. Available online: ⟨https://www.statista.com/chart/27561/evolution-of-the-crypto-economy/⟩ (Accessed 26 December 2022).

[24] UNIDO. (2023). *Báo cáo phân tích tình hình tuân thủ tiêu chuẩn từ chối nhập khẩu tại cửa khẩu của một số thị trường chính.* Trung tâm WTO và Hội nhập, Phòng Thương mại và Công nghiệp Việt Nam.

Retrieved from

https://trungtamwto.vn/file/23338/sca_vietnam_vietnamese_final.pdf

[25] Voora, V., Bermudez, S., Larrea, C., & Balino, S. (2022). *Global market report coffee.* International Institute for Sustainable Development.

[26] Wang, Y., Wang, Z., Yang, G., Ai, S., Xiang, X., Chen, C., & Zhao, M. (2023). *On-chain is not enough: ensuring pre-data on the chain credibility for blockchain based source-tracing systems*. Digital Communications and Networks, Vol.9(5), pp.1053-1060.

[27] Xu, X., et al. (2020). *Blockchain-based solutions for supply chain management in agriculture*. Journal of Agricultural Technology.

[28] Yacoub, G., & Castillo, M. (2022). *Blockchain in your grocery basket: Trust and traceability as a strategy*. Journal of Business Strategy.

[29] Zhang, L., & Zhao, Y. (2021). *Blockchain applications in agriculture: Addressing transparency and traceability challenges*. Journal of Agricultural Economics.

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