The Blockchain Technology Architectures to Improve the Value Creation of Crop Agriculture Supply Chain in Indonesia: A Literature-Based Overview

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Abstract

Businesses are adapting to build supply chain resilience to ensure long-term sustainability in response to globalization, rising climate, health, and poverty issues. The recent global health crisis has forced us to contribute to the Sustainable Development Goals in the supply chain, especially Agriculture Supply Chain Management (ASCM), which is responsible for food production and distribution. Farmers have a function as producers but are frequently disadvantaged, and stakeholders often lack coordination. There is a paucity of knowledge regarding data transmitted between players and goods from the upstream to the downstream. The ASCM can consider employing blockchain technology (BT) to address these concerns. The ASCM anticipates that blockchain technology will enhance its operation and sustainability by maximizing value creation in each supply chain phase. This study aims to investigate the current state of Indonesia's ASCM, provide insight into the usage of blockchain, and propose a blockchain architectural model to enhance the value creation of ASCM in Indonesia. The researcher evaluates and assesses 15 publications, compares them to current situations, and recommends an improvement analysis for the future's system. The final analysis reveals the proposed architectural model in ASCM using blockchain technology with Ethereum, and Interplanetary File System that enables traceability, transparency, and great coordination among stakeholders. The possible created values mentioned are Business process improvements; Improving customer experience; Data security; Learning – developing of new capabilities; Coordination; and Tokenization.

Keywords
Agriculture Supply Chain, Architecture Model, Blockchain Technology, Literature Review, Value Creation.

1. Introduction
Supply chains are critical to the present and future success of the global economy. This role corresponds to the evolution of development issues and the industrial revolution 4.0. The Sustainable Development Goals (SDGs) are a global action plan for ending poverty, reducing inequality, and protecting the environment. All aspects are expected to contribute to this long-term development. SDGs linked to global supply chains are met through the United Nations (UN), which requires an inclusive, sustainable, efficient, nutritious, and healthy food system (Banker 2021; Quaralia 2022). With a 50% increase in the world's population, global food demand is expected to double by 2050. Most growth occurs in developing countries, notably on the African and Asian continents (Pullman and Wu 2021). The most crucial food crop agricultural harvest commodities are produced by China, Brazil, India, Argentina, Indonesia, and the United States. Food crop agriculture is critical to Indonesia's economic development. According to the Indonesian Central Statistics Agency (BPS), agriculture contributed 13.70 percent of Indonesia's GDP in 2019 and employed 29.46 percent or 33.4 million people. Food crops are one of agriculture's many sectors. Food crops are a sector capable of producing staple foods for more than 90% of Indonesia's population (Nurliza et al. 2017). Rice, corn, cassava, potatoes, vegetables, and fruits are examples of food crops. This sector is regarded as having a remarkable ability to generate quality growth (growth with equity) (Lokollo 2012). Therefore, agriculture in the food crop sector requires improvement and development to distribute agricultural products of food crops from producers to consumers, ranging from raw materials to semi-finished and finished products. It is necessary to apply the Supply Chain Management (SCM) concept. Agriculture Supply Chain Management (ASCM) is an integrated system between a network of

companies (independents/groups) that work together to create and distribute a product to the hands of the user/end consumer (farm-to-table (Lu 2011; Jaya et al. 2020). Supply chain management generally consists of the flow of goods, information, and money (Vorst 2004; Jaya et al. 2020). Meanwhile, ASCM stakeholders start with farmers as producers, intermediaries, processors, distributors, or retailers and end up with consumers to create value. Farmers need several tools and materials to produce crops, including fertilizers, seeds from suppliers, and irrigation systems. They sometimes need the help of workers to prepare the land and harvest.

Figure 1. Indonesian Supply Chain Data and Product Flow

For example, one food crop product, rice, has a harvest cycle of 3-4 months as the primary food commodity. After harvest, some farmers sell them to intermediaries or the Indonesian Logistics Affairs Agency (BULOG). After that, usually, the rice will be sold to distributors and processed at rice milling centers, distributors will distribute it to retailers, and they will sell it to end consumers (Figure 1,). However, farmers often lose money, and most farmers sell their rice to intermediaries due to the scarcity of private transportation to transport their rice-to-rice milling centers. The existence of farmer groups makes farmers constrained by the decisions of farmer groups in determining commodities. In addition, most smallholder farmers in Indonesia do not have relations, market access, and bargaining position. The government also has decided on the selling price, not to mention other farmers' losses as crop failure (Paramitha and Sulomo 2018). The long agricultural distribution chain causes the prices received by farmers and consumers to have differences (Perdana 2014; Saptana et al. 2019). It also indicates the involvement of the intermediaries. Farmers must increase their resources to have better market information, marketing skills, and direct access to other stakeholders. Furthermore, the problem faced in the agricultural supply chain is the lack of coordination between actors. Most farmers are smallholders who live and cultivate land in rural areas, resulting in long distances and routes to reach urban consumers, constraints in yield handling, staging, and storage, cooling process problems in postharvest, and issues with packaging, tracking, and inventory control. Based on the Professor of Agricultural Technology Universitas Gadjah Mada, Sigit Supadmo Arif in 2017 stated that Indonesia's agricultural sector is challenging to develop and even continues to experience setbacks because the national food policy is not based on factual data and binds all stakeholders.

Data or information flow is crucial in every aspect, especially in the economy. Data in agriculture can convey a lot of information, such as the quality of agricultural products, transactions, and other data can provide transparency between consumers as the last chain and farmers as producers and the first chain (Maghfirah 2019). Technology is needed to facilitate data access for stakeholders in the supply chain where stakeholders can access it as near-time. Data is also necessary to make it easier for farmers to access raw materials and financial assistance (Maghfirah 2019). It is needed to adopt Blockchain Technology (BT) that can provide solutions to the problems faced by agricultural supply chain management. Blockchain technology began in the 1980s with the advent of the invention of the digital currencies concept. For several years in a row, the use of digital documents has become commonplace. In 2008, anonymous Satoshi Nakamoto took the concept of digital currencies and the basics of existing cryptography. They brought the idea of blockchain technology by implementing the first blockchain as a public ledger for transactions carried out using "Bitcoin" (Panda et al. 2021). Bitcoin uses a unique feature in the form of Proof of Work (PoW), nodes called miners, and miners will later collect transactions on the network on blocks. This collection of blocks later forms a chain called a blockchain. Since 2014, blockchain applications have begun to develop in the management and administration sectors, digital signatures, authentication and voting, verification, and tracing of IPR and patent rights, health records in hospitals and the health sector, including supply chains (Tayeb and Lago 2018; Kamilaris et al. 2021). Indonesia's ASCM ecosystem involves complex networks and many actors but is still stand-alone and not integrated, which requires this technology to improve the effectiveness and efficiency of the supply chain system.

This technology allows everyone in the agricultural sector to access real-time data. Farmers can input their agricultural production data to receive suitable agrarian loans and better market price insights. Food companies that require agricultural products can understand the product's origin and quality better. The track record of farmers and every actor is stored on the blockchain and helps farmers connect with buyers. Blockchain technology in the ASCM will make the process more transparent, effective, and efficient. In addition, companies can more easily maintain the quality of their food products because they have more reliable information about their sources (Maghfirah 2019). As a result of the issues above, blockchain technology is here to help overcome the problem of coordination and integration of actors in the system. Allowing them to increase trust, and share value, information, and data without intermediaries, allowing ASCM to be more effective and efficient in the future. For the system's sustainability to continue running in the future, every business and concept must create value to continue obtaining future benefits. All supply chain actors contribute to creating value by participating in an activity. With blockchain, the agricultural supply chain of the future can make it possible to create more value so that the supply chain continues to be sustainable.

Therefore, based on observations in the field and preliminary studies that have been carried out and presented above, the researchers conducted a literature review to find out the condition of agricultural supply chains in Indonesia and found existing facts. From these current facts, the researchers proposed a blockchain architecture model in ASCM. In the end, the researcher analyzed the proposed architectural model to determine the flexibility of its application in Indonesia, the advantages, and disadvantages of the system in the model, and its potential value created in the supply chain system.

1.1. Objectives
Based on the above-described introduction, several formulations of the specified problem include.

- RQ1: How can the framework/conceptual blockchain technology be applied to agricultural supply chains in Indonesia?
- RQ2: How can conceptual blockchain technology improve value creation in agricultural supply chains?

The researcher will answer the two formulations of this study's problem by conducting a literature review of several types of literature that have been gathered and selected for analysis in advance.

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2. Literature Review
Since the blockchain concept was first proposed in Satoshi Nakamoto's paper (Zou et al. 2020) in recent decades, blockchain technology has evolved from a prototype to popular technology. Blockchain is not a new concept. The time-stamp ordering algorithm inspired this technology in the 90s, which was used to prevent document destruction. The same concept is used as a ledger and transaction to facilitate a secure payment mechanism. Since being discovered in Satoshi Nakamoto's paper, various programmers, cryptographers, and scientists have started working on this blockchain concept to produce a bitcoin cryptocurrency (Rathee 2020). Bitcoin is a digital coin or digital money. A blockchain is a collection of blocks containing information connected by several cryptographic mechanisms ((Rathee 2020); (Jena and Dash 2021)). Blockchain technology also helps transmit digital coins or assets from one user to another, so there is no need for a third party.

As already explained, a blockchain is a collection of blocks. Each block in the chain consists of data, the hash to the following data, and the hash to the previous one (Figure 2.). The data recorded by the blockchain depends on the type of blockchain. If the blockchain system uses bitcoin (another digital currency), the block will store transaction data, information regarding senders and recipients, and the number of bitcoins on the network. Each block in the chain has a hash value that will be compared to the fingerprint. When a new block is created, a hash is also generated. Hash is a cryptographic technique that converts data of any size into a unique fixed-size output. Therefore, the hash value is an essential factor when making modifications to the block. If the hash value of each block changes, then the data is not considered to be in the same block. In addition to the hash of the current block, the block also stores the hash of the previous block. It helps to create a chain by linking the previous blocks. The block feature in this chain makes blockchain technology more secure ((Rathee 2020); (Jena and Dash, 2021)). Users can interact with the blockchain using public and private keys. There are several types of blockchain technology which are shown in Table 1.

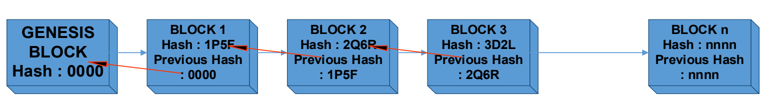

Figure 2. Blockchain Structure

Supply chain management in Agriculture can be defined as activities from production to distribution that bring agricultural or horticultural products from the farm to the table (Aramyan and Van Gogh 2014); (Despoudi et al. 2021). The agricultural supply chain consists of different entities: producers, distributors, processors, retailers, and consumers. The unique characteristics that distinguish agricultural supply chain products from other supply chains include limited shelf life, varying prices, the importance of quality, and product dependence on weather. These characteristics make ASCM more complex (Despoudi et al. 2021).

Agriculture includes food crops. Indonesia seeks self-sufficiency in rice, corn, soybeans, peanuts, and green beans (Nasikh et al. 2021). The agricultural supply chain's problem is farmers' welfare. It involves many actors, a lack of coordination, transportation challenges, inventory tracking control issues, and various prices on the market. (Saptana et al. 2019). This matter requires agricultural development. One of the ways to support agricultural development is by presenting advanced technology (Nasikh et al. 2021). Industry 4.0 is based on technology instruments such as big data, Internet of Things (IoT), blockchain, simulation, and artificial intelligence that can help agricultural development in this industrial era. Startups are developing blockchain for agricultural supply chains. For company goals and sustainability, supply chain management must consider economic, environmental, and social factors. Technology-based supply chain management systems share information and collaborate with each actor, increasing creativity (value creation) (Jaya et al. 2020). According to Stephen L. Vargo et al, 2008 in Dora (2015) value creation is often considered a series of activities carried out by the company. Companies in many industries have found that they can create value by applying digital and analytics technologies to new business models and product offerings. Now, actors in ASCM, ranging from farmers to end consumers, can discover and feel that this technology can play a role in optimizing such a complex agricultural supply chain (Denis et al. 2020).

Table 1. The most popular blockchain type (Panda et al. 2021).

Parameter	Public	Private	Consortium
Permission	Permission less	Permissioned	Permissioned
Decentralization	Fully Decentralized	Centralized	Less centralized
Participants	Anybody	Permissioned and known entities	Permissioned and known entities
Authority	Anyone	Single central authority	Multiple central authority
Reading Rights	Anyone	Invited users	Depends on scenario
Writing Rights	Anyone	Approved users	Approved users
Consensus	PoS/PoW	Multiparty consensus	Multiparty consensus
Speed	Slow	Fast	Fast

3. Methods

This section describes the research methodology. The researcher used the literature review method to answer the objectives. The literature review includes a discussion of methodological issues and suggestions for future research. According to Palmatier et al, 2018 in Snyder (2019) several phases that will be carried out to conduct a literature review are shown in Figure 3. and Table 2.

(1) Phase 1: Designing the literature review
This phase indicates the initial problem that arises in Indonesian ASCM that motivates the researchers to contribute by conducting this literature review. The goal of this literature review was to improve the ASCM system with blockchain technology by providing references and considerations based on the research findings.
(2) Phase 2: Conducting the literature review.
Some reviewers will read the literature one by one; this is useful but takes a long time. Another option is to focus on reading the research methodology and findings. The third option is to read the abstract from the literature, select and then read the complete literature. In this study, researchers used the third option. The articles used for the literature review were obtained and selected from Science Direct, Research Gate, and IEEE and several e-books from Google Play Book sites using the keywords: Agriculture Supply Chain Blockchain. From several searches, the researcher selected articles with the following conditions:

- The application of blockchain technology focuses on ASCM. Other than that context (e.g., other supply chains, other sectors such as health, and automotive) are not included.

- The document/article explains the conceptual integrase of blockchain technology with agricultural supply chains not only displaying the algorithm of using the blockchain. Based on these criteria, 15 documents have been selected and shown in Table 3.

(3) Phase 3: Analyzing the findings.

The analysis is carried out by following the objectives and problem formulations that have been determined in Section 1) Introduction. The framework to explain the blockchain technology section refers to research by (Afrianto et al. 2020) and (Kamilaris 2021).

(4) Phase 4: Organizing and writing the review.

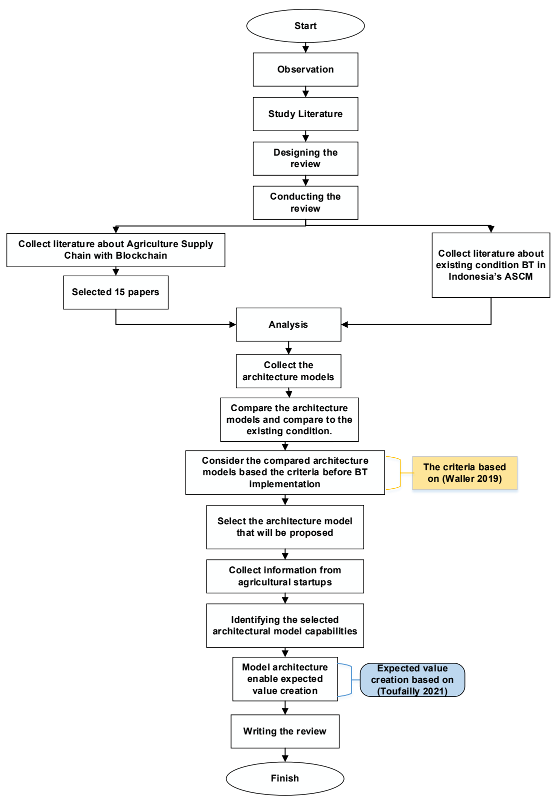

Figure 3. Literature review steps in this research

Table 2. Phases Description

Phase	Steps
Designing	• Observe ASCM in Indonesia. • Identify problems in the Indonesian. ASCM in the Background of the Study. • Identify the blockchain potentials to ASCM in the Background of the Study. • Determine the objectives.
Conducting	• Identify studies that are relevant to the topic. • Select papers by reading titles, abstracts, and keywords in the section Methods.
Analysis	• Analyze the condition of ASCM and blockchain technology in Indonesia in section Background of the Study. • Analyze blockchain technology from the selected 15 papers in the section Discussion. • Choose a proposed blockchain architectural model in the section Discussion. • Analyze the value creation of the proposed model in Discussion.
Structuring and Writing	• Compile and structure the paper.

4. Discussions

The use of blockchain technology in various sectors has become popular since 2014 and is predicted to continue to increase every year. Therefore, the researchers, want to know the adoption of blockchain technology in agricultural supply chain management in Indonesia by conducting a literature review to provide theoretical contributions to research in this field of study. The following analysis in the Discussion section answers the problem formulations stated in Section 1) Introduction.

4.1. Blockchain Technology

4.1.1. ASCM and Blockchain Technology Integration

As is well known, ASCM in this study is a food crop agricultural supply chain management system that involves several processes and actors from raw material suppliers to finished products that are received by end-users. Then how can blockchain technology play a role in the supply chain system? Based on Table 3. four studies from fifteen [DS], [KU], [X], [PE] analyzed that all participants (individuals/companies) involved in the agricultural supply chain system environment (in general are suppliers, producers, processors, distributors, retailers, and consumers) will pre-register on the blockchain system with a unique ID so that they can upload the required data into the system. When the food crops have been successfully harvested, the crops will be packed in sacks, the sacks will be labeled with a special tag. At this stage of the supply chain, blockchain technology will require assistance from Internet of Things (IoT), with the same ID as the rice sack tag. Later, digital profiles and all related data from the harvested product will be created by farmers and uploaded to the blockchain, stakeholders in the next stage of farmers as producers, suppliers, processing, distributors, retailers, and finally the consumers. At each stage, the product's process and data will be updated on the blockchain and stored in each block.

Table 3. Selected documents.

Paper Code	Authors	Title	Type of Document
[DS]	Dey and Shekhawat (2021)	Blockchain for sustainable e-agriculture: literature review, architecture for data management, and implications	Journal Paper
[KU]	Kumar et al. (2021)	Employing blockchain in rice supply chain management	Conference Proceeding
[X]	Xue et al. (2021)	A blockchain-based rice supply chain system	Journal Paper
[SB]	Sekhar Bhusal (2021)	Blockchain technology in agriculture: a case study of blockchain start-up companies	Journal Paper
[KP]	Kassanuk and Phasinam (2022)	Design of blockchain based smart agriculture framework to ensure safety and security	Conference Proceeding
[A]	Afrianto et al. (2020)	Disrupting agro-industry supply chain in indonesia with blockchain technology: current and future challenges	Conference Proceeding
[M]	Maghfirah (2019)	Blockchain in food and agriculture supply chain: use-case of blockchain in indonesia	Journal Paper
[KA]	Kamilaris et al. (2021)	Food technology disruptions chapter 7; blockchain in agriculture	Book Section
[KH]	Khan et al. (2022)	Blockchain technology for agricultural supply chains during the covid-19 pandemic: benefits and cleaner solutions	Journal Paper
[PI]	Patil et al. (2018)	A framework for blockchain based secure smart green house farming	Conference Proceeding
[PE]	Patel et al. (2021)	KRanti: blockchain-based farmer's credit scheme for agriculture-food supply chain	Journal Paper
[AK]	Akella et al. (2021)	Design of a blockchain-based decentralized architecture for sustainable agriculture	Conference Proceeding
[H]	Hong et al. (2019)	An agri-product traceability system based on iot and blockchain technology	Conference Proceeding
[V]	Vikaliana et al. (2020)	The application of blockchain technology in agribusiness supply chain management in indonesia	Journal Paper
[S]	Subramanian et al. (2020)	Blockchain and supply chain logistics: evolutionary case studies chapter 3; blockchain agriculture in food supply chain	Book Section

4.1.2. Actors

Actors or stakeholders are the parties that flow information, products, and transactions in the agricultural supply chain at every stage so that the information that is transcribed on the blockchain can vary. In general, these actors are producers, distributors, and consumers. Based on Table 3. two studies out of fifteen [KA], [KH] analyzed that the actors involved in the agricultural supply chain are suppliers/providers – producers – processors – distributors – retailers – consumers, one study [PE] also shows actors in the agricultural supply chain system. are suppliers – producers – distributors – retailers – consumers. Two other studies [KU], [M] state that the actors involved are producers, suppliers – farmers – intermediaries – processors – distributors – consumers. There are various other actors, including insurance companies, transportation [KP], blockchain service companies [V] IoT [DS], [KA], [PI], [PE], [AK], [H], [V]. Four studies [DS], [KU], [KA], [KH] describe what data actors need to input into the blockchain system.

- Provider /Supplier: Information about seeds, fertilizers, pesticides, people involved, labor, machinery, processes, and transactions.
- Producer /Farmers: Information about agricultural processes and activities implemented in them for example certified farming/cropping methods, crop cultivation processes, and agricultural environmental conditions.
- Processors: Information about the mill and its equipment, methods of processing the produce, transactions with farmers, and product-specific identification.
- Distributors: Information that needs to be recorded and recorded is shipping and travel data, inventory conditions, distance, time to transit, types, and methods of transportation as well as transactions with retailers.

- Retailers: Information that needs to be recorded on the blockchain is data about products; current inventory conditions, quality, and quantity.
- Consumers: Able to access all information related to agricultural products, starting from conditions, processes, and methods must be transparent.

In addition to these actors, if the blockchain scenario in ASCM has been widely applied to the government, there will be administrative data. For example, they were starting from subsidy data for farmers, such as requests for subsidized urea fertilizer. Thus, blockchain technology will integrate e-Governance (government for the people) with existing databases where intelligent algorithms will get data on farmers who need subsidies. Second, farmers will get a loan from a financial institution with the same concept as the previous input subsidy concept. Finally, there is land registration data or what we usually call land certification. So that farmers can easily show official documents of land ownership as their own property or assets, and this data can also be easily accessed by the government [DS].

4.1.3. Blockchain Infrastructure

In general, blockchain integration and agricultural supply chain data flow architectures are the physical and the blockchain layers. The physical layer is the stage where the flow of agricultural products moves from suppliers, and producers to consumers as stated in [KA] based on Table 3. The blockchain layer is where decentralized bookkeeping takes place. The blockchain layer contains information and transactions agreed upon by all parties involved [PI]. In addition to the two layers already mentioned, five studies of fifteen based on Table 3. describe and design Interface layers [DS], [KU], [PI], [AK], [H], the Interface layer is a layer designed for end-users, which can be in the form of websites or mobile applications. Two studies [A], [PE] mention the IPFS layer after blockchain layer, IPFS layer is a layer for off-chain blockchain storage platforms. In addition, there is a smart contract layer [A], [AK], [H]. A smart contract is a contract that is agreed upon by all participants, this smart contract is in the form of a programming language so that it can run automatically (self-executing). Two studies mention that at the physical layer in the architecture they designed using the IoT, this IoT device is used to record environmental data in the planting process (soil conditions, weather, etc.) [DS], [PI]. Meanwhile, other IoT products commonly used are RFID tags, QR codes, and barcodes.

4.1.4. The Benefit of Blockchain Technology on ASCM

As we know, ASCM in Indonesia is a centralized supply chain system, this system has drawbacks, one of which is trust issues and data errors for each stakeholder in the supply chain, with blockchain technology, ASCM will get many benefits and changes. Based on Table 3. nine studies out of fifteen [DS], [KU], [SB], [A], [M], [KH], [PE], [AK], [V], [S] mention that by applying blockchain technology in the agricultural supply chain will create a network environment that is transparent and traceable (traceability). So that all members of the individual/company that are joined will be able to access each other's data. Five studies [DS], [X], [KA], [KH], [V] analyzed that this integration can improve the management of data and information collected in the agricultural food crop supply chain, which has been underdeveloped and *lacking*. Six studies [KU], [X], [SB], [A], [M], [KA] stated that the integration of blockchain technology with ASCM facilitates coordination between stakeholders besides that it can also help small farmers to get positions in a market that they rarely get. Twelve of the fifteen studies [DS], [KU], [X], [SB], [KP], [A], [KA], [KH], [PI], [PE], [AK], [V] also analyzed that the security in communicating and transacting is guaranteed in the blockchain network even though the data is distributed and decentralized. This is because the blockchain has special encryption. Blockchain can also reduce and simplify the transaction costs of each chain and the whole process [DS], [SB], [KP], [A], [M], [KA], [PE], [AK], [V]. Seven studies [DS], [SB], [KA], [KH], [PE], [AK], [S] analyzed that the application of blockchain technology that has traceability capabilities or traces the flow of data/information, products or transactions to create more sustainable agriculture for the future.

4.1.5. Barriers and Challenges of Blockchain Technology Adoption

Blockchain technology is still relatively new and not yet stable (mature), refer to Table 3. Three papers reveal that the barriers to implementing blockchain technology into agricultural supply chains are accessibility as well as government and sustainability [SB], [A], [KA]. Four papers state that regulation regarding the use of blockchain technology is one of the barriers to adopting the technology [SB], [A], [KA], [S]. Two papers mention the barriers to adoption of this technology are technical challenges and design decisions as well as digital gaps between users [A], [KA]. In addition, it is also necessary to have a high cost to implement it [DS], [S]. The state of the agricultural supply chain in Indonesia is still relatively traditional, most farmers are small farmers in rural areas with unproductive age and low human resources, this causes dependence on middlemen for farmers to get loans and sell their agricultural products. The actors in this system lack coordination with each other to share information and share values. The integration of the concept of blockchain technology, allows actors to share information, value, and costs. Blockchain allows transactions and products to be tracked and traced. Inequality between actors in this management system can be minimized because mutual trust between actors and improved coordination is easier, but blockchain technology is still immature, which creates barriers to its adoption.

4.2. Marriage Value Creation with Integration ASCM and Blockchain Technology

A company wants to be sustainable by increasing value. No literature reviewed mentions and explains explicitly how blockchain technology and agricultural supply chains can create value and what values will be created. The company's focus is value creation. The company uses value creation to generate profits. Value creation is also called "finding a value." This value was likely hidden or unused." All value-creating actors perform an activity to create value. In this study, the researcher proposed a conceptual model in which ASCM can integrate with blockchain technology when Indonesia is ready. From this conceptual model, we can analyze it's capability to enhance the value creation for businesses to ensures their financial well-being and keeps them competitive in the market, and consumers require value creation because it provides the products and services they require in their daily lives.

4.2.1. The Proposed Blockchain Technology on ASCM Architectural Model

As we all know, ASCM in Indonesia still uses the traditional system. To prosper and eliminate the inequality of actors in the SCM system, it is necessary to have more advanced technological innovations and adaptations. The technologies that can be adapted are blockchain technology and IoT. It is not impossible to apply blockchain technology to ASCM in Indonesia. This is demonstrated by the emergence of the HARA project. HARA is a food and agriculture-focused blockchain-based data exchange platform and ecosystem. The HARA Blockchain, however, has only served as a source of agricultural data up until now. In the agricultural supply chain system, practical implementation of this technology is limited due to a lack of resources and infrastructure (Patel et al. 2021). Before entering what value can be created when in the future implementing blockchain technology integration, IoT in ASCM, the researcher will present a proposed architectural model of how to implement blockchain technology integration in ASCM, which was selected from 15 papers that have been reviewed to provide an overview of its components, the architecture is shown in Figure 1. Selection is based on considerations of the 15 papers shown in Table 4.Selection of the proposed architectural model from the 15 papers based on the analysis in Table 4. and the criteria that need to be considered in the proprietary book (Waller et al. 2019), including :

Table 4. Considerations for choosing architecture in the literature

Paper Code	Blockchain Technology			Actor							Advantages	Barriers & Challenges	Additional Information
	Integration	Architecture	System Layer	S	F	M	P	D	R	C			
[DS]	√	√	5	×	√	×	√	√	×	×	√	×	Government, Logistics actors; Detail backward & forward integration; more wide, complicated, and advanced architecture.
[KU]	√	√	3 (not explicit)	×	√	√	√	√	√	√	√	×	-
[X]	√	√	×	×	×	×	×	×	×	×	√	×	General
[SB]	√	×	×	×	×	×	×	×	×	×	√	√	Explain BT on ASCM case study esp on startups
[KP]	√	√	3 (not explicit)	×	√	×	×	√	√	√	√	×	Additional actors Wholesaler; Insurance Company; Transporter Registration
[A]	√	√	3 (not explicit)	×	√	×	√	√	√	×	√	√	Not specified
[M]	√	×	×	×	×	×	×	×	×	×	√	×	Focused on HARA startups in Indonesia
[KA]	√	√	3	√	√	×	√	√	√	√	√	√	Simplified
[KH]	√	√	3	√	√	×	√	√	√	√	√	√	Simplified
[PI]	√	√	4	×	√	×	×	×	×	×	×	√	Focused on smart farming (IoT)
[PE]	√	√	3	√	√	×	×	√	√	√	√	√	Focuses more on traceability, finance for farmers, quality assurance of the product provides full transparency of the data to all

													the stakeholders in AFSC. Had passed the experimental/study pilot.
[AK]	√	√	6	×	√	√	×	×	√	√	√	×	-
[H]	√	√	4	×	×	×	×	×	×	×	×	×	Not specified actors
[V]	√	×	×	×	×	×	×	×	×	×	√	×	Explain theoretical BT in ASCM
[S]	√	×	×	×	×	×	×	×	×	×	√	√	Explain the advantages BT in ASCM
Description: S=Supplier; F=Farmer; M=Middlemen; P=Processor; D=Distributor; R=Retailer; C=Consumer													

(1) It should have the support of senior leaders.
(2) It should be simple.
(3) It should complement legacy systems (IoT).
(4) It should have clear business objectives that blockchain might solve.
(5) It should create shared value.
(6) It should consider key markets.
(7) It should have the potential to scale to other partners and/or markets.

Finally, paper [PE] was selected based on considerations.

- Actors. According to Indrajit & Supranoto (2003) in Rantung et al. (2016)) the supply chain has the main players with the 1-2-3-4-5 chain, namely Supplier (Raw Material) - Manufacturer (Farmer) - Distributor - Retail Outlet - Customer. Based on Table 4., the architecture of the paper [PE] has five actors in its system that have previously been mentioned. It is also a consideration to eliminate middlemen between farmers.
- Paper [PE] explains that it can provide financial assistance to farmers.
- Based on Table 4. Paper [PE] consists of 3 layers. Physical layer – Blockchain Layer (On-Chain) – IPFS (Off-Chain).
- This architecture is a consortium blockchain; this kind of blockchain is semi-private and only pre-selected participants are accepted. Each participant has an equal amount of power, and a smart contract is used to establish a consensus mechanism.

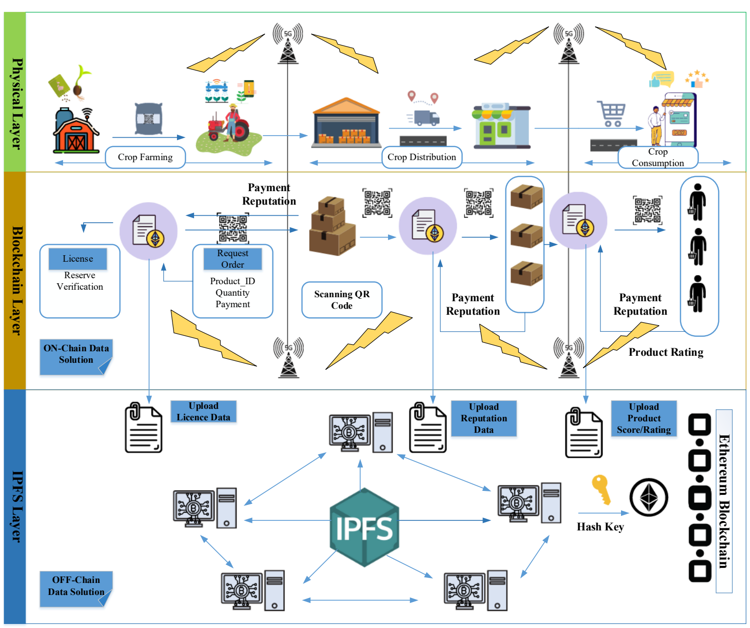

Figure 4. KRanti: Blockchain-IoT architecture system (Source: (Patel et al. 2021))

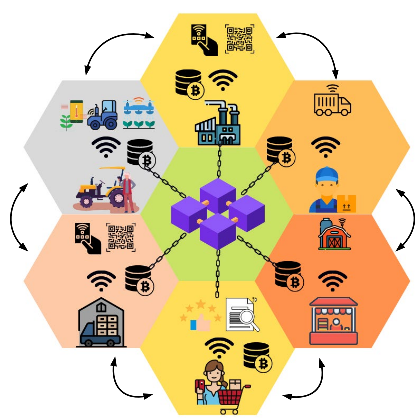

Figure 5. Blockchain Change Market into Circular Economy Source:(Casado-Vara et al. 2018); (Kamilaris et al. 2021))

A pilot study of the architecture has been done, the legacy system is equipped with QRCode, has a clear motivation, and can be applied in other sectors, and Figure 4. shows the proposed architectural model. Figure 4. was chosen because it was built with a controlled supply chain system flow to facilitate data flow and interaction between producers, farmers, distributors, retailers, and consumers. Figure 4. called KRanti architecture uses Ethereum for safer transactions and higher rewards than bitcoin. Ethereum is a decentralized blockchain platform that creates a peer-to-peer network for securely executing and verifying application code known as smart contracts. Smart contracts are simply programs that run when certain conditions are met and are stored on a blockchain. Ethereum has its own cryptocurrency called Ether. Moreover, the KRanti architecture uses IPFS to store data off-chain. IPFS also helps address data scalability issues, or the system's ability to handle growing data and concurrency without affecting performance. IPFS in KRanti architecture stores big data off-chain at low cost and optimal bandwidth. The KRanti architecture was chosen to be the proposed improvement in this research with the consideration that this architecture involves a small and main network. KRanti involves the main supply chain network, namely provider - farmer - distributor - retailer – the consumer. Refer to (Waller et al. 2019), in their book titled Integrating Blockchain into Supply Chain Management: A Toolkit for Practical Implementation, suggest that the basic criteria for implementing blockchain on supply chain are "it should be simple" because it can be developed and implemented quickly. Adding expensive RFID technology will be easy if the project focuses on simple, well-defined things in the future. Patel, Shukla, Tanwar, and Singh pilot-tested this architecture in 2020 refer to [PE] based on Table 3.

The study found that the KRanti architectural model has limited cost optimization when using IoT goods to predict system issues and anomalies. This architecture hasn't been deployed in heterogeneous situations; therefore, its adaptability can't be measured. Integrating agricultural supply chains with blockchain technology and the IoT is a disruptive innovation that creates new markets, disrupts existing markets, and replaces the old system. Blockchain might boost industry 4.0 and transform supply chain roles from linear (Figure 1.) to circular (Figure 5.). Integrating these technologies into the ASCM is intended to provide greater value, give benefits, and establish a sustainable ASCM in the future with economic, technological, and human population expansion. Blockchain implementation is still immature. Lack of infrastructure and practical application issues have hampered blockchain development. Many firms haven't started using blockchain in enterprise practice since they're waiting for its maturation. Blockchain offers significant value and asset processing capability. The application of blockchain technology is expanding, and it is thought that it will drive many industries from closed to open distributed systems (Xue et al. 2021).

4.3. Expected Value Creation

Researchers analyzed how the integration of blockchain technology, IoT in ASCM can create value by referring to the literature on what contributions have been made by startups and the blockchain community in the ASCM sector collected from various sources. Startup AgriDigital, AgriLedger, AgUnity, Ricult, and Farmshare community (Kamilaris et al. 2021), (Sekhar Bhusal 2021) report that blockchain technology can create value by granting participation rights and helping smallholders who initially do not have a bargaining position, do not have market access, and depend to middlemen by providing opportunities to connect with global supply chains and markets. TE-FOOD and Ripe.io say their startups can integrate blockchain technology with IoT to provide product information from IoT sensors and Open Interface. In real-time, Ripe.io uses blockchain, IoT, AI, and ML to record land temperature, soil conditions, humidity, and weather. TE-FOOD and Ripe.io can provide product origin, growing environment, and shipping footprint data. Because products can be tracked, transparency is created. (Kamilaris et al. 2021), (Sekhar Bhusal 2021).

Blockchain technology can reduce transaction costs, make payments faster and more secure, and lessen the burden on farmers. Blockchain can also eliminate the role of middlemen who have been bridging farmers with markets (Dey and Shekhawat 2021), (Sekhar Bhusal 2021), (Kassanuk and Phasinam 2022), (Khan et al. 2022). Three startups, Demeter, Agridigital, and AgriLedger, say this technology can provide cheaper and faster payment options. AgriLedger's app can reduce production costs by sharing resources, products, and processes. Etherisc's crop insurance apps and smart contracts reduce fraud and boost efficiency. AgriLedger says blockchain can help farmers get loans. AgUnity plans, trades, and tracks farmer transactions. Demeter's platform can lease or sell land without middlemen. Startup Ripe.io reports that by integrating blockchain with IoT, AI, and ML, product data stored on the blockchain can be processed, analyzed, and shared to improve ASCM capabilities.

For the sake of system sustainability, supply chains that adopt new technology certainly require value creation to continue to gain profits, the proposed improvement, namely the KRanti architecture based on Table 3. in paper [PE] shows 3 layers, the first Physical layer involves 5 main actors, namely producers, farmers, distributors, retailers, and consumers. The second layer of this architecture is the blockchain layer, at this layer the system uses blockchain technology containing various supply chains based on Ethereum. This layer is used to make the data flow more secure and transparent and to describe the payment mechanism based on blockchain. The last layer, the IPFS layer to keeps big data off-chain.

As explained above, the supply chain is a value-creating activity from producers to consumers. However, the development of times and technology, inevitably, forcing sellers and buyers to innovate and adapt to more advanced technology to fix current supply chain management problems, creating a more sustainable supply chain for the future. Consideration of the values that are expected to be created and emerge when the Indonesian ASCM implements blockchain technology with the proposed architectural model, which are analyzed by.

(1) Seeing and considering the benefits obtained by blockchain-based startups that are already running their business in the agricultural supply chain (e.g. AgriDigital, AgriLedger, AgUnity, Ricult, TE-FOOD, Ripe.io, Etherisc, and Demeter)
(2) Analyzing the model's capabilities, resources, and the outcomes of the architectural pilot paper [PE] based on Table 3. that was selected before.
(3) It is stated in the research by Shanker (2012) that the company's resources and capabilities are one of the company's value creation strategies. So that, the capabilities and resources of the proposed architectural model become a source of value and their potential value is analyzed based on the results of interview research refer to Toufaily et al. (2021) about what expected values are created when adopting blockchain technology in the public sector, private sector, and startups.

Based on the consideration above, the researchers have analyzed the value creation that is expected to be obtained if implementing the proposed architecture in the agricultural supply chain in Indonesia, is shown in Figure 6.

4.3.1. Business Process Improvement
ASCM with the blockchain technology enables the system to use IoT and help data automation, improving the efficiency, payment automation. The application of IPFS and Ethereum also help the optimum costing, the transaction uses consensus protocol and because blockchain technology is a decentralized system, the stakeholders can see the distributed data that help traceability and transparency hence making the business process improvement. Business process improvement (BPI) is a practice in which enterprise leaders analyze their business processes to identify areas for improvement in accuracy, effectiveness, and efficiency, and then make changes within the processes to achieve these improvements. This matter is supported by the results of interviews in research conducted by Toufaily et al. (2021) it is stated that one of the blockchain technology expected value creations is business process improvement.

4.3.2 Improving Customer Experience
From traditional agricultural supply chains to supply chains integrated with blockchain technology, all stakeholders who have been registered and verified in the system can have their own unique ID, they can also access transaction history and information stored in IPFS through a QR Code. Customers can feel the ability to trace and transparency in the food crop products they consume, besides that customers can provide a score or rating based on quality so that with this blockchain technology can improve customer experience in the system. Customer experience is the overall impression your customers have of your brand throughout the buyer's journey. This is evidenced by Toufaily's research, which notes that improving customer experience is one of the anticipated value creations of using blockchain technology (Toufaily et al., 2021).

4.3.3 Data Security
Blockchain technology allows data security in ASCM. Furthermore, data security in the agricultural supply chain is realized by using Ethereum and its smart contract to make data flow and payment systems more secure. A massive amount of computing power – contributed by all computers on the network – verifies and secures every transaction, making it nearly impossible for any third party to interfere. Toufaily et al. (2021) also revealed that the use of blockchain technology is expected to create value in the form of data security. All stakeholders will be more trustworthy when data is more secure.

4.3.4 Coordination
In the proposed KRanti architecture model, all stakeholders must register, if the official registration details are submitted to the board of authorities and consortium, where stakeholders verify and are successfully verified, all these details are stored in IPFS and all stakeholders who are successfully verified will get their respective private keys. All

stakeholders will discuss and make the agreements through smart contract and consensus mechanism. A smart contract's main goal is to automatically carry out a contract's terms and conditions, eliminating the need for middlemen in the process. On the other hand, the consensus mechanism is a method of decision-making where the users of the network concur and support a choice for the network's benefit (Panda et al. 2021).

4.3.2. Learning-Developing New Capabilities

With blockchain integration in ASCM, the supply chain network can learn and develop new capabilities. When the adoption of blockchain technology in agricultural supply chains is mature and stable, for instance, other technologies can be incorporated into systems such as smart farming, in which farmers use IoT products to collect and monitor soil, irrigation systems, temperature, weather, and other variables using sensors on IoT devices. A system of borrowing and financial insurance by the government or financial authorities for the widely dispersed small farmers in Indonesia's rural areas is another capability that can be developed. This value creation mentioned on the study own by Toufaily et al. (2021).

4.3.3 Tokenization

The next value embodied in the proposed architectural model in the study is tokenization. Tokenization is the process of converting a valuable item into a digital token that can be used on a blockchain application. Blockchain enable cryptocurrencies, namely ether created by Ethereum, and bitcoin. This does not seem difficult to implement as the use of e-money and e-wallet grows in Indonesia. Based on Toufaily et al. (2021) research it is also stated that one of expected value creation by blockchain technology is tokenization. (Figure 6)

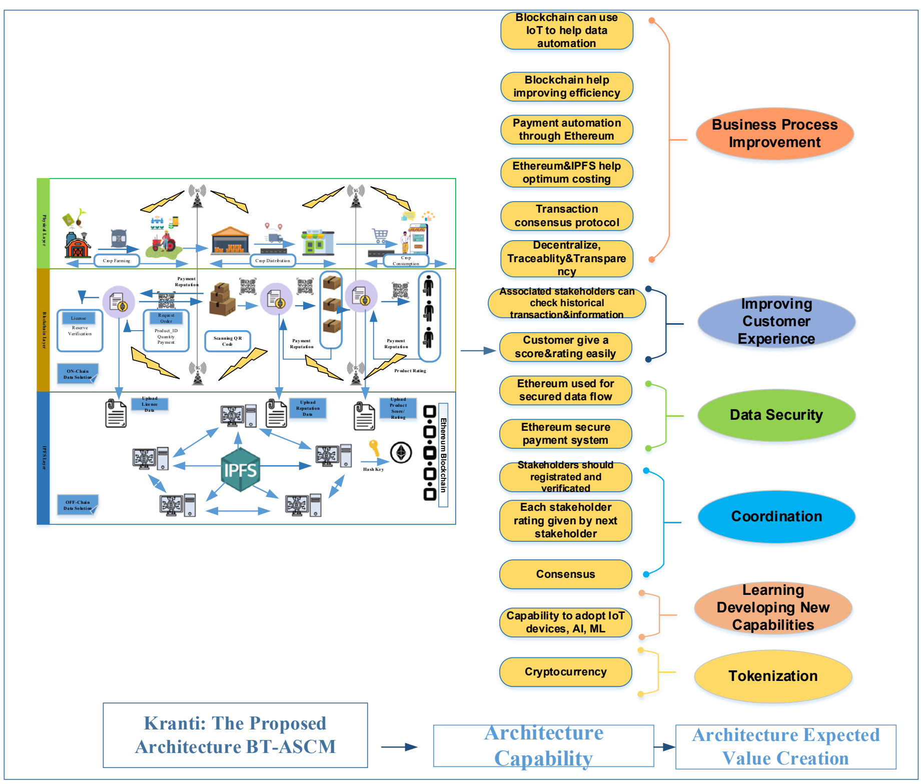

Figure 6. The Proposed Architecture Enables Expected Value Creation

6. Conclusion

Indonesia's agriculture is a natural resource-rich sector. Indonesia's agriculture supply chain is unbalanced. Lack of coordination between actors, length of the supply chain from raw material suppliers to consumers, and inequality between actors, especially farmers, from the difficulty of supply and financial assistance for farmers' needs, the inability of farmers to access resources and market access, plus the presence of middlemen. Lack of collection and access to agricultural data causes supply chain setbacks due to unclear information flow, making it difficult for authorities to analyze problems. As technology, economy, and population growth, the agricultural supply chain must innovate and create value to remain sustainable. Blockchain technology is expected to help the flow of information in the agricultural supply chain. Researchers have reviewed 15 papers to find out how the current state of the agricultural supply chain is in Indonesia. Then, describes the integration between agricultural supply chains with blockchain technology assisted by IoT products, and proposes an architectural model of blockchain technology implementation in agricultural supply chains in Indonesia regarding (Patel et al, 2021) and analyze the expected value creation that is realized from the resource, activities, and capabilities of the proposed architectural model. Based on the literature and researcher's analysis of the capabilities of the proposed architectural model, the values that are expected to be obtained from value creation are Business Process Improvement; Improving Customer Experience; Data Security; Coordination; Learning-Developing New Capabilities; and Tokenization.

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