blockchain network

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The design blockchain network of palm oil FFB supply from certified farms and traceability system of CPO from independent smallholders

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Abstract. Mills produce Crude Palm Oil (CPO) from procurement channels of their plantation, plasma farm, and independent smallholders' farm. The mill manufactures and sells CPO with low Free Fatty Acid (FFA) CPO for foods and Industrial Vegetable Oil (IVO) from all channels. CPO with low FFA for export consists of premium-grade CPO with FFA level < 2% and super-grade CPO with FFA level <3.5%. This Low FFA CPO is exported to the food industry in developed countries. The food industry as a CPO customer needs a lot of information about the origin of the CPO commodity and information about sustainable oil palm agriculture governance. The challenges of building low FFA CPO traceability system raw material of CPO come from three-channel of FFB procurement and produce the various quality of CPO. This study aims to map the Fruit Fresh Bunch (FFB) supply at PT.RSI from Roundtable on Sustainability Palm Oil (RSPO) certificate farm in independent smallholders' groups' channel in the Hyperledger Fabric blockchain network and smart contract. The interaction of entities with smart contracts is described in the ERD diagram, and the form of collaboration between entities is illustrated in the sequence diagram. The design of blockchain network FFB supply and traceability of FFB from independent smallholders group procurement channel based on CPO sales data from the exporter. The contribution of Independent smallholders' groups' channels to produce low FFA CPO can calculate. By presenting the CPO supply system on a map, Independent smallholders' farms' source of low FFA CPO can be identified. Various sustainable information in the farms can be shared

1. Introduction

Low Free Fatty Acid (FFA) of CPO is an essential vegetable oil for the food industry thanks to its high calory content and affordable price compared to other vegetable oil. Therefore, the global CPO industry keeps growing, including in Europe. The hike in CPO consumption occurs because most people are eager to change their consumption pattern and avoid consuming hydrogenated fat and solid fat derived from the animal. [1]. Low FFA of CPO for export commodity coming from the plantation owned by big enterprises. Meanwhile, Indonesia's smallholder only contributes 3% of 9% of the export value of smallholders worldwide. [2] . Low FFA of CPO for export comprises premium-grade with less than 2% of FFA and super-grade with less than 3.5% of FFA.

European Union (EU) is the world's 3rd highest importer, ensuring only import of CPO from sustainable sources [1]. A few parties in Europe and CPO producer countries are now trying to

increase smallholders and independent smallholders contributions to CPOs for export. Such as done by the *terpercaya* initiative in Indonesia, which is a part of the CPO sustainable program between Malaysia and Indonesia, a collaboration of stakeholders in developing sustainable agriculture commodities [3]. *Terpercaya* initiative has aided smallholder's and local farmers in CPO centres, such as in Seruyan and Kotawaringin Barat, Central Kalimantan. There, they have achieved RSPO/ISPO certificate through jurisdiction approach [4]. Owning Roundtable on Sustainability Palm Oil (RSPO) certificate, smallholders united in a group of farmers can access the international market and achieve an added value by trading off their RSPO certificates credit through virtual trading or book claim GreenPlatform. The book & claim system use supports the sustainable production of palm oil. The importer only claims it through virtual trade.

For instance, Nissin, a Japanese food company, highlights more on the rights of independent smallholders in the CPO supply chain. They identify and evaluate the default that may occur in the CPO supply chain in Asia. Working along with Serikat Petani Kelapa Sawit (SPKS) and Kredit Petani Primer Anggota (KKPA), Nissin surveys the independent smallholders' life who domicile 25 KM in the distance from mills. The survey purpose of strengthening human rights and the sustainability issues in the CPO supply chain. [5].

Like other supply chains of agriculture commonly, the safety and the quality of CPO are highly required to ensure the health and safety of the end-users. As a producer, the mill is necessary to think about how to sell CPO. The mill is also required to offer added value to its customers. Consequently, the mill is required to provide an information service to convey the source of its low FFA of CPO through a traceability system. The market is eager to ensure a sustainable CPO, especially the European Union market that accepts imported CPO from a reputable source [1]. CPO certification is a prerequisite to be accomplished to make CPO acceptable in Europe and other developed countries. To ensure sustainable CPO, RSPO owns the principles and the criteria on the CPO production that significantly impacts the environment and the society, including the direct production input in the plantation, starting from the seeds, chemical, water, and the social impact regarding the connection between the workers and the society around the farm. The farm as a producer of FFB and mill as a producer of CPO become the essential objects of RSPO certification. The sustainable information service from the plantation and mills is easier to share with their end-users through a traceability system.

The government, mills, and smallholders are obliged to work side by side in building the traceability system' for both downstream and upstream. Mill may start identifying and building the database of the certified farm as the source raw material to produce CPO for export purposes. The government. through its plantation service owns Surat Tanda Daftar Budidaya Perkebunan (STDB) data, source of palm oil farm data. STDB comprises the farm owned by independent smallholders and plasma smallholders, particularly those who own less than 25 hectares of land. Despite not all the independent smallholders listed, the STDB data of palm oil farms can be used to classify and build a valid database of farms with valid legality, good productivity, and a supply system that can support low FFA of CPO production. Besides ensuring an accurate source, the traceability system may also benefit: enhancing people's trust in the product and the company [6]. On the other flip, RSPO lacks because RSPO cannot ensure a sustainable CPO supply chain [6], especially downstream.

The long supply chain, a complicated network, and dynamic information make it uneasy about being traceable. A strategy used in developing a traceability system is decomposing the CPO supply chain into sub-FFB procurement and production low FFA CPO network and sub-delivery of CPO from the factory to food companies in exported countries. In each sub-network, numerous parties interact with one another based on an agreement made. In sub-FFB procurement network and CPO production, core plantation farmers, a group of plasma smallholders, and a group of independent smallholders interact with mills in the business process of FFB procurement. At the same time, exporters interact with mills in CPO trade transactions.

CPO production in mill comes from three channels of FFB procurement. Interaction among the parties in a separate channel with the other channels and FFB procurement transactions is varied from one to another. The procurement from the core farmers' plantation without a trade process, the procurement from the plasma smallholders is more accessible because they are guided and bound with

the mill. In contrast, the procurement from the independent smallholders consists of two types: smallholders with no partnership and group of smallholders who own RSPO and collaborate with mill (fig.1). The partnership can be in the form of a procurement contract or MoU of procurement only. The more independent smallholders who partner with the mill, the bigger their opportunity to produce low FFA of CPO for export purposes. Consumers from developed countries wish to receive low FFA of CPO coming from the smallholders. The farm information and their contributions are shared with the consumers, making the traceability system of low FFA of CPO more informative.

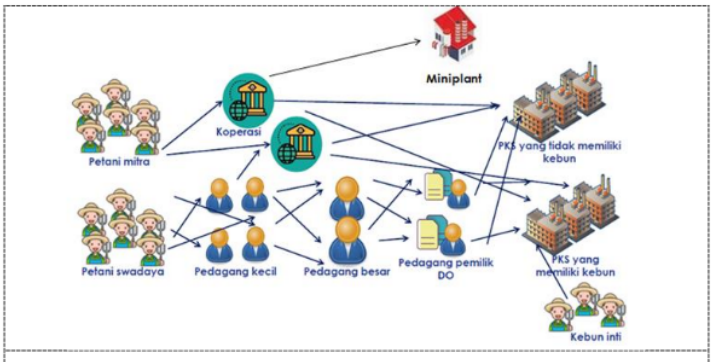

Figure 1. Independent smallholder FFB supply chain

To ensure information needed can be shared in the traceability system of low FFA of CPO from the different channels of FFB procurement, so it needs the support of advanced technology. Blockchain and smart contracts are the combinations of advanced technology that can develop a Distributed Application (DApp) to support the FFB supply system. Public blockchain technology becomes popular in developing bitcoin, a digital currency. The characteristic of traceability, immutability, auditability, and provenance are equipped by blockchain that disrupts the supply chain [7]. The consortium chain is developed to facilitate the supply chain [8], a particular blockchain type requiring registration and permission. The participants are restricted and verified through the determined note. The Consensus algorithm on the consortium chain only validates data and blocks through a previously selected node, not all nodes. By this work pattern, consensus and data validation can be promptly achieved. A consortium chain is only accessible in a particular organization. Data access of transactions in the consortium chain is manageable and viewable by certain interested parties, based on the authority given. Consortium chain technology and smart contract can be used in developing DApp FFB supply system. The FFB supply chain characteristic consists of numerous procurement channels, and each channel owns a varied supply chain that is suitable to use a consortium chain.

This research aims to design a DApp of FFB supply and traceability system for low FFA CPO procurement and production channel of independent smallholders using a consortium blockchain. From the sale data of low FFA CPO by a mill, we can know the contributions of each channel of FFB producing low FFA CPO. Food companies in exported countries can identify FFB supplier farms and mills that produce low FFA CPO they import through the traceability system. Besides information on farm location, it can also share detailed information on the sustainable farm with InterPlanetary File System (IPFS) support.

2. Blockchain dan smart contract

Blockchain is renowned as the internet of value and is the third generation of the internet. Previously, we know the internet of things (IoT) as the second generation and the internet of people as the first generation [9]. Blockchain technology is a part of advanced technology for industry 4.0 [10]. Blockchain can be applied to develop a traceability system on the supply chain. All actors are connected in one network and can operator numerous rules and groups of business processes in the

blockchain platform. Blockchain technology encourages all parties to be involved in a more spacious business process, more effective and efficient without involving third parties and centralized authority. As a credible digital network [11], all parties connected in the blockchain network may do their transaction automatically and safely without a reconciliation process that makes ineffective operation. The main issue highlighted in the supply chain is eliminating asymmetric information and inefficient process among the partners. The causes of inefficiency are infrastructure and incompatibility issues. The more application used, the more companies become inefficient and uneconomical to reconcile both data and process continually.

The difference of the information system applied makes an ineffective connection and makes end-to-end traceability difficult among the parties[12]. On the other flip, blockchain offers immutability, audit ability, and provenance. All these capabilities have not been found in the previous technology. Decentralization is another superiority of blockchain. Blockchain technology is an important technology in the supply chain transformation, It makes it more powerful, and several parties collaborate in a transparent ecosystem [13]. The transaction is stored in a block, starting from its production process to its distribution and sale. Transparency and visibility are essential to increase product traceability and ensure product originality and validity [14]; [15].

Smart contracts and blockchain integration can increase the business process of supply chain operation to be more accurate, more valid, more transparent, more secure, and more efficient. The smart contract is a small program stored in the blockchain, and it works when information conditions in a determined contract are fulfilled. Automatically, the smart contract sends a determined data source, including the cause (the trigger) of the occurrence. Smart contract receives the transaction and causes the occurrence in the form of a function call, enabling the entity and node to monitor, track, and receive a relevant warning once a violation occurred. Node is a component inside the blockchain and an entity that participated in the supply chain. Nodes function gathers, validates, executes the transaction, stores the data, and all transaction results in the ledger. This ledger is then replicated and synced by all nodes. FFB procurement that consists of numerous channels is more suitable when using a consortium chain. The transaction in the consortium chain supported by smart contracts does not require a central institution and mediator. Th enhances the integrity, reliability, and security of the transaction.

3. Research Method

Independent smallholders FFB supply system to produce low FFA CPO and the traceability system of low FFA CPO are supported by Decentralization App (DApp). This application is developed using consortium chain technology and smart contract. The blockchain platform used in this research is Hyperledger Fabric. DApp development method of FFB supply and low FFA CPO traceability with system approach[16], developing input & output diagram, identifying system components in diagrams, starting the involved actors and their roles. Input & output rules data and resources needed (fig.2). Next, analyze and design DApp using UML. The diagram to be developed is the Entity-Relationship Diagram (ERD) and sequence diagram. Blockchain network design in this research only uses one channel of FFB procurement from independent smallholders. This blockchain network design will then be developed by integrating FFB procurement channels of groups of plasma smallholders and core farmers' plantations.

The implementation of advanced technology 4.0 like blockchain is tested on a small-scale pilot project to grasp the requirements [17]. The user and system requirements for developing FFB supply and low FFA CPO DApp in this research are obtained through the case-study process at PT. RSI is located in Suka Damai village, Ujung Batu district, Rokan Hulu regency, Riau province. The capacity of CPO production of PT. RSI is 90 tons/hour. Two weighing terminals support the FFB procurement, one terminal is for FFB trucks from its farm, and another is for weighing the trucks from outside the mill, so PT. RSI also receives FFB from outside. A group of independent smallholders fostered has received RSPO certification with a plantation area of 250 ha has established an MoU on the supply of FFB to PT. RSI. At the end of this year, two more farmer groups will join so that the area of the plantation that already has RSPO certification and cooperates with PT RSI is 800 ha of land owned by about 200 independent smallholders.

CPO product coming from fostered smallholder's farms is processed to be part of low FFA of CPO for export purposes. As one of a mill that owns RSPO certification, PT. RSI would like to maximize the low FFA of CPO for export purposes. Only for FFB procurement from independent smallholders who own RSPO certification will be supported by the DApp of blockchain. DApp of FFB supply and low FFA CPO traceability system are parts of the company's effort to enhance their service to their customer's food industries in developed countries. DApp of FFB supply and low FFA CPO traceability system will be developed on delivery network, starting from the farm to the food industries in exported countries.

This research only focuses on a group of independent smallholders, a mill, and an exporter. With the coordination of the local industry office, the blockchain network can be scaled up by integrating many farmer groups and mills in the Rokan Hulu district that archives RSPO certificates.

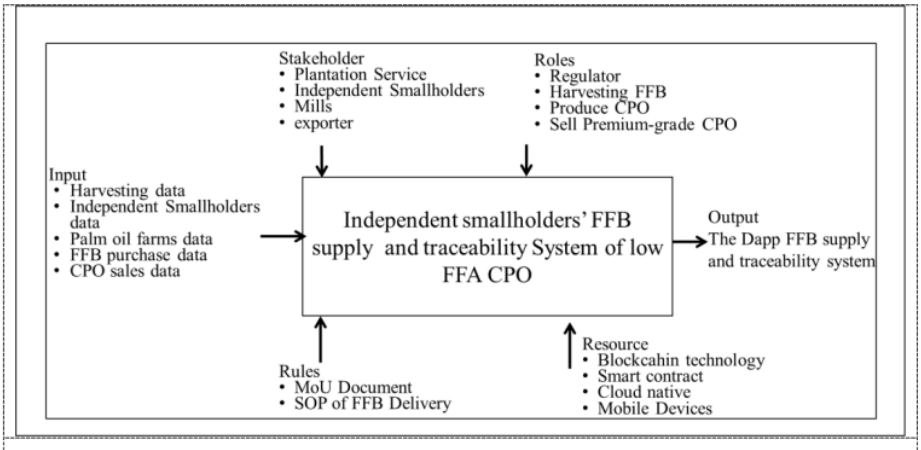

Figure 2. Component analyst of Independent smallholders' FB supply and traceability system for low FFA CPO.

4. Result and discussion

4.1. The design consortium chain dan smart contract

The FFB supply system from the independent smallholders' procurement channel to produce low FFA CPO is equipped with information recording and adding unique identity & lot numbers once each transaction gets started. They were noting hash values to ensure the validity of the transaction. Batch is a unique identifier for identifying the material originality of CPO. Hash data is stored in Hyperledger, and data of transactions is stored in IPFS. Consortium chain provides a function of access control on all transactions. The access control policy aims to restrict user reading and write to the ledger, ensuring that the transaction is executed by authorized users and optimizing data safety. Certain entities can run smart contracts. These certain entities comprise registered entities in the system, and those authorized can interact through smart contracts. Each entity is described as follow (fig.3)

Independent smallholders: The independent smallholders who become a part of the blockchain network of FFB supply and low FFA CPO traceability are selected. They are responsible for planting and determining harvest rotation and harvesting. The condition of farms is in pictures or video stored in IPFS. Those who can access these media are given the authority to access them. For the system of harvest time, traceability and the venue are recorded on the blockchain.

Mills: Processes FFB becoming CPO. Mill stores batch information, quantity, and inspection information of CPO comprising the level of FFA, water content, and CPO purify in IPFS. Hash data is stored in the blockchain, and label data, including a batch number, is brought together once CPO is

delivered. Mills also store GPS farm coordinate location that supplies FFB for low FFA CPO production. The map of the farms that harvest raw material of low FFA CPO is stored in IPFS. Consumers who use and process low FFA CPO obtain information about the low FFA CPO source.

Exporter: Exporter is responsible for storing CPO and sell it to the importers in batch. The company information, time of selling product, price, and other information are kept in IPFS. The hash value is stored in the blockchain to ensure the following data cannot be disturbed.

Regulator: The regulator is a representative of the government who manages STDB data of farms. The regional farm's service receives and processes the registration of farm STDB from the group of Farmers. The farm service can only view selling transactions from smallholders to Mills, monitor and ensure whether the farms of FFB source that produce low FFA CPO have owned update STDB or not.

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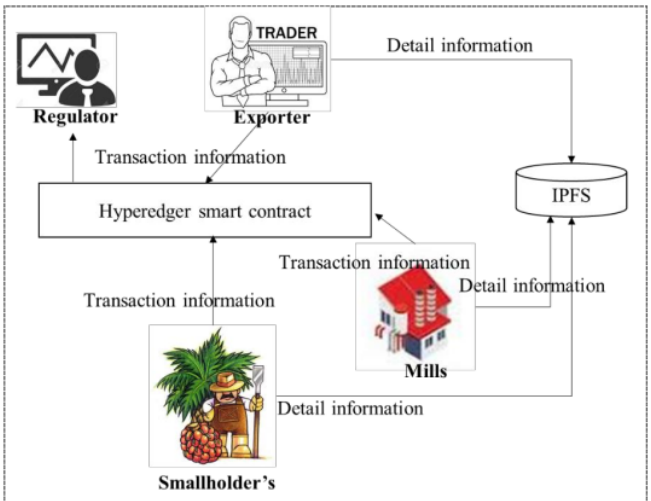

Figure 3. Consortium chain and smart contract supply FFB dan traceability system of low FFA CPO

4.2. Entity Relationship Diagram and Sequence Diagram

ERD displays several main entities and the connection between several entities and smart contracts (fig.4). Each entity works on the blockchain of the Low FFA CPO supply chain by calling function in the smart contract. Smallholders start smart contracts by uploading harvest rotation data and farm information in pictures and video along with RSPO/ISPO certificates they own to IPFS. by calling *UpdateFarmInfo()* and renewing *UpdateFarmInfo()* until harvest rotation can be reached. The selling transaction between the smallholders and mills is based on an agreed price by both parties.

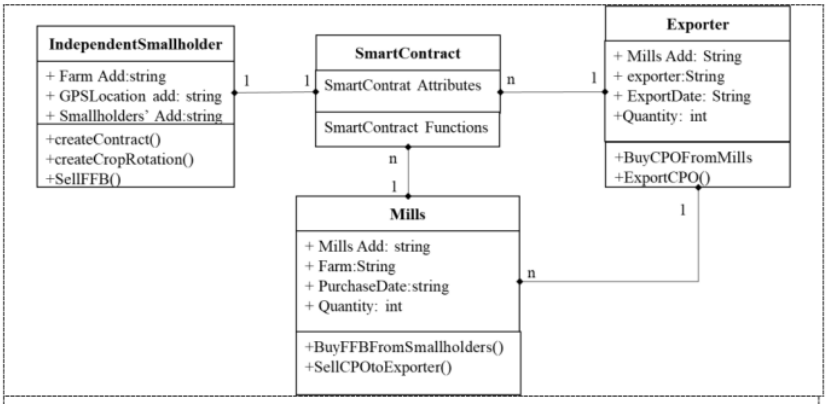

Figure 4. Entity Relationship Diagram.

Fig. 5 is a sequence diagram of collaboration between smallholders and Mills. Each runs the function of *SellFFB*() and *BuyFFB()*. At first, independent smallholders run *SellFFB()* after they harvest and receive price information of FFB from the mill. The function of *SellFFB()* forwards the addresses of smallholders, mills, and time of harvest to activate smart contrast that triggers an event. *FFBWeighed()* informs the participants and forwards and records quantity parameters and weighing time. Afterwards, mills run the function of *BuyFFB(),* forwards Mills address, quantity, and date of purchase along with the smart contract that triggers the event. *FFBBought()* informs the transaction closing time, forwards, and records the parameter.

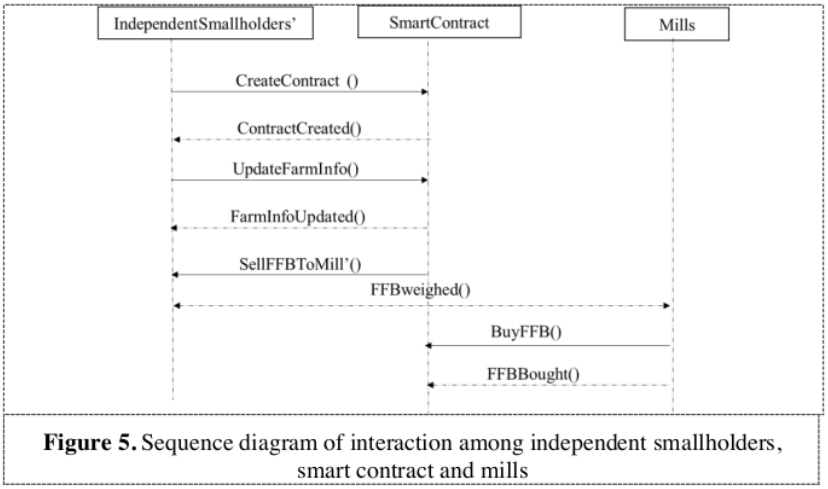

Figure 5. Sequence diagram of interaction among independent smallholders, smart contract and mills

Fig. 6 is a sequence diagram between Mills and exporter. Exporter purchases low FFA CPO on a big scale from various Mills to be exported. First, the exporter triggers the event of *BuyCPOFromMill()*, forwards the address of exporter, the address of mills, quantity, and the parameter of selling date to inform Mills who sells CPO to them. The mill runs the function of SellCPOToExporter(), forwards the address of Mills, the address of exporter, the quantity of sale, and the parameter of selling date to activate the event *CPOSoldToExporter()* to inform the interaction among entities.

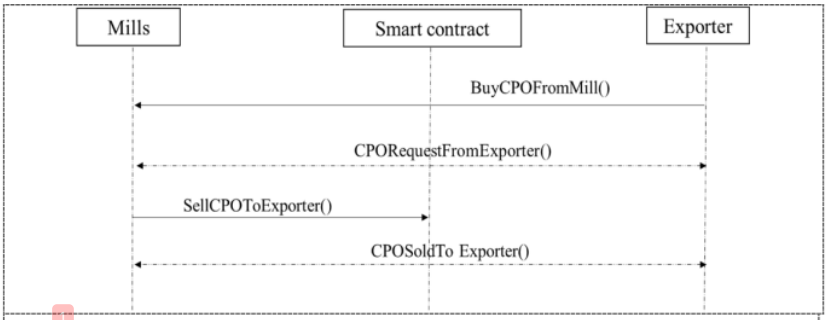

Figure 6. Sequence diagram of interaction among mills smart contract and exporter

The design of decentralization application in the consortium chain is only for FFB supply from certified farms in the procurement channel of independent smallholders. This system requires a database of independent smallholders to supply FFB to PT.RSI and database of independent smallholders who own STDB issued by plantation service and RSPO certified. It is crucial to ensure whether the farms which supply FFB for low FFA CPO production already have a valid database. The blockchain network of the FFB supply from the certified farm from the FFB procurement channel from plasma farmers should be applied for the next stage. Decentralization Application is more effective to be used by massive users. In this research, the only mill involved is PT. RSI. Once it is applied in the future, the other RSPO certified mills and farms may also be involved with this DApp FFB supply and low FFA CPO traceability system.

5. Conclusion

The contribution of independent smallholders of Indonesia is still tiny, approximately 3% of 9% of all smallholders worldwide. It cannot be preconcerted whether the farms owned by independent smallholders can contribute more to the production of low FFA CPO for export purposes. RSPO traceability system only aids smallholders in selling RSPO in credit systems through virtual trading. By supporting the FFB supply from the certified farms and the CPO for export traceability system designed in this research, smallholders become active actors in this supply chain, not only virtual trading. The contribution of independent smallholder groups channels to produce low FFA CPO can be calculated. By presenting the FFB supply system on a map, independent smallholder farms are contributing to producing low FFA CPO can be identified. The increased number of smallholders who register RSPO can increase their contribution in making low FFA CPO for export purposes. The active role of independent smallholders gives the added value of income and the environment. The farms are objects of RSPO certification. Therefore various sustainable information in the farms can be shared.

With the coordination of the District of Industry office as the regulator, the blockchain network can be scaled up by integrating many farmer groups and mills in the Rokan Hulu district that archives RSPO certificates. Decentralization of government in Indonesia has given district governments the authority to manage their industries. FFA low CPO traceability blockchain network managed by the Rokan Hulu district government will increase the trust of CPO production from Rokan Hulu district consumed by the food industry in developed countries. The increase of DApp users from RSPO certified farms of Independent smallholders in the Rokan Hulu district make it possible to integrate the blockchain network with the traceability system of RSPO.

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Pada bagian research method di halaman 5 paragraf terakhir sudah ditambahakan toal petani dan toal lahan petani swadaya yang akan diintegrasikan dalam jaringan block cahin sistem ketertelusuran CPO tujuna eksport

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