Security System for Digital Land Certificate Based on Blockchain and QR Code Validation in Indonesia

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Abstract— **In this research, we developed a land certificate security system based on blockchain technology and a qr code validation scheme to prevent counterfeiting of land certificates and illegal levies in the process of making land certificates in Indonesia. The process of making land certificates is currently still being carried out by involving various related parties so that it requires a complex and long process. This triggers cases of illegal levies carried out by related parties on the grounds of speeding up the process of obtaining land certificates, thereby reducing the transparency aspect. Conventional paper certificates are prone to forgery and easy to lose, besides that electronic certificates designed by the government still use the concept of a centralized system, so they are vulnerable to being hacked. Another problem is the falsification of ownership of land certificates by the land mafia. Therefore, a land certificate security system is needed for the online land certificate data storage process. From the test results, it was found that the system built with the implementation of blockchain technology guarantees data validity, based on verification by smart contracts and consensus mechanisms, and ensures that processes that occur in blockchain-based systems are guaranteed transparency, data is stored globally in a peer-to-peer and immutable.**

Keywords— *Blockchain, Smart Contract, Land Certificate.*

I. INTRODUCTION

A land certificate is proof of a person's ownership and rights to the ownership of land. Currently, there are many cases of falsification of land certificates, which makes people worried. The Director-General of Land and Space Control (PPAT), Ministry of Agrarian and Spatial Planning / National Land Agency (ATR/BPN), said that in 2021 found cases of forgery of land, which were mostly carried out by the land mafia, one of the methods is with a condition or status so that land rights can be transferred by using figures[9]. Therefore data security and guaranteeing the validity of land certificates need to be improved. Referring to Government Regulations No. 24 of 1997 paragraph Article 37 explains that a land title can only be made if it is proven by a deed made by the Land Titles Registrar (PPAT) according to the provisions of the applicable laws and regulations [1,16].

The government has taken anticipatory steps for cases of falsification of certificates, by issuing Ministerial Regulation of Ministry of Agrarian and Spatial Planning / National Land Agency (ATR/BPN) Number 1 of 2021 concerning Electronic Certificates. Certificates are issued through the Electronic System in the form of electronic documents, but in this electronic certificate system, the database used is still centralized[2].

Blockchain technology is a data storage concept that utilizes a cryptographic hash mechanism in data storage and this technology uses a distributed system, meaning that all data storage will be the same from one node to another [5,10,14,15,17,18,19,20,21]. One of the objectives of using distributed systems such as Blockchain is to mitigate attacks such as in [22,23].

In a research paper entitled Blockchain-Based Land Ownership Management System for Bangladesh [4] discusses the development of a blockchain-based land title management system and smart contracts generating khatiyan as ownership. The advantages of the system built are blockchain-based solutions that offer data synchronization and transparency, ease of access, immutable records management, faster and cheaper solutions. However, the developed system still has limitations, namely the role of the government in the system does not yet exist, so it cannot be implemented in real life.

The research paper entitled 'Land records on Blockchain for implementation of Land Titling in India' [3] describes the design of a blockchain-based land certificate ownership registration system, the system has several nodes representing government institutions, banks, courts, Tehsil offices. The government's role in this system exists, and is neatly arranged like a real land sale and purchase transaction, so that it can be implemented in real life. Information related to land records, registrations and surveys is stored at different levels separately at different levels.

Therefore, in this paper, our goal is to design a land certificate system that uses blockchain technology and smart contracts to support securing land certificate data from counterfeiting and preventing criminal acts of liars to increase transparency in the land certificate process. In this paper, the system built uses the rules of the regulatory mechanism in Indonesia so that it can be implemented in real terms in the future. The system built uses a QR code validation mechanism so that it can be used more practically and efficiently
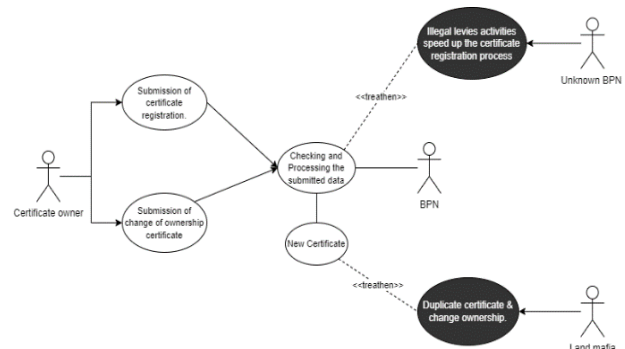
II. RESEARCH METHODS

Figure 1. Misuses Diagram Land Certificate.

Figure 1 shows the threats that occur in land certificates. In the mechanism for submitting certificates manually, there are cases of illegal levies that occur with the aim of speeding up the process of making land certificates [8]. This threat can be anticipated by designing a digitalized land certificate application system. National Land Agency (BPN) is The National Land Agency is an Indonesian government agency in charge of formulating and determining policies in the land sector in accordance with the provisions of laws and regulations.

The second threat is that when the land certificate is in the hands of the owner, there may be cases of forgery by plagiarizing land certificate information and changing ownership rights to the suspect, this is often done by land mafias [9]. This second threat can be anticipated by creating land certificates that have unique identities that are stored and managed in blockchain-based systems and smart contracts.

In this paper, we design a digital land certificate security system based on blockchain technology and smart contracts. The use of blockchain technology and smart contracts was chosen because this technology has a decentralized data security mechanism and is secured by a cryptographic hash that supports data integrity. Blockchain technology is also immutable, which means that any data that has been stored in the ledger cannot be changed or deleted [5,7,12,18,20]. Blockchain technology uses the SHA-256 algorithm to hash data and then it is stored in blocks. SHA (Secure Hashing Algorithm) is a powerful one-way function that generates checksums for digital data that cannot be used for data extraction. This hash provides security on blockchain-based systems because data integrity is ensured by this cryptographic mechanism[11]. The system built can increase transparency in the process of making land certificates with the mechanism of land owners submitting digital land certificates directly in this system which can then be processed directly by the land agency as a node in this system, so that the possibility of illegal levies can be minimized.

Figure 2 shows the flow chart of the certificate registration process in this system. The use of smart contracts in the digital land certificate security system aims to automate the digital land certificate registration process.
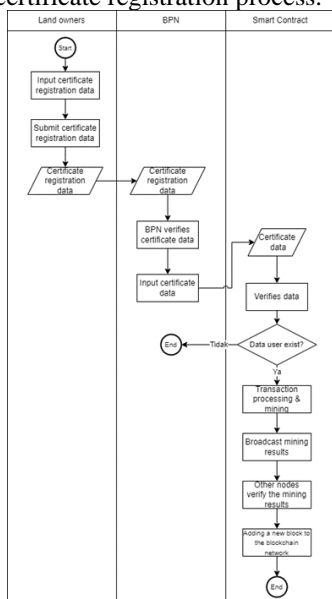

Figure 2. Flow Chart.

Another benefit of smart contracts is that it eliminates the role of a third party, namely a notary, so that the user (land owner) can directly apply for a land certificate registration to the land agency after it is proven valid, it can proceed to submit data, processed by smart contracts and stored in the blockchain network.
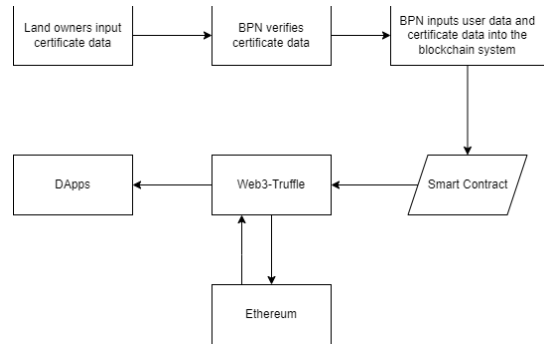
A. *Land certificate registration*

Figure 3. Registration Process.

The land certificate registration process is illustrated in Figure 3 with the following details, the land owner (applicant) inputs certificate data and documents on the land certificate registration website. After everything has been inputted, it can be submitted for processing by the Land Agency. Then, land agency verifies the certificate data and applicant documents to ensure that the data submitted is valid. After the data and documents are valid, the next process is to calculate the hash value of the certificate data. The smart contract process is carried out for the land certificate registration process, which is an automatic computational mechanism that functions to verify the contract. If the contract verification has met the requirements, the transaction can be continued by paying a certain amount of gas to process the transaction. Web3-Truffle is used to an intermediary between Dapp and Ethereum blockchain. Valid transactions that have been computed by the smart contract, then uploaded to the blockchain network.

B. *Validation of Land Certificate*
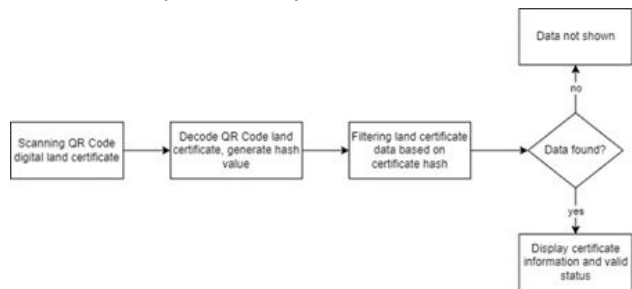
Figure 4. Validation Process.

Figure 4 shows the validation process to find out whether the land certificate is genuine or fake by checking this application. The validation feature uses QR Scan technology to process the hash value of the land certificate. Next, the system will filter the land certificate data based on the hash value, if the data is found it will display information related to the land certificate. However, if the certificate data is not found, the system does not output data.

The system built implements a smart contract that functions to validate land certificate data recording transactions. This system implements 2 types of main functions smart contract, that is function CreateUser function and function CreateSertif.

```
Function CreateUser
bool duplicate = false;
require(bytes(_name).length > 0);
require(_nik > 0);
for(uint i = 0; i < list_user.length; i++){
    if (list_user[i] == _nik){
        duplicate = true;}}
if (duplicate == false){
    list_user.push(_nik);
    user_count ++;
    users[user_count] = User(user_count, _name,
    _nik, msg.sender);
    emit UserCreated(user_count, _name, _nik,
    msg.sender);}}
```

The function CreateUser is used to record user data, in this case the intended user is the owner of the land certificate. This function has a data validity checking feature, the goal is to avoid Null data processing, and ensure all parameter variables are filled in completely. NIK is a resident identity or personal number that is unique or distinctive, single and attached to a person who is registered as an Indonesian resident. User data must be unique in the NIK section, meaning that one NIK can only be used to represent one person and cannot be used for more than 1 user entity. So as to avoid user data redundancy.

```
Function createSertif
bool user_exist = false;
require(_no_sertifikat > 0);
require(_nik > 0);
require(bytes(_alamat).length > 0);
require(bytes(_kota).length > 0);
require(bytes(_prov).length > 0);
require(_panjang > 0);
require(_lebar > 0);
for(uint i = 0; i < list_user.length; i++){
    if (list_user[i] == _nik){
        user_exist = true; } }
if (user_exist == true){
    list_sertifikat.push(_no_sertifikat);
    sertifikat_count ++;
    bytes32 _data_hash = fullhash(_no_sertifikat,
    _nik);

    sertifikats[sertifikat_count] =
    Sertifikat(sertifikat_count, _no_sertifikat,
    _nik, _alamat, _kota, _prov, _panjang, _lebar,
    _terbit,_data_hash, msg.sender);

    emit SertifikatCreated(sertifikat_count,
    _no_sertifikat, _nik, _alamat, _kota, _prov,
    _panjang, _lebar, _terbit,_data_hash,
    msg.sender); } }
```

The function createSertif is used to record certificate data, the recording process can only submit data if the ID of the owner has been registered first. Similar to the createUser function, the createSertif function also has a data validity checking feature, the purpose of which is to avoid processing Null data, and to ensure that all parameter variables are filled.

III. RESULTS AND DISCUSSIONS

The system built is divided into 3 parts : frontend, backend, and blockchain network. The frontend is built using the react js framework, and implements node js technology, which then after the compilation process is successful, the application will be displayed through the browser. The backend uses the javascript programming language and also like the frontend, the backend is built using node js technology, so that the application runs on the node js web server. The blockchain network section uses an EVM application called Ganache, this application is an Ethereum

Virtual Machine that automatically provides 10 account addresses, each filled with 100 Ethereum for the process of developing ethereum-based blockchain applications.

Figure 5. Transaction Detail.

Every transaction that occurs in this system can be recorded in the blockchain network as shown in Figure 5, the recorded information includes the return address, gas used, gas price, gas limit, mining in the block, and encrypted transaction data. The amount of gas fee for transactions may vary from another transaction, as shown in table 1.

Table 1. Transaction Gas Fee.

Transaction	Gass Fee	
Type	Transaction-1	Transaction-2
Input User	0.00705264ETH	0.00712974ETH
Input Certificate	0.01307234ETH	0.01314944ETH

A. Backend

This system is developed using node js, javascript, and Web3js technologies. Node js is used for javascript based web application runtime. Web3js is an API used as an intermediary for applications, and the ethereum blockchain network. Web3js contains information regarding account address, network id, account balance, IP, etc. This system uses ganache as a blockchain network environment, and through metamask to perform transactions through the browser.

The certificate validation feature and data transfer rights use a table filtering mechanism from data that has been previously loaded from the blockchain. This filtering is implemented using javascript so that the results can display data that match the input query.

B. Frontend

- User Data Input

    This feature is used to add land certificate owner data into the blockchain. Figure 6 shows the user data input form. The data inputted are Name and NIK. Each NIK represents a different individual so that a NIK can only be recorded by the system exactly 1 time. After filling in the data, then click the submit button, then the system will display a gas fee notification for the transaction and click Confirm to continue.

Input User

Nama
Surya Kencana

NIK
3318112607000338

Submit

Figure 6. User Data input form

The owner's user data that has been successfully saved will appear in the Registered Users table as shown in figure 7.

User Terdaftar

#	Nama	NIK
1	Ricko	3173052607000001
2	Michael	3318112607000026
3	Nisrina	3318112607000027
4	Fitri	3318112607000339
5	Surya Kencana	3318112607000338

Figure 7. Registered Users table

- Certificate Data Input

This feature is used to add land certificate data into the blockchain. Figure 8 shows the certificate data input form. The data that needs to be input is the certificate number, NIK, address, city, province, length of land, land width, and the date of issuance of the certificate.

Input Sertifikat

Nomor Sertifikat
11070132080092

NIK
3318112607000338

Alamat
Jl. Bend. Jatiluhur No.34, RT.4, RW.2, Bend. Hilir, Kec. Tanah Abang, Kota Jakarta Pusat 10210

Kota
Jakarta Pusat

Provinsi
DKI Jakarta

Panjang Tanah (M)
278

Lebar Tanah (M)
78

Tanggal Penerbitan
12/14/2021

Submit

Figure 8. Certificate Data input form

Sertifikat Terdaftar

#	Nomor	NIK	Alamat	Kota	Provinsi	Tanggal Terbit
1	11070132080091	3173052607000001	Jl. Bend. Jatiluhur No.26, RT.4, RW.2, Bend. Hilir, Kec. Tanah Abang, Kota Jakarta Pusat 10210	Jakarta	DKI Jakarta	2017-08-17
2	11070132080092	3318112607000338	Jl. Bend. Jatiluhur No.34, RT.4, RW.2, Bend. Hilir, Kec. Tanah Abang, Kota Jakarta Pusat 10210	Jakarta Pusat	DKI Jakarta	2021-12-14

Figure 9. Registered Certificate table

After filling in the data, then click the submit button, then the system will display a gas fee notification for the transaction and click Confirm to continue, the illustration is as shown in figure 9. Successfully saved certificate data will appear in the registered certificate table.

- Certificate Validation

This feature is used to check the authenticity of land certificate data by searching for data in this system. This feature uses QR Scanner technology which makes it easier for users to carry out the validation process. Point the QR code directly in front of the camera for the system to interact appropriately. After the system has successfully read the code, the hash value will be displayed in the Hash column as shown in figure 10, then click 'Check' to process data validation.

Klik tombol Scan untuk memulai pemindaian kode QR.

Hash Sertifikat
0xb5fb85c0e35db44486b14b2fc496699505821101fef70b2d7cc3970097e6844f

Check

Figure 10. QR Code scan result.

If the certificate data is valid (recorded in the system), the system will display a table containing information on the certificate data, namely Certificate Number, Address, City, Province, QR Code, and Validation Status, as shown in figure 11.

Klik tombol Scan untuk memulai pemindaian kode QR.

Hash Sertifikat
0xb5fb85c0e35db44486b14b2fc496699505821101fef70b2d7cc3970097e6844f

Check

Badan Pertanahan Nasional Republik Indonesia

Nomor	Alamat	Kota	Provinsi	QRCode	Status
1	111111141000005	Ds. Pantirejo, RT.02, RW.01, Kec. Gabus, Kab. Pati 59173	Pati	Jawa Tengah		Valid

Figure 11. Certificate validation results.

The validation results can be printed into a pdf file extension, by sorting the 'Valid' button, and then clicking 'Save'. Figure 12 shows the print feature of the file validation results carried out by the user, then saved to their device.
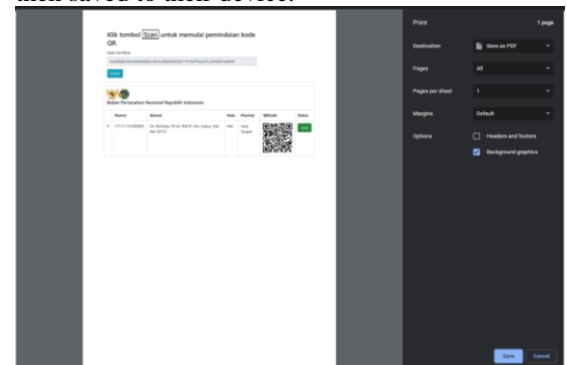

Figure 12. Save validation results as pdf

This feature is used to check the certificate ownership history that is searched by certificate number. On the Navigation bar, the page is named 'Data Peralihan Hak'. Then, input the certificate number for which property rights will be checked, then click the 'Check' button.

Figure 13. Certificate ownership history.

The system will short the certificate data based on the certificate number that matches the input and will display the results in the form of a table with information on the Certificate Number, Owner's NIK, QR Code, and certificate issuance date, as shown in figure 13.

- Certificate Registration

    This feature is used by the public whose function is to submit a digital land certificate data recording to the BPN, which then BPN will verify and validate the data of the applicant/owner of the land certificate which, if valid, will be recorded on the blockchain system. The use of this feature is, the first step is to fill in the required data as a certificate registration, the data are email, name, NIK, and link drive documents that have been previously uploaded by each user (community), this document consists of a scan of KTP, KK, Deed of Sale and Purchase, proof of payment of Land and Building Rights Acquisition Fee (BPHTB), proof of payment of Non-Tax State Revenue (PNBP).

    After all the data is filled in completely, click the 'Send' button to submit your data. The data that has been sent will then be processed by the BPN admin and if the data recording has been successful, the results will be sent via email to each community used by the community in this registration process.

C. Evaluation Scenario

This system is evaluated by 2 mechanisms, the first test relates to the flow of data from the user (the certificate holder) to the admin BPN. The results of the test can be concluded that certificate registration data from community users can be sent and received by the admin BPN properly, although it takes a few minutes to load the latest updated data regarding the submission of land certificates on the admin BPN page, as shown in figure 15.

Figure 15. Certificate registration applicant data.

The second test is used to test the certificate data validation feature as proof that the certificate is a genuine certificate. The results of this test, the system can scan the QR Code, translate

the QR Code, search / filter certificate data properly and display the appropriate data, as shown in figure 16.

Figure 16. The results of succesful validation.

The third test, carried out by scanning a qr code whose data has not been recorded by the system, Figure 17 shows the results of this test. The system can still decode the qr code, but in the data validation process it proves that the data is not recorded by the system, so the system will not display the results of this validation.

Figure 17. The result of failed validation.

Figure 18 shows the testing of historical data features of land certificate ownership. The certificate number data will be inputted in the search form, and after searching, the system successfully displays data based on the certificate number along with the certificate ownership history.

Figure 18. History of land certificate ownership.

The fifth test was carried out with a login scenario as a BPN admin user. The test is done by inputting an incorrect password, and the result is that the system will pop up a password input form and display a warning that the password is entered incorrectly and asks the user to re-enter the password, as shown in figure 19.

Figure 19. Login as BPN admin user.

The next test is carried out by the BPN admin user role by inputting user data with a previously recorded NIK. The

smart contract will reject / reject the storage of the user's data because the inputted NIK has been recorded by the system, and cannot be re-recorded. This aims to avoid data redundancy, and double ownership. Then the certificate data is inputted with owner data that has not been started before, the system will produce a warning output in the form of rejection. The smart contract will reject / reject the data storage because the certificate owner's ID has not been recorded by the system. The rejection process is aimed at mapping errors between the certificate and the owner's data because the legal owner of the data has not been recorded. The data entered in this test will not be stored in the system.
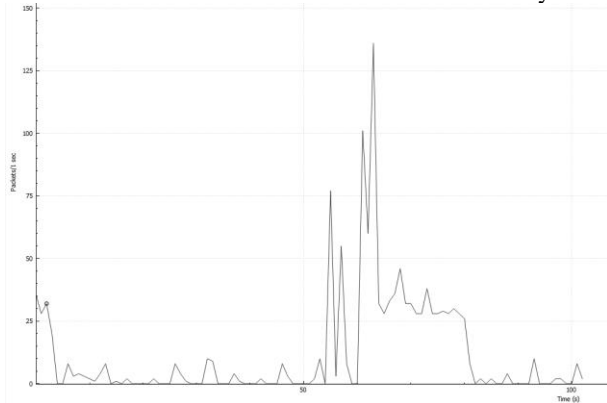
Figure 20. Performance measurement.

The system is built using the ethereum virtual network, so performance measurements are limited. According to the results shown in figure 20 is about performance diagram of this system. The system is able to process several packets with good performance, 63 seconds shows the highest packet processing, which is 136 packets.

IV. CONCLUSIONS

The system built can be used as a data recording system for land certificates and their ownership rights. This system can prevent the act of forging digital land certificates because each data stored on the blockchain network has a unique hash function between certificates with each other. The certificate validation mechanism is carried out by scanning the QR Code, the system will decode and then the results will be matched directly with the certificate data imported from the blockchain network. The certificate registration process is carried out directly through this application, making the implementation of this process more transparent and minimizing the practice of illegal fees by related parties.

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