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Theme

Using smart contracts for land management

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Index :

List of Abbreviations

NEO : New Economic Opportunities.

CHT : ChromaWay token .

List of Figures

List of Tables

Introduction

Introduction:

At the beginning of this study, we asked this question: How can we use a sales smart contract instead of a regular sales contract according to the Algerian law for land ownership? This question leads us to other questions: How can we prove land ownership in Algerian law? How can we transfer ownership in a regular sales contract? What are the institutions involved in this process? How will smart contracts help us to make it easier? How will we create this smart contract?

In today's rapidly digitizing world, the merger of technology and law presents opportunities that can revolutionize traditional systems. Particularly, the integration of smart contracts into the realm of real estate sales can not only expedite processes but also ensure transparency, reducing potential fraud or miscommunication. As Algeria's legal framework for land ownership has its intricacies and nuances, adapting and introducing smart contracts within this system requires a meticulous understanding. Through our comprehensive study, we aim to bridge the gap between conventional practices and the potential of blockchain technology.

The smart sales contract is an important subject to study if we want to implement a new concept. Smart contracts make it easier for all individuals and institutions involved in the operation and facilitate obtaining the real estate register without involving a third party. This will enhance and secure regular contracts.

We began by introducing in chapter one the concepts of land ownership and the transfer of ownership in Algerian Law. Chapter Two presents the basic concepts of blockchain and smart contracts. Blockchain-based solutions for land management are explored in the subsequent chapter. In the final chapter, we present our solution, wrapping up with a conclusion and some perspectives.

Chapter 01:

Land Ownership and Ownership Transfer under the Algerian Law

1.1 Introduction :

This chapter presents a study about Land Ownership and Ownership Transfer under the Algerian Law of the real state, We will see the process of getting the ownership of surveyed lands and unsurveyed lands to obtain The real estate register which is delivered by the real estate conservatory '' لمحافظة العقارية''. Finally, we give a sales contract as an example of how to transfer the ownership and the different institutions and individuals involved in this process like a notary and his relationship with The real estate conservatory.

1.2 The real estate ownership :

Real estate ownership in Algeria has undergone legal and historical developments and stages, resulting in legal texts and regulations that have contributed throughout history to the stability and regulation of private real estate ownership. This protects and preserves the rights of property owners from encroachment by others.

1.2.1 The ownership definition: [1]

The Algerian legislator defined the ownership in Article 674

''Is the right to enjoy and dispose of things provided that they are not used in a way that violates laws and regulations.''

1.2.2 Real estate definition : [2]

The Algerian legislator defined real estate in Article 683

''Everything that is stable in its place and cannot be moved without damage is considered real estate, and anything else is considered personal property.''

1.3 The ownership for surveyed lands and unsurveyed lands :

1.3.1 Surveyed lands :

1.3.1.1 The real estate survey definition : [3]

Article 2 of Order Nb. 74-75 dated 1975/11/12, which includes the preparation of the general land survey, stipulates the following:

''The general land survey determines and defines the natural boundaries of properties and serves as a material basis for the real estate register .

1.3.1.2 Types of real estate survey :

There are two types of real estate survey :

1/The general land survey [4]:

The land survey plan, divided into sections and specific places

2/ Forest survey [5]:

Forests are considered natural and public national properties.

1.3.1.3 The objectives of the Real Estate Survey :

The most important objectives of the Real Estate Survey are :

1/ Regulating and conducting real estate transactions [3]:

And this is achieved by establishing the real estate registry, which registers each property as proof of ownership.

2/ Protection of the owner :[6]

And this is done by identifying the legal status of the property.

3/ The social objective :

The elimination of violations that often occur between relatives.

1.3.1.4 The institutions involved in the real estate surveying process :

A/National Agency for Land Surveying وكالة الوطنية لمسح الاراضي **:**

1/Definition : [7]

The legislator defined it in Article 1 of the decree as a "public administrative institution with civil personality and financial independence. This institution is subject to the laws and regulations in force and the provisions of this decree ‘’

2/Organization of the National Agency:

The agency is composed of a board of directors and a director

Director: The director is appointed by executive decree based on a proposal from the Minister of Finance.

The Board of Directors: The council consists of representatives from various central departments (planning, interior defense, transportation, agriculture, etc.)[8]

3/The tasks : [9]

- Preparing contracts and files related to the work of land survey committees and the demarcation of specified boundaries for which land surveying is required.

- Conducting real estate investigations.
- Preparing general land survey plans.
- Examining the extent of conformity between land surveys and the land registry.
- Monitoring the work carried out by surveyors.

B/ Land Survey Committee لجنة مسح الاراضي **:**

1/The formation of the committee [10]

Is stipulated in Article 7 of Decree 62-76 regarding land survey**.**

*The president of the municipal council or his representative, as a vice president.

*A judge from the court within the municipality's jurisdiction.

*A representative of the local tax administration department.

*A representative of the Ministry of National Defense.

*A representative of the urban development department in the province.

*A notary appointed by the authority, and a real estate expert engineer.

* real estate administrator or his representative.

2/The tasks and powers of the committee :[11]

Are stated in Article 9 of Decree Nb 62/76, which are:
Collecting documents and data to facilitate the preparation of survey documents.

Verifying the agreement of those concerned regarding the boundaries of their properties.

Mediating in all disputes that can be settled amicably.

Note : Decisions of the Land Survey Committee

Article 8 of the same decree number 62/76 stipulates that the committee's decisions are implemented by a decision from the governor(الوالي)[12]

C/The employees affiliated :

The employees affiliated with the State Property and Real Estate Conservatory

administration are :

The investigating employees play a significant role in real estate rights by studying the deeds and contracts to relieve the real estate conservator المحافظ العقاري from the burden of studying them. he only number the properties based on the data resulting from the investigation.

It consists of two investigators, one of whom belongs to the Real Estate Conservatory لمحافظة العقارية and the other from the State Property أمالك الدولة, with the participation of a municipal employee as their

representative according to the instruction issued by the National Property Directorate on 1998/5/24.**[13]**

If the property does not have proof of ownership, a temporary numbering is either assigned for a period of 7 months if the legal possession conditions are met, or a numbering is assigned for a period of 2 years if the owner of the property does not have a possession that gives him ownership of this property by prescription.

If the property has the official proof of ownership, a final numbering is issued that ends with the real estate register دفتر عقاري, which is considered the only document to prove real estate ownership in the surveyed lands.

1.3.2 Unsurveyed lands :

For unsurveyed lands there is Contracts that establish real estate ownership .

After the issuance of Order Nb. 70/91 dated 15/12/1970 regarding the profession of notary, which came into effect on 1 January , 1971, all informal transactions in the real estate sector were closed off.

And this date marks the turning point between the erea of informality and formality in real estate transactions. No real estate transaction is accepted unless it is an official contract.

1.3.2.1 The definition of an official contract :

The civil law, specifically Article 342, stipulates that the official contract is: ''A contract in which a public servant or officer, or a person tasked with a public service, attests to what took place or was received by the concerned parties, in accordance with legal formalities and within the limits of his authority and jurisdiction.''[14]

1.3.2.2 The types of official contracts :

The contracts vary depending on the person who is legally qualified to prepare them, so they can be , Notarial deeds ,administrative, or judicial

A /Notarial deeds :

Notarial deeds are those documents that the notary public is authorized to draft and certify.

For exemple

The sale contract : a contract that transfers property ownership.

The will " الوصية" : an act related to the inheritance added to what comes after death

B/The administrative bonds :

The administrative bonds are those official documents that the public administration is responsible for recording. For exemple :

Contract of exchange (عقد المبادلة) : is the contract in which both contracting parties agree to transfer ownership of non-monetary property to each other.

C /Court documents"السندات القضائية" :

Judicial documents, which are judgments and decisions issued by judicial authorities, are considered real estate ownership documents and are published in the real estate Registry

1.3.2.3 The file that must be submitted in order to obtain a real estate register in Algeria :

*A certificate issued by the real estate administration

*Birth certificate number 12 of the owner

*A copy of the owner's ID

*A certified copy of the ownership document (authenticated deed, administrative deed, gift contract, etc.) or any other document that proves ownership.

*Receipt of payment for issuing the property register.

1.4 The real estate register:

1.4.1 The definition and the important of the real estate register : [9]

There is no article recognize it directly, It is a document serves as a property birth certificate, confirming an individual's ownership of a property and serving as evidence against any claims from others delivred by The Real Estate conservatory. In the absence of the real estate register, no transfer of ownership (sale, gift, etc.) can be carried out .

1.5 The Real Estate conservatory "المحافضة العقارية" :

1.5.1 The Real Estate conservatory definition[15] :

The Real Estate conservatory is a public service whose primary function is to preserve contracts and various documents subject to registration, including the transfer, creation, or modification of property rights.

Under the supervision of the Ministry of Finance and managed by a real estate conservator.

1.5.2 The tasks of the Real Estate conservatory Office :

According to Article 03 of the decree Nb. 76/63, these tasks consist of:

1/Preparing and maintaining the collection of property cards.

2/Providing the necessary procedures for advertising requests for various documents and agreements.

3/Examining contracts and ensuring their compliance with formal and substantive conditions.

4/Writing data on property records for various rights.

5/Preserving contracts, plans, and all documents related to advertising properties.

6/Providing information to the public upon request.

1.6 Sales contract :

1.6.1 Sales contract definition : [16]

Article 351 of the Algerian Civil law defines a sale contract as follows: a contract in which the seller undertakes to transfer ownership of a thing or another financial right to the buyer in exchange for a cash price."

1.6.2 Conditions : [17]

There are serval condition in sale contract the importants are :

A/ The consent : االتراضي

Article 59 of the Civil Code (The contract is concluded as soon as the two parties express their mutually matching intentions without any violation of legal provisions

B/The age :

"From the age of discernment and before reaching the age of majority, according to Article 43 of the Civil Code, his actions are valid if they are beneficial to him, and void if they are harmful. It depends on the authorization of the guardian or custodian whether they are in the interest or detriment of the individual. In case of dispute, the matter is referred to the judiciary."

The age of discernment, according to Article 42 of the Algerian Civil Code, is 13 years, while the age of majority is 19 years complete.

C/ The existence of the property or its potential for existence in the future :

Article of the Algerian Civil Code states that "it is permissible for the subject of an obligation to be a future and certain thing."

D/ Designation of the sold property :

"The designation of the property is made by specifying its location, boundaries, area, and number, if it is included in the general land survey. It is necessary for the designation to be clear."

E/ The sold property must be owned by the seller at the time of the sale.

The seller cannot transfer more ownership rights to the buyer than what they actually possess. Therefore, if the seller is not the owner of the property being sold, they cannot transfer ownership to the buyer. This condition is necessitated by the nature of the sale as a contract that transfers ownership itself. Thus, if the seller is not the owner of the property at the time of the sale, the transfer of ownership from the seller to the buyer becomes impossible upon the mere conclusion of the contract.

F/ The price :

According to Article 351 of the Civil Code, the "ثمن" (price) is defined as a sum of money that the buyer undertakes to pay to the seller in exchange for the seller's commitment to transfer ownership of the sold property to the buyer.

G/The reason : The Algerian legislator did not specify the reason for the contract and contented itself with stating it in Article 97 of the Algerian Civil Code: "If the contracting party commits for an unlawful reason or a reason contrary to public order and morals, the contract is void."

1.6.3 The individuals involved in drafting the official contract [17]

The notary public: The notary public, as a public officer, is responsible for drafting official contracts related to real estate

The seller and the buyer: The parties to the real estate sales contract must mention their full name, title (seller or buyer), residence, and the date of birth.

The witnesses: Similarly, the full name, title, residence must be mentioned. If there are no witnesses, the contract is considered void. This is stipulated in Article 324 repeated 3 of the Algerian Civil Code."

The translator: In some cases, one or both parties may not know the Arabic language."

1.6.4 The relationship between the notary and the Real Estate conservatory:[18]

The role of notaries is not limited to preparing official contracts ; it is also necessary to deposit these contracts at the Real Estate conservatory for registration, preservation, and issuance of a land register for the new owner. This is in accordance with Article 90 of Decree 63/76 .

Therefore, the notary plays the role of an intermediary between the owner and the Real Estate conservatory .

Here's a figure 1 that summarises the process of a regular sales contract :

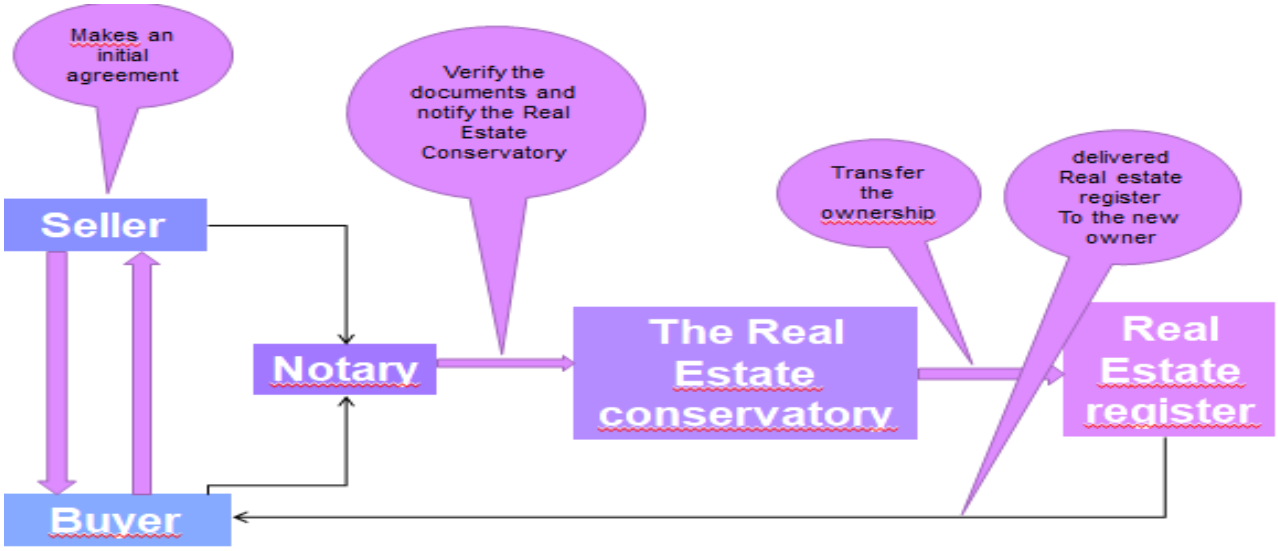


Figure 1 The process of a regular sales contract

1.7 Conclusion :

This chapter gave us a clear idea about the process of proving the ownership and how to transfer it according to the algerian laws.

In our proposed model, we will focus a transfering of the ownership that is already proved their surveyed lands and unsurveyed lands. The objectif is minimise and reduce the steps of the regular sales contract and implement the smart contract instead.

Chapter 02 :
Basic Concepts of Blockchain and Smart Contracts

2 Chapter 02 : Basic Concepts of Blockchain and Smart Contracts :

2.1 Intruduction :

Blockchain and smart contracts represent foundational shifts in decentralized technology, altering our approach to trust and digital transactions. This chapter will unpack the essence of these concepts.

We'll start by defining both blockchain and smart contracts, offering clarity for newcomers to these subjects. We'll then briefly trace their historical development, providing context to their modern significance.

Next, we'll outline the structure of the blockchain, highlighting the process of adding a new block and the unique security it offers. We will also touch upon the mechanism of smart contracts .

By the end of this chapter, readers will have a concise yet comprehensive grasp of the fundamental aspects of blockchain and smart contracts.

2.2 Blockchain :

2.2.1 Definition :[19]

Blockchain is a peer-to-peer network , distributed ledger that is cryptographically secure, available only for addition, immutable (extremely difficult to modify) and can only be updated by consensus or agreement between peer nodes

peer-to-peer network :

peer-to-peer or P2P network , means that there is no central controller in the network, and all participants (nodes) communicate to each other directly. This property allows transactions to be conducted directly between nodes without the involvement of third parties.

Distributed ledger :

means that the data is distributed over the network to all peer-to-peer nodes in the network, and each peer-to-peer node contains a copy of the complete data.

2.2.2 History of blockchain : [20]

1991-2008 : Early Years of Blockchain Technology :

> Blockchain technology originated in 1991 with Stuart Haber and W. Scott Stornetta's work on secure, tamper-proof timestamps. Enhanced with Merkle trees in 1992, the technology gained significant relevance in 2008 when an unknown entity, Satoshi Nakamoto, applied it to create Bitcoin. Nakamoto's 2009 whitepaper further explained how blockchain's decentralization could offer enhanced digital trust, laying the groundwork for broader applications beyond just cryptocurrency.

Evolution of Blockchain : Phase 2- Contracts

2013-2015 : Blockchain 2.0 : Ethereum Development

Vitalik Buterin, initially a contributor to Bitcoin, founded Ethereum in 2013 to overcome Bitcoin's limitations and expand blockchain's capabilities. Launched officially in 2015, Ethereum introduced features like smart contracts and became a platform for decentralized applications, not just a cryptocurrency. This innovation marked a pivotal moment in blockchain history, making Ethereum a key player in the technology's evolution and fostering an active developer ecosystem.

Evolution of Blockchain : Phase 3- Applications

2018 : Blockchain 3.0 : the Future

Since 2018, blockchain technology has evolved beyond Bitcoin and Ethereum, with new projects like NEO addressing various limitations and expanding features. NEO aims to be China's Ethereum, gaining support from influential figures like Alibaba's Jack Ma. Other platforms like Monero, Zcash, and Dash enhance security and privacy. Besides public blockchains, the rise of private, hybrid, and federated blockchains has been significant, with major companies like Microsoft investing in these technologies for operational efficiency.

2.2.3 The structure of a block :[19]

The structure of a block is also dependent on the type and design of a blockchain. Figure 2 shows basic elements of a block :

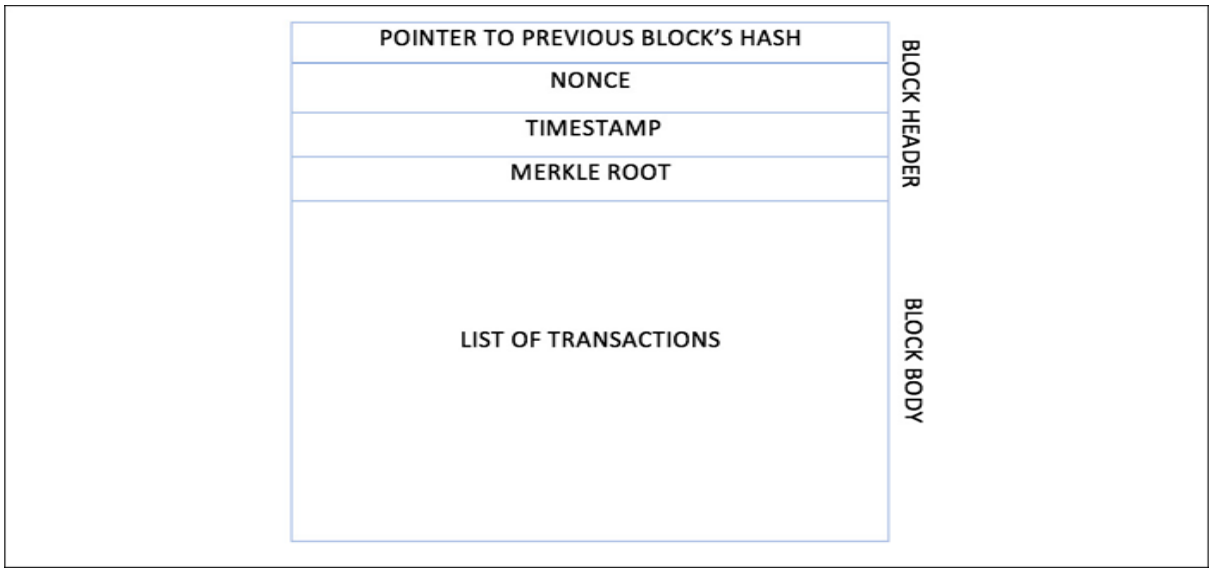


Figure 2 illustrates the fundamental components of a block

A block contains two parts header and body .The header elements are :

1/The Block header :

1.1A reference to a previous block is also included in the block unless it is the Genesis block. This reference is the hash of the title of the previous block.

Block Genesis is the first block of blockchain .

1.2 A nonce is a number that is generated and used only once. A nonce is used extensively in many cryptographic operations to provide replay protection, authentication, and encryption.

1.3A timestamp is the creation time of the block.

1.4Merkle root is a hash of all of the nodes of a Merkle tree. In a blockchain block, it is the combined hash of the transactions in the block. Merkle trees are widely used to validate large data structures securely and efficiently. In the blockchain world, Merkle trees are commonly used to allow efficient verification of transactions.

2/The block body

contains the list of transactions and its size varies depending on the type and design of the blockchain.

2.2.4 Adding a New Block to the Blockchain : [19]

To understand the intricacies of the blockchain process, it's crucial to explore how new blocks are integrated into the chain . Figure 3 provides a visual representation of the steps involved in adding a new block to the blockchain.

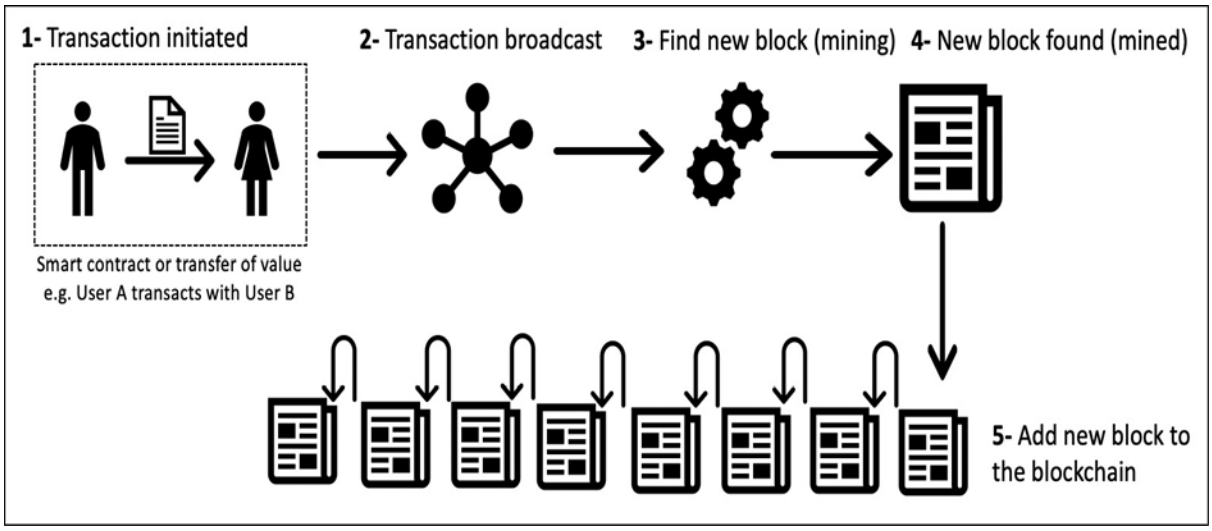


Figure 3 steps involved in adding a new block to the blockchain

1/ Transaction Initiation : A node starts a transaction, digitally signs it with its private key, and sets its structure. Transactions can signify various actions, often representing value transfers between users or calls to smart contracts on the blockchain. They typically involve two or more parties.

2/Validation & Broadcast : The transaction is disseminated to other nodes using data distribution protocols like the Gossip protocol. Other nodes validate the transaction based on set criteria. Before broad distribution, the transaction's validity is ascertained.

3/Block Mining : Once validated, the transaction is included in a block, marking the onset of the mining process. Here, miners compete to complete the block.

4/Block Completion : A miner, after solving a complex mathematical puzzle or meeting the consensus mechanism's conditions, successfully « finds » the block. Once this happens, the transaction is deemed confirmed. In blockchain systems like Bitcoin, the successful miner receives coins as a reward.

5/Block Integration : The newly found block is added to the blockchain.

2.2.5 Types of blockchain :[19]

There are two main types of blockchain public and private :

1/public blockchain :They are open to the public and everyone can participate as a node in the decision making process. Users may be rewarded or not rewarded for their participation.

All users of these «unauthorized» or «unauthorized» registries maintain a copy of the registry on their local nodes and use the distributed consensus mechanism to determine the final state of the registry. Bitcoin and Ethereum are considered public blockchains.

2/Private blockchains : they are open only to a consortium or a group of individuals or organizations that have decided to share the roster with each other. Various blockchains such as Kadena and Quorum are now available in this category. Both of these blockchains can also work in public if necessary, but their main purpose is to provide a private blockchain.

2.2.6 Advanteges of blockchain :[19]

enhances security by creating immutable, end-to-end encrypted records that deter fraud and unauthorized activity. It addresses privacy concerns through data anonymization and permission-based access. By distributing information across a network of computers rather than a single server, it makes hacking more challenging.

Greater transparency :

Blockchain's distributed ledger technology allows for identical transaction and data records across multiple locations, ensuring transparency among network participants with permissioned access. Transactions are immutably time- and date-stamped, offering a complete transaction history and significantly reducing the potential for fraud.

Instant traceability :

Blockchain provides instant traceability through an audit trail that documents an asset's entire journey. This is valuable for verifying product authenticity, addressing consumer concerns about environmental or human rights issues, and identifying supply chain inefficiencies. The technology allows for transparent data sharing directly with customers.

Increased efficiency and speed :

Blockchain streamlines traditional, paper-heavy processes, reducing human error and eliminating the need for third-party mediation. Transactions are faster and more efficient, with documentation and transaction details securely stored on the blockchain. This also speeds up clearing and settlement by removing the need to reconcile multiple ledgers.

Automation :

Smart contracts on blockchain enable automated transactions, increasing efficiency and speed. These contracts automatically execute the next step in a process once pre-defined conditions are met, reducing the need for human intervention and third-party verification. For example, in insurance, claims can be automatically settled and paid once all required documentation is submitted.

2.2.7 Disadvantages of blockchian :[21]

Scalability : Blockchain networks, unlike centralized systems, face scalability issues that can lead to slower transaction times, especially as more nodes join the network. For example, transactions on the Bitcoin network can be delayed due to network congestion.

Some Blockchain Solutions Consume Too Much Energy : Blockchain technology, originally introduced with Bitcoin, uses a Proof-of-Work consensus algorithm that relies on miners to solve complex mathematical problems. While miners are incentivized for their efforts, the high energy consumption required for these calculations makes the system less ideal for broader, real-world applications.

Blockchain Cannot Go Back — Data is Immutable : Data immutability in blockchain is both an advantage and a limitation. While it benefits systems like supply chains and financial networks, its effectiveness depends on a fair distribution of network nodes. Immutability can be compromised if the network isn't adequately decentralized.

Blockchains are Sometimes Inefficient : Various blockchain technologies exist, including popular ones like Bitcoin's, but they often contain inefficiencies that are considered significant drawbacks of the technology.

Users Are Their Own Bank : Private Keys : The decentralization of blockchain allows individuals to act as their own banks but poses risks related to private key management. Users must securely store and not share their private keys to access their digital assets. Losing the private key means losing access to the wallet permanently, making user reliance a significant drawback of blockchain technology.

2.2.8 Consensus :

The consensus is a process of ensuring that all the different users in a blockchain come to an agreement regarding the current state of blockchain and make sure that all nodes are synchronized with each other and agree on transactions which are legitimate and added to the blockchain.

It also ensures validity and authenticity of blockchain .The choice of consensus algorithm used depends on the type of blockchain used .

Types of consensus algorithms : [19]

there are many consensus algorithms types used in blockchain we list the important onces :

1/Proof of Work (PoW) : This type of consensus mechanism relies on proof that adequate computational resources have been spent before proposing a value for acceptance by the network. This scheme is used in Bitcoin, Litecoin, and other cryptocurrency blockchains.

2/Proof of Stake (PoS) : This algorithm works on the idea that a node or user has an adequate stake in the system ; that is, the user has invested enough in the system so that any malicious attempt by that user would outweigh the benefits of performing such an attack on the network .

2.3 smart contract :

2.3.1 Definition of smart contract :[19]

A smart contract is a self-executing digital program that automatically enforces the terms of a contract between parties. It uses computer code to automate the process of verifying and enforcing the terms of an agreement, and runs on a blockchain network, which makes it transparent, secure, and tamper-proof.

2.3.2 History of Smart Contracts : [22]

Early Beginnings In the 1990s, Nick Szabo, a pioneering computer scientist and cryptographer, first introduced the concept of smart contracts. Szabo specialized in digital currencies and protocols, laying the groundwork for the digital contracts that would later be implemented on blockchain platforms.

Rise of Blockchain :

In 2008, the blockchain world saw a significant milestone with the advent of Bitcoin, the first successful cryptocurrency. While Bitcoin itself did not support smart contracts, it paved the way for the broader acceptance of blockchain technology.

Emergence of Ethereum :

A few years following the introduction of Bitcoin, the Ethereum blockchain was launched. Ethereum provided the ideal technological platform for the practical implementation of smart contracts, thereby gaining them widespread popularity. Unlike Bitcoin’s blockchain, which was designed primarily for financial transactions, Ethereum’s blockchain was built to support decentralized applications, including smart contracts.

Current State :

Today, smart contracts are a staple in the blockchain ecosystem, serving as digital agreements with a set of executable codes. These contracts automatically execute when predetermined conditions are met, eliminating the need for intermediaries. This evolution has opened up a wide array of possibilities, particularly in areas like decentralized finance (DeFi), supply chain management, and digital identity verification.

2.3.3 components of smart contract [24]

A smart contract typically contains the following components :

State Variables : Smart contracts have state variables that hold the contract’s current status and data. These can include things like the balance of a token, the ownership of an asset, or any other relevant information.

Functions : Functions are snippets of code that can be executed to interact with or modify the state of the contract. These can be public, private, or restricted to certain parties.

Permissions : Specifies who can interact with the contract and in what manner. This might involve multi-signature requirements, whitelisting, or other conditions for executing functions.

Data Storage : Some smart contracts may have a need to interact with external data storage for more complex operations. This could be off-chain databases or other decentralized storage solutions like IPFS.

Events : These are special constructs that allow external consumers (like web applications) to listen for things that happen within a contract. Events are often used for logging and can serve as triggers for other actions.

Dependencies : Many smart contracts interact with other smart contracts, creating a chain of dependencies. These could be libraries or other contracts that provide specific services like price feeds, random numbers, etc.

2.3.4 How a smart contract is signed ?

Smart contracts are typically signed using digital signatures, which are based on public-key cryptography algorithms. Here's an overview of the process figure 4 [19]

1/ Public-key Cryptography : This is a cryptographic technique that allows for the generation of two distinct keys – a public key (which can be shared openly) and a private key (which must be kept confidential).

2/Signing the Smart Contract : Using the private key, the contract initiator signs the smart contract. This signature serves as a unique identifier that the contract was indeed created or approved by the holder of the private key.

3/Verifying the Signature : This is a crucial step that allows anyone to confirm the authenticity of the signed contract. By using the signer's public key, one can decrypt the signature and match it against the hash of the smart contract. If they align, it's an indication that the contract was genuinely signed by the private key holder and has not been tampered with since.

In the traditional sense, contracts involve at least two parties. If both parties are to sign the smart contract digitally, they would each repeat the process described above. Each party would use their private key to sign the contract, and anyone wishing to verify those signatures would use the respective public keys of the signing parties. This ensures that both parties have approved the terms and conditions stipulated in the smart contract.

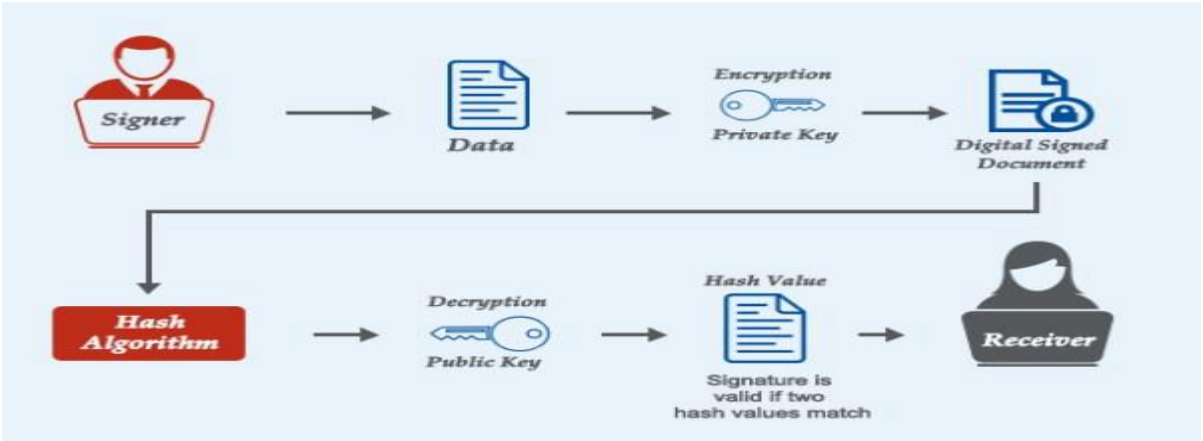


Figure 4 Process of signing smart contract [19]

2.3.5 differences between smart contracts and ordinary contracts :

Here's a table comparing some of the key differences between smart contracts and ordinary contracts [23] :

Aspect	Smart Contracts	Ordinary Contracts
Execution	Self-executing and automated	Requires manual enforcement by intermediaries
Transparency	Transparent and tamper-proof due to blockchain	Subject to disputes or ambiguity due to unclear terms or misunderstandings
Efficiency	Faster and more efficient, saving time and reducing costs	Slower and may require significant time and resources to enforce
Security	Highly secure due to decentralization and cryptography	More vulnerable to security breaches and fraud
Trust	Helps build trust between parties due to transparency and automation	Trust may be more difficult to establish, especially in new relationships
Flexibility	Programmable to execute a wide range of conditions and actions	Limited by legal system or terms of the agreement

Tableau 1 the key differences between smart contracts and ordinary contracts

2.3.6 Advanteges of smart contract [25] :

Smart contracts have several benefits, including :

Efficiency : Smart contracts automate the process of verifying and enforcing agreements, which can save time and reduce costs.

Transparency : Smart contracts are transparent and tamper-proof, which can increase trust between parties.

Security : Smart contracts are stored on a blockchain network, which makes them resistant to hacking and fraud.

Accuracy : Smart contracts are programmed to execute exactly as written, which can reduce errors and misunderstandings.

2.3.7 Desadventeges smart contract [26]

Ther are some desaventiges of smart contrect :

Legal Uncertainty : Smart contracts exist in a digital realm, often bypassing traditional legal frameworks, which may make their legal status questionable.

Lack of Flexibility : Smart contracts are rigid and unmodifiable once deployed, making them susceptible to hacks and difficult to correct or update.

2.4 Fields of The applications : [27]

Here are some fields and sectors where they are making an impact :

Finance and Banking :

Cryptocurrencies : The original and most famous application.

Decentralized Finance (DeFi) : Creating financial instruments, like loans or yield farms, in a decentralized manner.

Cross-border Payments : Making international transactions faster and cheaper.

Tokenization of Assets : Creating digital tokens for physical assets like real estate or art.

Healthcare :

Patient Records : Secure and immutable storage of patient health records.

Drug Traceability : Tracking the production and distribution of pharmaceuticals.

Research Data Sharing : Facilitating secure and transparent sharing of medical research data.

Real Estate

Property Records : Storing property records securely on a blockchain.

Tokenization of Property : Enabling people to buy and sell portions of properties.

Smart Contracts for Leases : Automating the rental process, including payments and even entry codes.

2.5 Conclusion ::

In this chapter, we've explored the intricate workings of blockchain and smart contracts. These technologies, with their unique structures and functionalities, offer a glimpse into their vast potential applications. As we advance in the digital realm, the importance of blockchain and smart contracts in ensuring a decentralized and trustworthy future becomes increasingly evident.

Chapter 03 :

Blockchain-based solutions for land management

3 Chapter 03 : Blockchain-based solutions for land management :

3.1 Introduction :

Before we list some applications using blockchain smart contract for land transfer ownership we present his interesting algorithm that describes a process for selling and splitting land in a blockchain based land registry system proposed by Krishnapriya S, Greeshma Sarath **:[28]**

3.2 Algorithm selling and splitting land :

Algorithm 1 Algorithm to sell and split land

```
1: function SendLandAlgorithm(senderPrvtKey, landid, cents, receiverPubKey, price)
2:     inputs = get all transaction pointing to the old land from the blockchain
3:     Find the specific land from the blockchain
4:     oldLand = getLand(landid,chain)
5:     create new Transaction t( PrvtKeySender, PubKeyreceiver,newland, oldland, inputs)
6:     sign the Transaction using the eliptic curve Algorithm for ed25519
         st = EdDSA(t,SenderPvtKey)
7:     check to see if the transaction was signed by the owner of the land itself.
8:     distribute the signed land for verification to the entire network
9:     if (st==signed by owner of land) then
10:        assert(verifyTranction(t.signature, land.owners)
11:    else
12:        return False
13:    end if
14:    if (user have land to sell) then
15:        newland=split(oldland,cents)
16:        compute hash for new land
17:        add land to blockchain by poW(newLand,3)
18:    end if
19: end function
```

Algorithm selling and splitting land[28]

A/ Explanation of the Algorithm :

Step 1 : Define Function and Parameters :
The function SendLandAlgorithm is defined with the following parameters :
senderPrvtKey : Private key of the landowner (sender)
landid : ID of the land to be sold
cents : Amount of land to be sold (presumably a portion of the whole)
receiverPubKey : Public key of the buyer (receiver)
price : Selling price of the land
Step 2 : Get Previous Transactions
inputs = get all transaction pointing to the old land from the blockchain : Fetches all transactions associated with the old land. This is to gather all historical data about the land.
Step 3 : Find Specific Land
Find the specific land from the blockchain : Look up the specific land parcel identified by landid.
Step 4 : Retrieve Land Details
oldLand = getLand(landid,chain) : Retrieves the details of the specific land parcel from the blockchain.
Step 5 : Create New Transaction
create new Transaction t(PrvtKeySender, PubKeyreceiver,newland, oldland, inputs) : Creates a new transaction t, capturing details of the sale.
Step 6 : Sign Transaction

st = EdDSA(t,SenderPvtKey) : Signs the new transaction using the elliptic curve algorithm (EdDSA) for the ed25519 curve with the private key of the sender.

Step 7 : Verify Ownership

check to see if the transaction was signed by the owner of the land itself : Verifies if the transaction was signed using the private key of the current landowner.

Step 8 : Distribute Transaction

distribute the signed land for verification to the entire network : Distributes the signed transaction to the network for consensus and verification.

Step 9-13 : Conditional Check

Checks whether the transaction was actually signed by the owner. If not, returns False.

Step 14-18 : Conditional Split and Add

If the user has land to sell, then the land is split according to cents.
Computes a hash for the new land.
Adds the new land details to the blockchain, using a Proof of Work (PoW) algorithm.

Step 19 : End Function

The function ends after executing the algorithm.

B/ Smart contract in this algorithm :

In the algorithm described, the term « smart contract » is not explicitly mentioned. However, if this algorithm were to be implemented within the context of a blockchain network that supports smart contracts, like Ethereum, the logic described could be encapsulated within a smart contract. Here's how that could be mapped :

Smart Contract Functions : The SendLandAlgorithm could be a function within the smart contract that is called when someone wants to sell and split land.

State Variables : oldLand, newland, and other variables that maintain the state of land parcels could be state variables in the smart contract.

Ownership Verification : Steps 6 and 7 that involve signing and verifying transactions could be handled within the smart contract using built-in functions for message signing and verification, effectively ensuring that only the owner of the land can initiate a sale.

Event Emitters : Distributing the transaction for verification across the network (Step 8) could be achieved using event emitters that announce when a new transaction has been added or land has been sold or split.

Public and Private Keys : These keys would be used for signing and verifying transactions within the smart contract, making sure the owner is the one initiating the sell.

3.3 Applications of land management using blockchain smart contract :

These are some examples of applications that uses blockchain smart contract :

3.3.1 Propy :[29]

Propy is a global property store and decentralised title registry that uses blockchain technology to provide secure and tamper-proof land records. Propy uses smart contracts to automate the transfer of property ownership and to ensure that all transactions are transparent and verifiable.

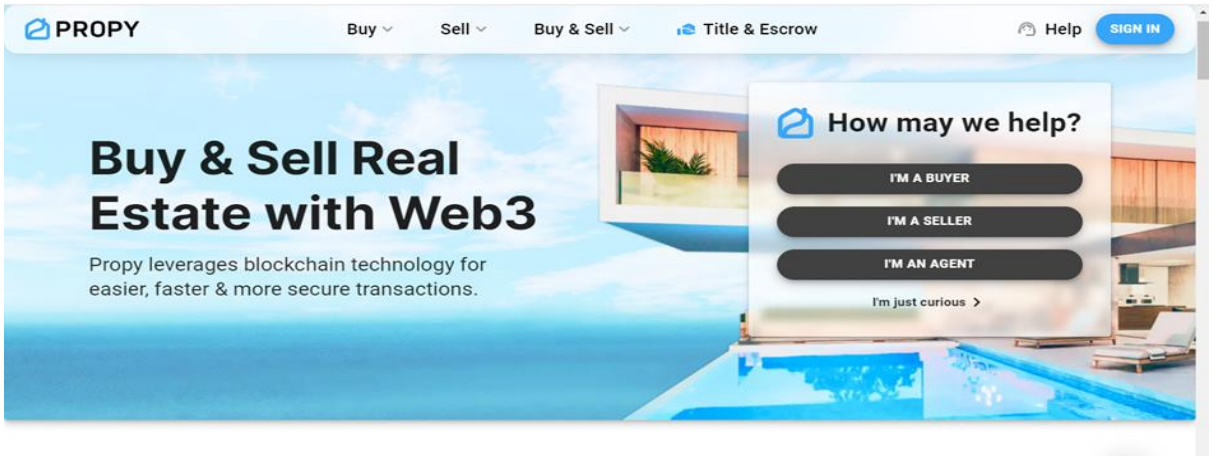


Figure 5 Propy interface

Steps of buying property on Propy :

1/Property Selection : Buyers find and select their desired property on Propy, which aggregates listings much like Zillow or Redfin. They choose an agent and make an offer.

2/Agreement Generation : Propy creates a digital Purchase and Sale Agreement. Ownership is verified, and all parties sign electronically. The signed agreement is encrypted and stored on the blockchain.
3/Document Upload : Title agents upload various documents, such as title reports and disclosure documents, for electronic signatures. They also provide escrow bank accounts to secure the transaction.
4/Payment : Buyers can pay using both fiat and cryptocurrency. Payments are automatically tracked via smart contracts on the blockchain.
5/Deed Transfer : The buyer receives the official deed, which is also recorded on the blockchain as an additional layer of secure ownership.

Advantages :

Custom smart contracts allow for flexibility and customization

Uses the Ethereum blockchain, which is widely adopted and has robust developer community

Supports international transactions

Disadvantages :

Limited support for other cryptocurrencies beyond ETH

Limited support for a small number of countries

3.3.2 RealX[30]

22ser sca a real estate platform that uses blockchain technology to enable fractional ownership of properties. The platform uses smart contracts to manage property ownership and transfers, and offers a transparent and secure way to invest in real estate.

RealX uses a private blockchain to manage fractional property investments ans also provides a secure ,transparent record-keeping.

RealX's platform utilizes smart contracts to automate investment transactions and provide investors with a legally compliant investment process.

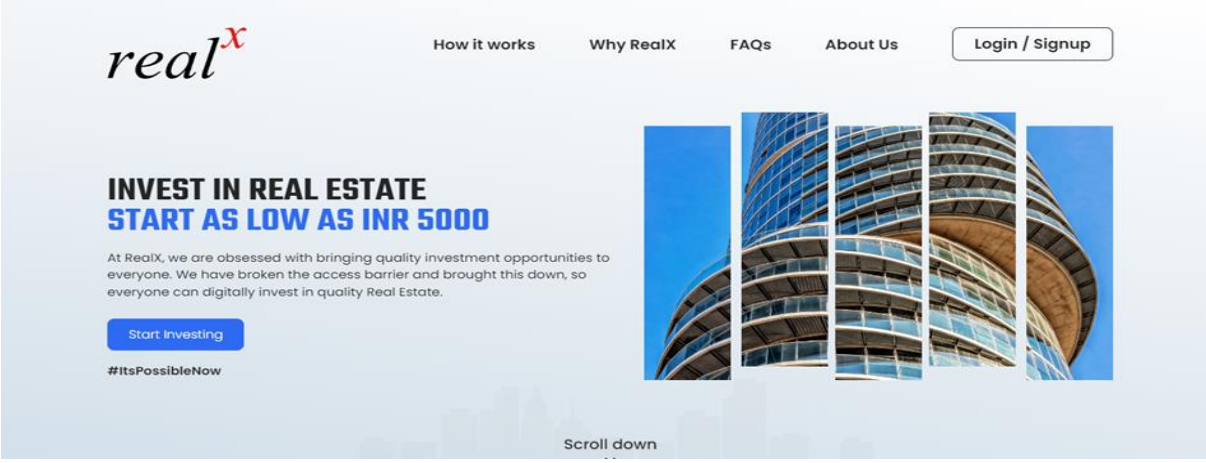


Figure 6 realx intereface

How it works :

The following steps explain how RealX works :

Choose property :

23ser scan browse through the range of properties listed on realx post login .And decide to invest in the property of their choice .

Chose investment mode and amount :

The user scan choose their investment mode and investment amount

Make a payment :

Complete payment for subscription .

Due diligence and registry :

Legal due diligence by 3 rd party law firms and property register by the custodian .

Minting of FRAX tokens :

Post registry co-ownership records are created and FRAX tokens are minted . Co-ownership is reflected in customer account and tokens in respective customer wallets .

Advantages :

Uses a private blockchain network, which allows for greater privacy and security

Can tokenize real estate assets to enable fractional ownership and investment

Offers a curated list of investment opportunities with transparent pricing

Has an investor dashboard for easy management of investments

Disadvantages :

Limited adoption and liquidity compared to some other platforms

Limited support for cryptocurrencies beyond Bitcoin

3.3.3 ChromaWay [31]

ChromaWay is a blockchain company that specialises in providing decentralised solutions for various sectors, including real estate, finance, and government operations. Their technology generally uses smart contracts to facilitate processes that are normally complex, cumbersome, and require the involvement of various parties. Below how ChromaWay uses smart contracts and blockchain technology in real Estate

Property Records : ChromaWay aims to provide a secure and immutable way to store property records on its blockchain. This would provide an immutable history of property transactions, making title searches quicker and reducing the risk of fraud.

Tokenization of Property : The company aims to allow for properties to be represented as tokens on the blockchain. This could make property transactions, such as buying, selling, and transferring ownership, much more efficient.

Automated Contracts : Smart contracts can automate much of the documentation and agreement process in real estate transactions, which reduces administrative burden, costs, and errors.

ChromaWay are pioneers in blockchain technology and have several times been ranked as one of the world's leading companies in the field. The company has its main office in Stockholm and employees around the world.[32]

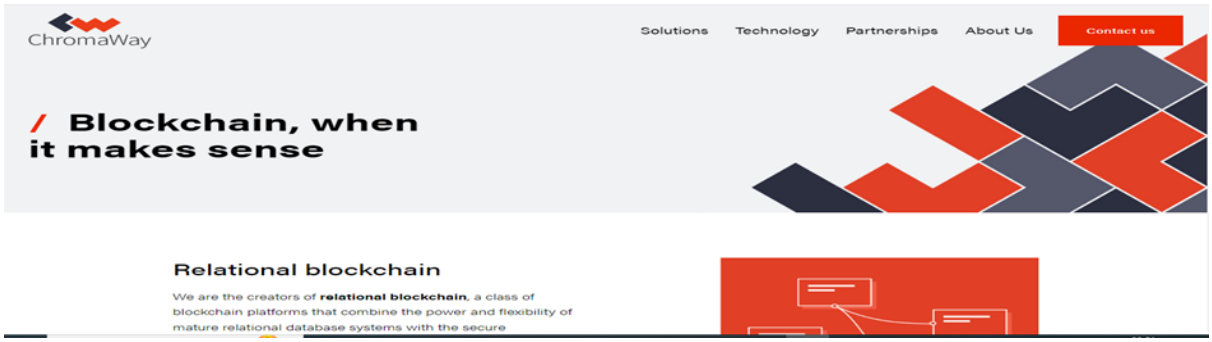


Figure 7 ChromaWay interface

Advantages

Uses the Postchain technology, which provides scalability, high throughput, and interoperability with other blockchains

Offers a smart contract editor and deployment tools, making it easy to create custom smart contracts

Disadvantages :

Limited support for tokens other than CHT

Here is a table resume some technical characteristics :

Characteristic	ChromaWay	RealX	Propy
Blockchain	Postchain	Ethereum	Ethereum
Geographic Coverage	Global	Specific regions or countries with an emphasis on U.S	in Europe and Asia
User Interface	Web-based interfaces and mobile applications	Web platform with mobile accessibility	Web platform with mobile application
Function	A blockchain platform tailored for decentralized applications, emphasizing real estate and finance. It integrates with existing databases and employs SQL-based smart contracts, facilitating adaptation for industries familiar with SQL.	A platform for tokenizing real estate properties, allowing fractional ownership and democratizing real estate investment. It promotes trade of tokenized properties, enhancing liquidity in traditionally stagnant markets.	Designed to simplify real estate transactions using blockchain. Propy aims to minimize middlemen, ensuring transparent, efficient, and secure property trades. It leverages blockchain's immutability and security for a more reliable real estate process.

Tableau 2 Some technical characteristics

3.4 Conclusion :

Throughout this chapter, we have delved deeply into various applications and comprehensive studies, all aimed at elucidating the intricate steps involved in real estate ownership technologies. These insights have not only provided us with a clearer understanding but also laid the groundwork for the development of smart contracts tailored specifically to the nuances of Algerian Law. As we've seen, adapting this global technology to local legal frameworks is both a challenge and an opportunity.

Having established this foundation, the upcoming chapter will be dedicated to the creation and intricacies of smart contracts.

Chapter 04
creation of sales smart contract

4 Chapter 04 : Creation of sales Smart Contract :

4.1 Introduction :

In this chapter we suggest a model for a regular sales contract that leads to get a land register by using a smart contract according to the Algerian law . in the first part we describe the actors involved in smart contract and their roles , also we used some uml diagrams to model the smart contract . In the second part we introduce the tools used to build the smart contract and show how to create,test and deploy it in the testnet in our case we chose sepolia testnet network [33] .

4.2 Descriptions of the actors and their roles :

There are multiple actors involved, each having different permissions and capabilities :

1/ Real Estate Conservator

Role : This is the most powerful actor in the system. Typically, this would be a governmental or semi-governmental body responsible for regulating real estate transactions. The Conservator has the power to add agents, and is the only one who can transfer the ownership of land after a request is approved.

Functions Accessible :

addAgent() : Can add new agents to the system.

transferLandOwnership() : Can transfer the ownership of land from the seller to the buyer after a buy request has been approved.

2. Agents :

Role : Agents are trusted entities allowed to register new lands for sale. An agent might be an individual or an organization that has been authorized by the Conservator.

Functions Accessible :

registerLand() : Can register new lands into the system by providing details like landId, seller's address, location, area, and price.

3. Sellers

Role : Sellers are the current owners of the lands registered in the system. They have the ability to set the sale status of their land.

Functions Accessible :

LandSaleStatus() : Can change the sale status of their land (whether it is for sale or not).

4. Buyers :

Role : Buyers are those who are interested in purchasing the lands available for sale. Any Ethereum address 26ser sc as a buyer.

Functions Accessible :

requestToBuyLand() : Can request to buy land that is available for sale. This request must be approved by the Seller.

Note : The permissions and roles are enforced using Solidity modifiers :

4.3 Diagrams :

Use case diagrams and activity diagrams are both important tools in systems engineering and business analysis. While they serve different purposes, they complement each other in providing a holistic view of a system or a process .

A/ use case diagram :

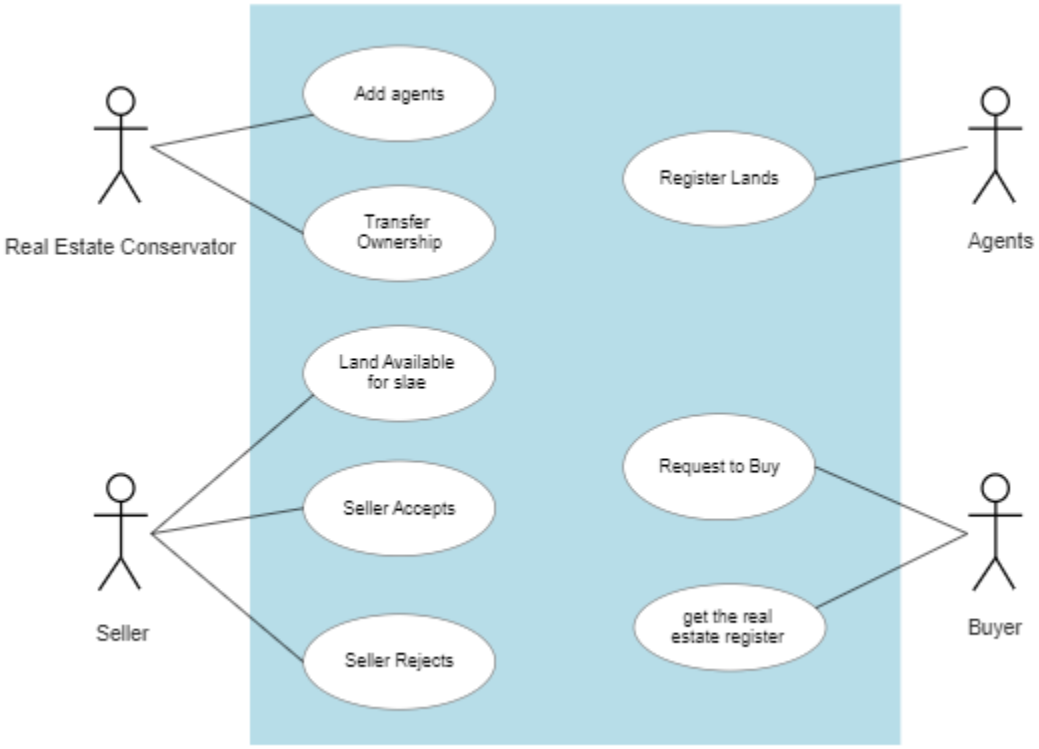


Figure 8 use case diagram

B / Activity diagram :

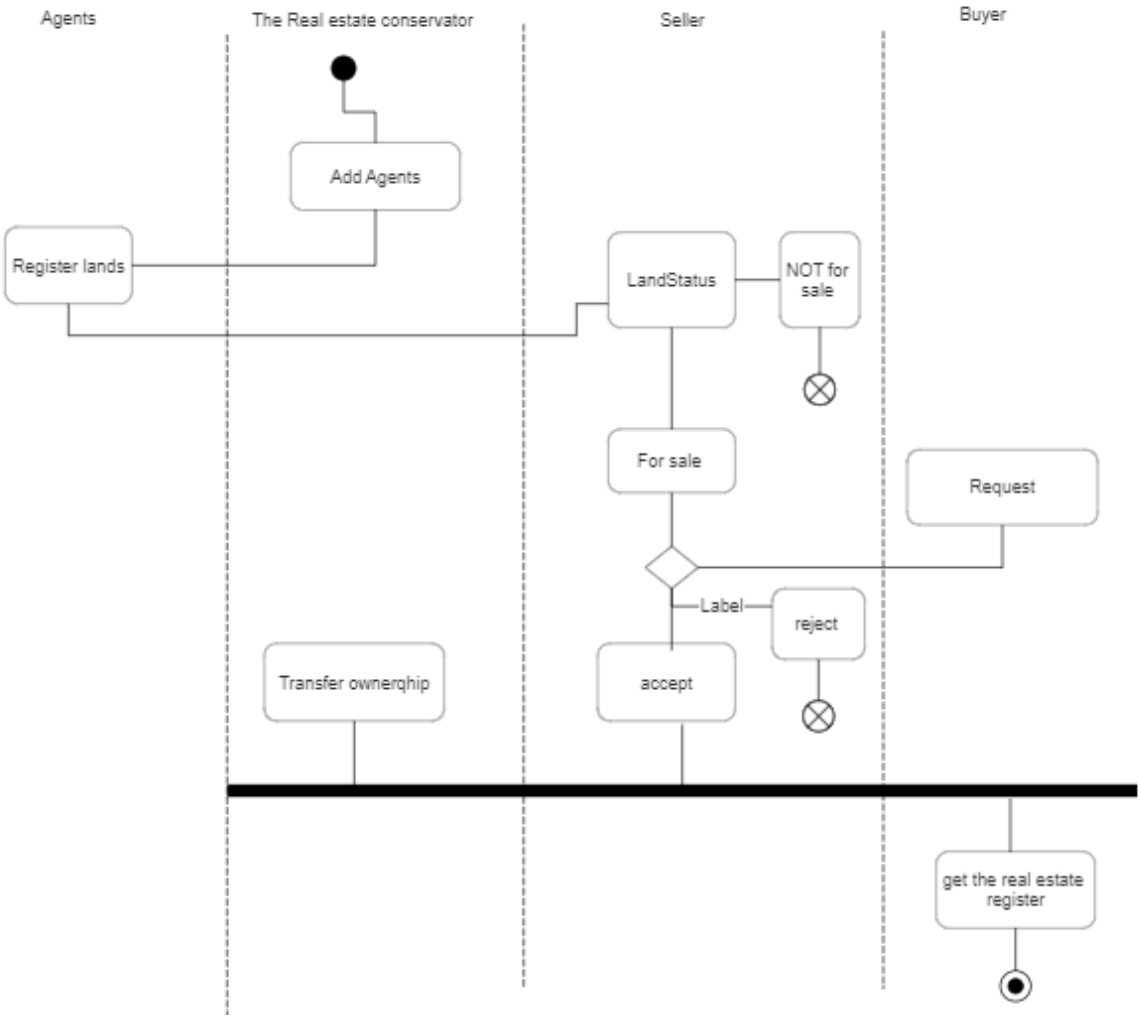


Figure 9 Activity diagram

C/ Interaction diagram :

the interaction diagram is to visually represent the interactions between different parties involved in the Real Estate Registry smart contract. By outlining each step and interaction in a visual manner

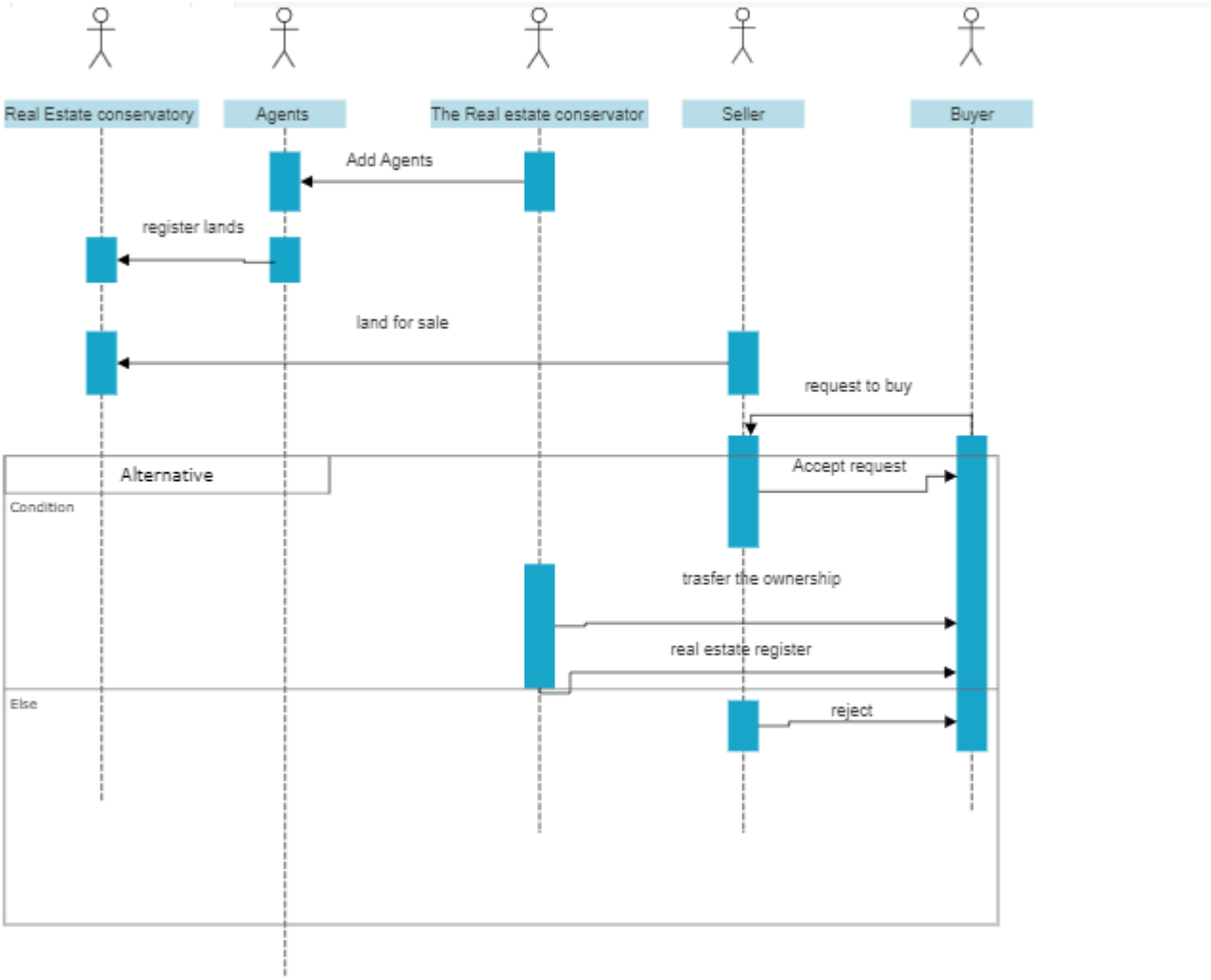


Figure 10 Interaction diagram

4.4 Tools used in smart contract :

A/Hardhat : [34]

Hardhat is a development environment for Ethereum software, which includes smart contracts. It provides a set of tools for smart contract development, debugging, testing, and deployment. Hardhat aims to make it easier for developers to create robust, well-tested smart contract projects. Here's a breakdown of some of its features :

Compile and Deploy : Hardhat can compile your Solidity code and deploy the compiled contracts to the Ethereum network.

Testing : It supports both JavaScript and Solidity for writing tests, making it easier for you to test your contracts thoroughly.

Local Development Environment : Hardhat comes with a built-in local Ethereum environment (often referred to as Hardhat Network) where you can deploy and test your smart contracts.

Debugging and Logging : Hardhat provides stack traces if your smart contract transactions fail, which is very useful for debugging.

Scripting : You can write scripts that interact with the Ethereum network. These scripts can be written in JavaScript, making it easier for developers who are already familiar with web development.

Plugin Support : Hardhat has a plugin system that allows you to extend its functionality. For example, you 30ser sc plugins for different types of wallets, decentralized application frameworks, or even integrations with decentralized exchanges.

Ethers.js and Web3.js : Hardhat can be easily integrated with Ethers.js and Web3.js, two of the most popular JavaScript libraries for interacting with the Ethereum blockchain.

B/ MetaMask : [36]

is a browser extension that serves as a crypto wallet and gateway to Ethereum-based decentralized applications (dApps). Available for various web browsers like Chrome, Firefox, and Brave, MetaMask allows users to interact with the Ethereum blockchain, including its smart contracts and tokens, without running a full Ethereum node. Here are some key features and functionalities of MetaMask :

Ethereum Wallet : MetaMask allows users to generate Ethereum addresses to send and receive Ether and ERC-20 tokens.

dApp Interaction : Through MetaMask, 30ser scan interact with decentralized applications (dApps) directly from their web browser.

Private Key Management : The private keys are stored locally on the user's device and are never sent to a central server. This is crucial for security.

HD Wallet : MetaMask is an HD (Hierarchical Deterministic) wallet, which means you can control multiple Ethereum accounts from a single seed phrase.

Transaction Approval : Before any transaction is processed, MetaMask will prompt the user for confirmation, detailing the transaction cost and the involved smart contract methods, if applicable.

Test Networks : It supports multiple Ethereum testnets like Ropsten, Rinkeby, and Goerli, in addition to the main Ethereum network. This is useful for developers and testers.

Swap and Trade : MetaMask includes a swapping feature that allows users to exchange tokens directly within the wallet interface, fetching rates from multiple decentralized exchanges.

C/ Solidity :[35]

Solidity is a high-level, statically-typed programming language designed for writing smart contracts on the Ethereum blockchain platform. Created in 2014 by Christian Reitwiessner and several other contributors, Solidity was designed to enable developers to write applications that execute on a blockchain, specifically Ethereum's EVM (Ethereum Virtual Machine).

Ethereum-Specific : Solidity is tailored for Ethereum smart contracts. It allows developers to define complex structures and manipulate the state of the blockchain.

Statically Typed : Variables must be declared with their types, which enables better type checking and more optimized bytecode at compile time.

Inheritance : Solidity supports multiple inheritance, enabling more robust and modular contract designs.

Event Logging : Smart contracts can log events that external 31ser scan31can listen for, which is a crucial feature for dApps (decentralized applications).

Modifiers : These are function decorators that can be used to change the behavior of functions, often used for access control.

Library Support : You can link smart contracts to libraries, allowing for code reuse and more efficient gas usage.

Integrated Development Tools : Various IDEs and tools, like Remix and Hardhat, offer robust support for Solidity, including syntax highlighting, debugging, and more.

Wide Adoption : Solidity is the most widely-used smart contract language as of now, supported by a large and active community.

4.5 steps of creating the smart contract :

we used hardhat envirement :

Basic Information

SPDX-License-Identifier : This indicates that the contract uses the MIT License.

Solidity Version : The contract is written using Solidity version 0.8.0 or higher.

Global Variables :

realEstateConservator : Address of the authority responsible for overseeing land transactions. Initially, it's the address that deploys the contract.
Agents, sellers, landForSale, landDetails, etc. : Various mappings used to keep track of different entities and land-related data.

Modifiers :

onlyRealEstateConservator : Ensures that only the realEstateConservator can execute certain functions.
onlyAgent : Ensures that only registered agents can execute certain functions.
onlyLandSeller : Ensures that only the actual land seller can execute certain functions.

Functions :

addAgent : Allows the conservator to add new agents.

registerLand : Allows agents to register new lands along with their details.

LandSaleStatus : Allows the land seller to change the sale status of their land.

requestToBuyLand : Any address can request to buy a land.

handleLandRequest : Allows the land seller to handle a buy request (accept/reject).

transferLandOwnership : Allows the conservator to officially transfer ownership after a successful sale.

getTheRealEstateRegister : A view function that returns details about a particular land, its sale status, and recent ownership transfer timestamps.

Events :

Events in Ethereum smart contracts are a way for your contract to communicate that something important has happened on the blockchain. Clients or server-side services can « listen » for these events and take action when they occur. Events are inheritable members of contracts and can be called in the contract and its derived contracts. Here's a breakdown of each event in the contract :

1/ AgentRegistered :

event AgentRegistered(address indexed agent) ;

When it's emitted : This event is emitted in the addAgent function.

Purpose : To notify that a new agent has been registered in the system.

2. LandRegistered :

event LandRegistered(uint256 indexed landId, address indexed seller) ;

When it's emitted : This event is emitted in the registerLand function.

Purpose : To signal that a new land has been registered.

3. LandSaleStatusChanged :

event LandSaleStatusChanged(uint256 indexed landId, bool isForSale) ;

4.LandRequested :

event LandRequested(uint256 indexed landId, address indexed buyer) ;

When it's emitted : This event is emitted in the requestToBuyLand function.

Purpose : To notify that a buyer has requested to buy a piece of land.

5.LandRequestHandled :

event LandRequestHandled(uint256 indexed landId, bool isAccepted) ;

When it's emitted : This event is emitted in the handleLandRequest function.

Purpose : To indicate that a buy request for a land has been handled (either accepted or rejected).

6. LandTransferred :

event LandTransferred(uint256 indexed landId, address indexed newOwner) ;

When it's emitted : This event is emitted in the transferLandOwnership function.

Purpose : To indicate that the ownership of a land has been transferred.

4.6 Compile smart contract :

Compiling smart contracts is an important step in the Ethereum development process. When you write Ethereum smart contracts, they are written in high-level programming languages like Solidity.

During the compilation process, the Solidity compiler checks for syntax errors and performs semantic analysis to catch potential issues in your code. This helps identify errors before deploying your contracts on a live network.

To compile smart contract we run this comand : yarn hardhat compile

```
sifo@DESKTOP-1N353HT:~/hat/smart contract$ yarn hardhat compile
yarn run v1.22.15
$ '/home/sifo/hat/smart contract/node_modules/.bin/hardhat' compile
Compiled 1 Solidity file successfully
Done in 2.25s.
```

4.7 Test smart contract :

Well-written tests can serve as documentation. Developers new to the code can look at the tests to understand what the code is supposed to do ,also for public and open-source projects, a comprehensive suite of tests can also serve to increase confidence in your project. If 33ser scan see that your contract has been rigorously tested, they may be more likely to trust it.

An important reason of why we write a test is Immutability once a smart contract is deployed to the blockchain, it can't be changed. Bugs, vulnerabilities, or incorrect logic in the contract are permanent once deployed, which could lead to loss of funds or other serious consequences. Testing helps catch these issues before deployment.

Test Cases

There are several test cases :

Should allow an agent to register land : This test ensures that an agent can successfully register a new piece of land.

Should not allow a non-agent to register land : This test makes sure that someone who is not an agent cannot register land.

Should allow a buyer to request to buy land : Verifies that a buyer can request to buy a land.

Should allow the land seller to handle the request : Ensures that the seller can handle a land purchase request.

Should not allow a non-seller to handle the request : Verifies that only the seller can handle a land purchase request.

Should allow the real estate conservator to transfer land ownership : Confirms that a conservator can transfer the land ownership.

Should not allow a non-conservator to transfer land ownership : Ensures that only a conservator can transfer land ownership.

Should return The Real Estate Register information : Tests that the smart contract can return all relevant details of a land after ownership has been transferred.

Figures 11.a,b,c,d shows the test code :

```
const { expect } = require("chai");
const { ethers } = require("hardhat");

describe("LandRegistry", function () {
  let LandRegistry, landRegistry, owner, agent, seller, buyer, malicious;
  let landId = 1;

  beforeEach(async () => {
    LandRegistry = await ethers.getContractFactory("LandRegistry");
    landRegistry = await LandRegistry.deploy();
    await landRegistry.deployed();
    [owner, agent, seller, buyer, malicious] = await ethers.getSigners();
    await landRegistry.addAgent(agent.address);
    await landRegistry
      .connect(agent)
      .registerLand(landId, seller.address, "Location1", 100, 2000);
  });

  // Agent tests
  it("Should allow an agent to register land", async function () {
    const newLandId = 2;
    await landRegistry
      .connect(agent)
      .registerLand(newLandId, seller.address, "Location2", 200, 3000);
    const { location, area, price } = await landRegistry.landDetails(newLandId);
    expect(location).to.equal("Location2");
    expect(area).to.equal(200);
    expect(price).to.equal(3000);
  });
```

Figure 11.a test code

```
it("Should not allow a non-agent to register land", async function () {
  const newLandId = 3;
  await expect(
    landRegistry
      .connect(malicious)
      .registerLand(newLandId, seller.address, "Location3", 200, 3000)
  ).to.be.revertedWith("Only agents can call this function");
});

// Buyer tests
it("Should allow a buyer to request to buy land", async function () {
  await landRegistry.connect(buyer).requestToBuyLand(landId);
  const request = await landRegistry.landRequests(landId);
  expect(request.whoRequested).to.equal(buyer.address);
});

// Seller tests
it("Should allow the land seller to handle the request", async function () {
  await landRegistry.connect(buyer).requestToBuyLand(landId);
  await landRegistry.connect(seller).handleLandRequest(landId, true);
  expect(await landRegistry.landRequestStatus(landId)).to.equal(true);
});

it("Should not allow a non-seller to handle the request", async function () {
  await landRegistry.connect(buyer).requestToBuyLand(landId);
  await expect(
    landRegistry.connect(malicious).handleLandRequest(landId, true)
  ).to.be.revertedWith("Only the land seller can call this function");
});
```

Figure 11 .b test code

```
// Transfer ownership
it("Should allow the real estate conservator to transfer land ownership", async function () {
  await landRegistry.connect(buyer).requestToBuyLand(landId);
  await landRegistry.connect(seller).handleLandRequest(landId, true);
  await landRegistry.transferLandOwnership(landId);
  expect(await landRegistry.sellers(landId)).to.equal(buyer.address);
});

it("Should not allow a non-conservator to transfer land ownership", async function () {
  await landRegistry.connect(buyer).requestToBuyLand(landId);
  await landRegistry.connect(seller).handleLandRequest(landId, true);
  await expect(
    landRegistry.connect(malicious).transferLandOwnership(landId)
  ).to.be.revertedWith(
    "Only the real estate conservator can call this function"
  );
});
```

Figure 11.c test code

```
// Information  of The Real Estate Register
it(" should return The Real Estate Register information", async function () {
  await landRegistry.connect(buyer).requestToBuyLand(landId);
  await landRegistry.connect(seller).handleLandRequest(landId, true);
  await landRegistry.transferLandOwnership(landId);
  const [
    sellerAddress,
    buyerAddress,
    location,
    area,
    price,
    requestStatus,
    transferTimestamp,
  ] = await landRegistry.getTheRealEstateRegister(landId);

  expect(sellerAddress).to.equal(buyer.address);
  expect(buyerAddress).to.equal(ethers.constants.AddressZero);
  expect(location).to.equal("Location1");
  expect(area).to.equal(100);
  expect(price).to.equal(2000);
  expect(requestStatus).to.equal(false);
});
);
```

Figure 11.d test code

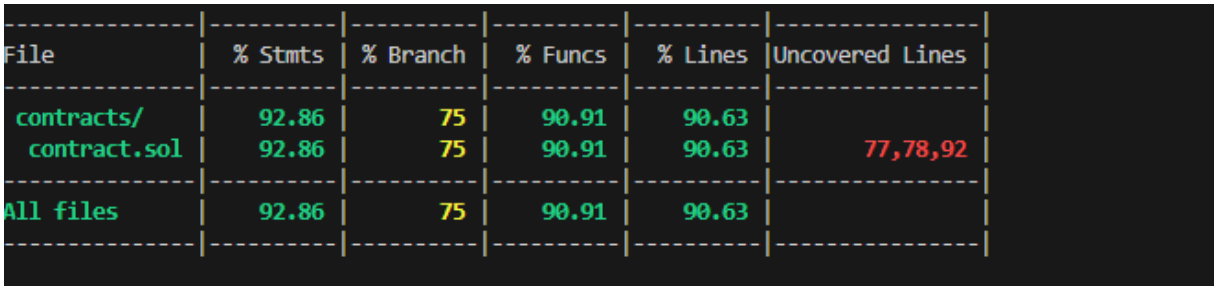
The results : by runing yarn hardhat test

```
sifo@DESKTOP-1N353HT:~/hat/smart contract$ yarn hardhat test
yarn run v1.22.15
$ '/home/sifo/hat/smart contract/node_modules/.bin/hardhat' test


  LandRegistry
    ✓ Should allow an agent to register land (95ms)
    ✓ Should not allow a non-agent to register land (75ms)
    ✓ Should allow a buyer to request to buy land (38ms)
    ✓ Should allow the land seller to handle the request (49ms)
    ✓ Should not allow a non-seller to handle the request
    ✓ Should allow the real estate conservator to transfer land ownership (65ms)
    ✓ Should not allow a non-conservator to transfer land ownership (55ms)
    ✓  should return The Real Estate Register information (71ms)


  8 passing (6s)

Done in 7.36s.
```

Figure 12 result of tests

4.8 code Coverage :

Code coverage is a metric used to measure the extent to which your codebase is being exercised by our tests. We run the comand : yarn hardhat coverage to see the result in figure 13



File	% Stmts	% Branch	% Funcs	% Lines	Uncovered Lines
contracts/	92.86	75	90.91	90.63	
contract.sol	92.86	75	90.91	90.63	77,78,92
All files	92.86	75	90.91	90.63	

Figure 13 result of Code coverage

Here's a breakdown of the information in the table :

File : This column lists the files within the « contracts » directory that are being analyzed for code coverage.

% Stmts : Percentage of statements covered by tests. This indicates the proportion of code statements that have been executed by the tests.

% Branch : Percentage of branches covered by tests. A branch is a decision point in the code (such as an if-else statement), and this metric shows the proportion of those branches that have been tested.

% Funcs : Percentage of functions covered by tests. This metric represents the proportion of functions that have been executed by tests.

% Lines : Percentage of lines covered by tests. This indicates the proportion of lines of code that have been executed by the tests.

Uncovered Lines : This column may list specific line numbers that have not been covered by tests. In your provided data, there are no line numbers listed, so it's assumed that all lines are covered.

Based on the provided data, our codebase's coverage is as follows :

Statements Coverage : 92.86%

Branches Coverage : 75%

Functions Coverage : 90.91%

Lines Coverage : 90.63%

4.9 Deploying the smart contract in a sepolia network :

Configure Network : configure it to use the sepolia network and the local hardhat network to deploy : figure 14 shows the configuration code

```
const SEPOLIA_RPC_URL = process.env.SEPOLIA_RPC_URL;
const PRIVATE_KEY = process.env.PRIVATE_KEY;
module.exports = {
  networks: {
    hardhat: {},
    sepolia: {
      url: SEPOLIA_RPC_URL,
      accounts: [PRIVATE_KEY],
      chainId: 11155111,
    },
  },
  solidity: "0.8.18",
};
```

Figure 14 The configuration code

Module Exports : The configuration settings are exported as a JavaScript object. This object has three main sections :

Networks : This section defines network configurations. In this case, it defines configurations for two networks : hardhat and sepolia.

The hardhat network is the default network provided by Hardhat for local testing and development. It does not require additional configuration options.

The sepolia network is a custom network we're using . It includes the following properties :

url : The URL for the RPC endpoint of the network. It's set to the value of the SEPOLIA_RPC_URL environment variable.

Accounts : An array containing the private key(s) of the accounts you want to use for transactions on this network. It's set to an array containing the PRIVATE_KEY environment variable.

chainId : The chain ID of the network. It's set to 11155111.

Solidity Compiler Version : The solidity key specifies the version of the Solidity compiler to use for compiling your smart contracts. In this case, it's set to « 0.8.18 ».

Then we write the deploying script see figure 15

```
const { ethers } = require("hardhat");

async function main() {
  // Deploying the LandRegistry contract
  const LandRegistry = await ethers.getContractFactory("LandRegistry");
  console.log("Deploying LandRegistry contract...");
  const landRegistry = await LandRegistry.deploy();
  await landRegistry.deployed();
  console.log("LandRegistry contract deployed at:", landRegistry.address);
}

main()
  .then(() => process.exit(0))
  .catch((error) => {
    console.error(error);
    process.exit(1);
  });
```

Figure 15 deploying script

Result : by runing the comand yarn hardhat run scripts/deploy.js –network sepolia

```
sifo@DESKTOP-1N353HT:~/hat/smart contract$ yarn hardhat run scripts/deploy.js --network sepolia
yarn run v1.22.15
$ '/home/sifo/hat/smart contract/node_modules/.bin/hardhat' run scripts/deploy.js --network sepolia
Compiled 1 Solidity file successfully
Deploying LandRegistry contract...
LandRegistry contract deployed at: 0x0Ff090CfEe0a865091d8C67b3DC422d5e47C7Fdc
Done in 11.69s.
```

after we deploy it we go to https ://sepolia.etherscan.io/ copy past the address of the smart contract to confirme that the smart contract is deployed in sepolia testnet see figure 16 et 17

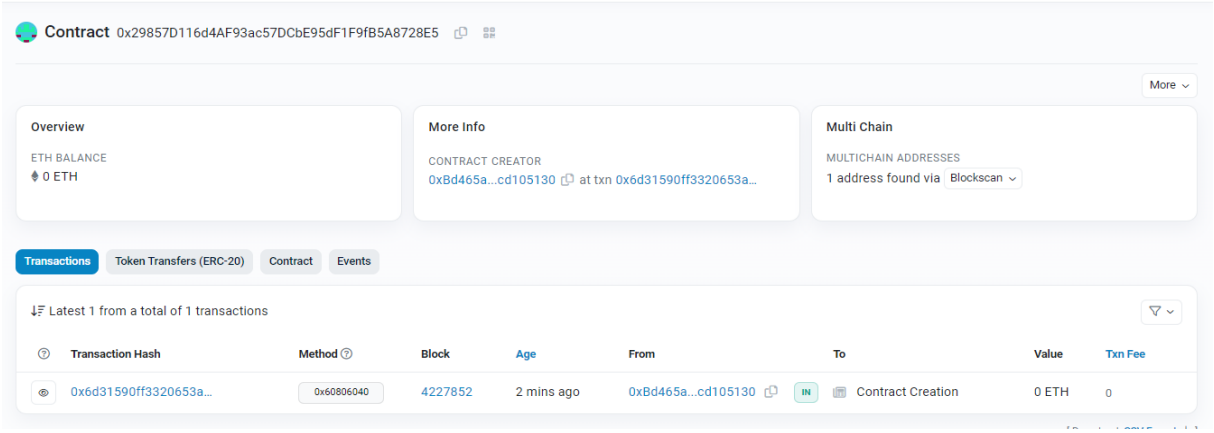


Figure 16 smart contract deployed in sepolia testnet

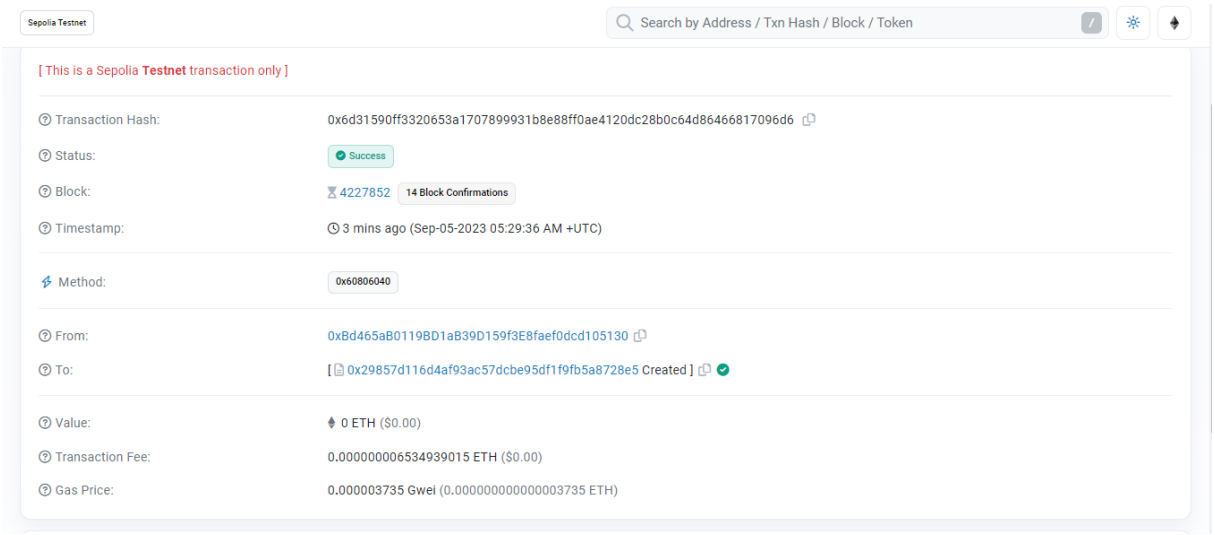


Figure 17 Transfer details of smart contract deployed in sepolia testnet

4.10 Conclusion :

In this chapter, we thoroughly explored sales smart contract technologies, from their foundational principles to the complexities of deployment and testing. Our smart contract code has also a good test coverage, with high coverage for statements and functions .

Conclusion and perspectives

Conclusion :

The primary objective of this study was to explore the possibility of integrating smart contracts into regular sales contracts, with a special focus on the Algerian laws. Smart contract technology brings efficiency, security, and transparency in legal transactions, particularly in land management and ownership transfer.

We successfully laid out the foundational principles of Algerian property law, blockchain technology, and smart contracts.

Some of the key challenges discussed include the difficulties of educating and convincing the individuals of using the smart contracts , the big number of laws and their modifications form time to time

Looking forward, that smart contract technology continues to evolve, so will its applicability in legal frameworks.

Perspectives :

*Implementing a blockchain where land records are registered and smart contracts will be used.

*Extend the applications to generate automatically the necessary the real estate register .

*Creation of a website for the real estate conservatory to allow remote access for all the actors.

.

References :

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[2] Article 683 from Algerian civil law

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[5] Article 37 of Order Nb.30-90 dated 1990/12/1

[6] Article 33 of Order Nb.32-73 dated 1973/1/5

[7] Article 1 of Order Nb.234-89 dated 1973/1/5

[8] Article 13 of Order Nb234-89 dated 1973/1/5

[9] Article 05 of Order Nb.234-89 dated 1973/1/5

[10] Article 07 of Order Nb 62-76-dated 1976/3/25

[11] Article 05 of Order Nb.62-76 dated 1976/3/25

[12] Article 05 of Order Nb. 62-76-dated 1976/3/25

[13] Directive No. 16 dated May 24, 1998, concerning the procedures of land surveying and real estate registration .

[14] Article 314 from civil law

[15] Article 03 Decree Nb 76/63

[16] Article 351 from civil law

[17] Article 324 from civil law

[18] Article 09 Decree Nb 76/63

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[34] https ://hardhat.org/hardhat-runner/docs/getting-started#overview last visited 20/09/2023

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Annexes

Articls in Arabic :

« .حق التمتع والتصرف في ألشياء بشرط أن ال يستعمله استعماال تحرمه القوانين واألنظمة » [1]

"كل شيء مستقر بحيزه وثابت فيه وال يمكن نقله من دون تلف فهـــو عقار، وكل ماعدا ذلك من شيء فهو منقول" [2]

.« إن مسح ألاراضي العام يحدد ويعرف النطاق الطبيعي للعقارات ويكون أساس مادي للسجل العقاري » [3]

[4]

المادة6: ان مخطط مسح الاراضي المقسم الى أقسام و الى أماكن معينة، يعطي التمثيل البياني لإقليم البلدية في جميع التفاصيل الخاصة بتقسيمها .الى قطع

المادة 37 "تلحق بلاملاك الوطنية العمومية الغابات والثروات الغابية التي تملكها الدولة حسب التشريع المتضمن النضام العام للغابات " [5]

قانون30-90 المؤرخ في 1990/12/1

" إن الدفاتر العقارية الموضوعة على أساس مجموعة البطاقات العقارية البلدية ومسح ألاراضي المحدث ستشكل حسب الكيفيات التي [6] ستحدد في نصوص الحقة المنطلق الجديد والوحيد إلقامة البينة في شأن الملكية العقارية"

مرسوم تنفيذي رقم 89-234 مؤرخ في ديسمبر سنة 1989 [9]+[8] +[7]

المادة1 : تنشأ مؤسسة عمومية ذات طابع إداري تتمتع بالشخصية المدنية وبالإستقلال المالي تسمى الوكالة الوطنية لمسح الأراضي و . » تكتب باختصار (و.و.م.أ) و تدعى في صلب النص " الوكالة

المادة13 : يتكون مجلس الإدارة من :- ممثل لوزير الإقتصاد, رئيسا,- ممثل لوزير الدفاع الوطني,- ممثل لوزير الداخلية,- ممثل لوزير التجهيز,- ممثل لوزير الفلاحة,- ممثل لوزير النقل,- ممثل للمحافظ السامي للبحث العلمي,- ممثل المندوب للتخطيط.

المادة5 :تتولى الوكالة في مجال إعداد مسح الأراضي العام على الخصوص ما يأتي :

- تنفيذ أعمال التحقيق العقاري الخاصة برسم الحدود والطبوغرافيا بأساليب أرضية أو بالتصوير المسامي الضوئي, اللازمة لوضع مسح عام للاراضي,

- تحضر العقود والملفات المتعلقة بأشغال لجان مسح الأراضي ورسم الحدود المنصوص عليها في إطار التنظيم الذي يخضع له إجراء إعداد مسح الأراضي العام و تتولى الكتابة لها,

تقوم بتحرير مخططات المسح العام للاراضي و الوثائق الملحقة بهاو تضبطها باستمرار,

تطبق عمليات تطابق مسح الأراضي مع السجل العقاري الذي تمسكه إدارات الحفظ العقاري,

- تنظم الأرشفة و الإستشارة و نشر الوثائق المتعلقة بمسح الأراضي بوسائل الإعلام الآلي و تسهر على ضبطها بانتظام,

- تراقب الأشغال التي ينجزها الماسحون و مكاتب الدراسات الطبوغرافية التابعة للخواص, لحساب الإدارات العمومية.

[10]+[11]+[12]

مرسوم رقم 62-76 مؤرخ فى 24 ربيع الأول عام 1396 الموافق 25 مارس سنة 1976

المادة 7 : قبل التعديل تنشأ لجنة لمسح الاراضى من أجل وضع الحدود فى كل بلدية بمجرد افتتاح العمليات المساحية وتتشكل هذه اللجنة] كما يلى : - قاضى من المحكمة التى توجد بدائرة اختصاصها البلدية, رئيسا, ويعين هذا القاضى من قبل رئيس المجلس القضائى, - ثلاثة أعضاء من الاتحاد الوطنى - ,منسق اتحاد الفلاحين البلدى, نائبا للرئيس - ,رئيس المجلس الشعبى البلدى أو ممثله, نائبا للرئيس للفلاحين الجزائريين تعينهم هذه المنظمة ويمثلون كلا من القطاع الخاص والقطاع المسير ذاتيا والصندوق الوطنى للثورة الزراعية, - ممثل عن ادارة الضرائب - ,ممثل عن ادارة شؤون أملاك الدولة والشؤون العقارية - ,رئيس التعاونية الزراعية البلدية المتعددة الخدمات .تقنى مصلحة مسح الاراضى, كاتبا لهذه اللجنة ,المباشرة

المادة9 :ان مهمة اللجنة هى مايلى

التثبت عند الاقتضاء من اتفاق المعنيين حول حدود عقاراتهم, – 2 ,جمع كل الوثائق والبيانات من أجل تسهيل اعداد الوثائق المساحية - البت, بالاستناد الى جميع الوثائق العقارية ولاسيما السندات وشهادات – 3 ,وفى حالة عدم وجود اتفاق, التوفيق فيما بينهم اذا أمكن ذلك الملكية المسلمة على اثر عمليات المعاينة لحق الملكية المتممة فى نطاق الثورة الزراعية فى جميع المنازعات التى لم يمكن تسويتها بالتراضى

المادة8 :تجتمع اللجنة بناء على طلب مسؤول الولاية لمسح الاراضى وبناء على دعوة من رئيسها ويحرر محضر مفصل عن

المداولات. وتتخذ قراراتها بأغلبية الاصوات ويجب أن يكون على الاقل ثلثا أعضائها حاضرين وفى حالة تساوى الاصوات يرجح صوت الرئيس. وتنفذ قرارات اللجنة بموجب مقرر من الوالى

[14]

القانون المدني المادة 342 التي تنص على أن العقد الرسمي: "عقد يثبت فيه موظف أو ضابط عمومي أو شخص مكلف بخدمة عامة ما .تم لديه أو تلقاه من ذوي الشأن وذلك طبقا لألشكال القانونية وفي حدود سلطته واختصاصه

[16]

المادة 351 من القانون المدني "عقد يلتزم بمقتضاه البائع بان ينقل للمشتري ملكية شيئ او حق مالي اخرفي مقابل ثمن نقدي "

The real estate register :

WILAYA DE : ..... ولاية : .....

CONSERVATION FONCIÈRE المحافظة العقارية

DE : ..... بـ : .....

دفتر عقاري

LIVRET FONCIER

N° : ..... رقم : .....

COMMUNE : ..... بلدية :

LOCALITE : ..... المنطقة :

QUARTIER : ..... الحي :

LIEU DIT : ..... المكان المذكور :

RUE ET N° : ..... الشارع و الرقم :

SECTION : ..... قسم :

ILOT DE PROPRIETE N ° : ..... مجموعة ملكية رقم :

CONTENANCE CADASTRALE : ..... مساحة المسح :

LOT N° : ..... Éventuellement – إحتمالياً ..... رقم القطعة :

- 1 -

ملاحظات هامة

1 - لا يمكن للحقوق الرضائية و الإتفاقات المقامة من طرف مالك العقار أن تكون موضوع تشهار في البطاقية العقارية بدون تقديم هذا الدفتر .

ويمكن أن يتعلق الإشهار بدون تقديم هذا الدفتر في جميع الأحوال الأخرى و بالخصوص في حالة الحجز .

و عليه فلا يعتبر هذا الدفتر تاما إلا عند حلول تاريخ آخر شهادة التطابق يوقع عليها المحافظ في الإطار VI المخصص لذلك .

يمكن تسليم شهادة التطابق مجانا في أية فترة .

2- عندما يسحب الأطراف دفاترهم يتطلب منهم أن يحققوا صحة التأشيرات المدونة بها .

3- لايوجد أي حق ملكية أو حق عيني آخر متعلق بعقار تجاه الغير إلا إذا شهر قانونا في البطاقية العقارية .

يجب على الأطراف أن تمتنع عن كتابة أية تأشيرة أو بيان على هذا الدفتر أو تنزع المخالفة المتعلق به و إلا تعرضت للعقوبات المقررة بحكم القانون في ميدان التزوير .

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Dans tous les autres cas, notamment en matière de saisies, la publication peut être opérée sans présentation du dit livret.

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Un nouveau certificat de concordance peut être obtenu gratuitement à tout époque

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3 - Tout droit de propriété et tout autre droit réel relatif à un immeuble n'existent, à l'égard des tiers, que par le fait et du jour de sa publication au fichier immobilier.

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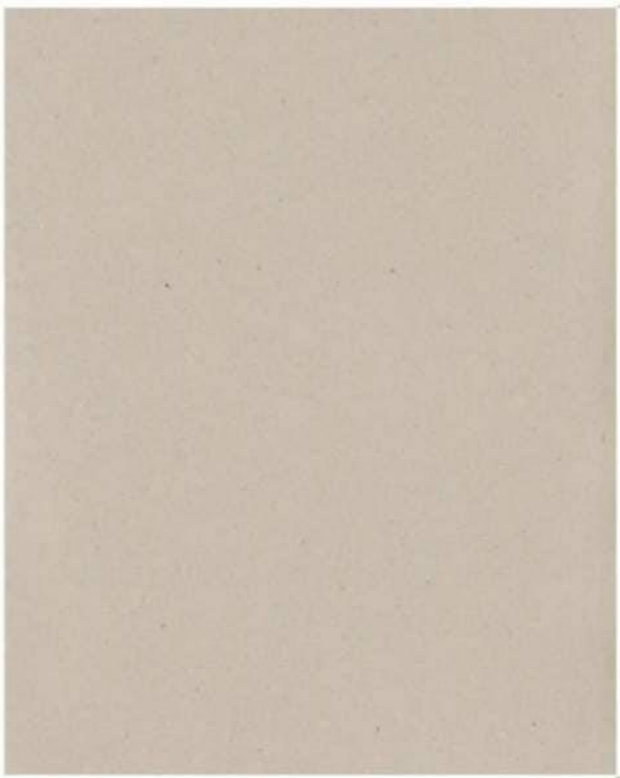

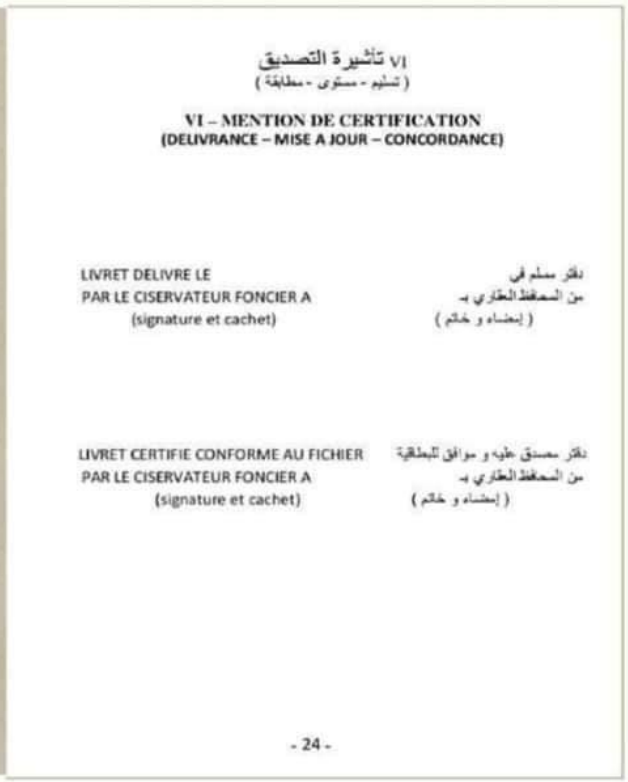

VI تأشيرة التصديق

(تسليم - مستوى - مطابقة)

VI – MENTION DE CERTIFICATION

(DELIVRANCE – MISE A JOUR – CONCORDANCE)

LIVRET DELIVRE LE دفتر مسلم في

PAR LE CISERVATEUR FONCIER A من المحافظ العقاري بـ

(signature et cachet) (إمضاء و خاتم)

LIVRET CERTIFIE CONFORME AU FICHIER دفتر مصدق عليه و موافق للبطاقية

PAR LE CISERVATEUR FONCIER A من المحافظ العقاري بـ

(signature et cachet) (إمضاء و خاتم)

- 24 -

.

Résumé

À l'ère numérique, les contrats de vente traditionnels, en particulier dans le domaine de la propriété foncière algérienne, sont confrontés à des défis d'adaptation et d'évolution. Cette recherche dévoile les subtilités de la preuve de propriété foncière selon le droit algérien, le rôle du contrat de vente conventionnel dans le transfert de propriété, et les cadres institutionnels garantissant la légitimité. Face à la demande croissante d'efficacité, de transparence et de sécurité, l'étude explore le potentiel des contrats intelligents comme alternative viable. La recherche aboutit à la conceptualisation d'une solution unique de contrat intelligent adaptée au système de propriété foncière algérien, combinant la sainteté juridique traditionnelle avec les avantages de pointe de la technologie blockchain.

Mots-clés (French): Propriété foncière, contrat de vente, blockchain, contrat intelligent,

Abstract

In the digital epoch, traditional sales contracts, especially in the realm of Algerian land ownership, face challenges of adaptation and evolution. This research unravels the intricacies of proving land ownership in Algerian law, the conventional sales contract's role in transferring ownership, and the institutional frameworks ensuring legitimacy. With the burgeoning demand for efficiency, transparency, and security, the study delves into smart contracts' potential as a viable alternative. The research culminates in conceptualizing a unique smart contract solution tailored to the Algerian land ownership system, combining traditional legal sanctity with the cutting-edge benefits of blockchain technology.

Keywords: *Land ownership, sales contract, blockchain, smart contract.*