Advancing Land Management in Bangladesh: A Comprehensive Blockchain-Based System for Efficient, Transparent, and Secure Land Management

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A Capstone project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering

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Declaration

We, **Md. Ashraful Islam, Sifat Ullah Sarkar, Ziaul Islam Rafi,** and **Abdullah Al Rafi** hereby, declare that the work presented in this capstone project report is the outcome of the investigation performed by us under the supervision of Dr. Mohammad Rifat Ahmmad Rashid, Assistant Professor, Department of Computer Science and Engineering, East West University. We also declare that no part of this project has been or is being submitted elsewhere for the award of any degree or diploma, except for publication.

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Letter of Acceptance

The capstone project report entitled "**Advancing Land Management in Bangladesh: A Comprehensive Blockchain-Based System for Efficient, Transparent, and Secure Land Management**" is submitted by **Md. Ashraful Islam, Sifat Ullah Sarkar, Ziaul Islam Rafi,** and **Abdullah Al Rafi** to the Department of Computer Science and Engineering, East West University, Dhaka, Bangladesh is accepted for the partial fulfillment of the requirement for the degree of Bachelor of Science in Computer Science and Engineering on (18/01/2024).

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Abstract

A system of land management must take land ownership into account. A rapidly developing technology, blockchain is used extensively in the land management industry. The three main issues of LAS characteristics, stakeholders, and blockchain technology assets are taken into account in this paper's proposal for a blockchain-based land administration system (LAS). The goal of the paper is to improve Bangladesh's land titling process by implementing a Blockchain-based solution. With the help of cutting-edge technologies like AI, machine learning, and IoT as well as taking into account smart contracts and DeFi solutions, the proposed research aims to enhance the land registration process. The system has been compared to paper-based systems and existing blockchain solutions to demonstrate how superior it is in terms of effectiveness and cost-effectiveness.

Acknowledgments

As it is true for everyone, We have also arrived at this point of achieving a goal in our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one’s mother language. Therefore, We would not like to make efforts to find best words to express my thankfulness other than simply listing those people who have contributed to this capstone project itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

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Chapter 1

Introduction

1.1 Background

The modern world is about leveraging technology to make things more efficient and structured. Bangladesh, a country with a large land area of around 148,460 square kilometers, is attempting to manage its 173 million inhabitants while increasing its economy (Worldometer, 2023). The value of land as a source of income and opportunity becomes obvious when cities grow causing farmlands to become more valuable for industrialization instead of farming. However, owning a plot of land in Bangladesh is cumbersome. Bangladesh's current land management administration consists of keeping records of each land plot along with the owner's details on paper. From 1500 BC till today the Land administration system of Bangladesh or the region has faced many changes. The Land administration was first aroused during the Muslim period known as the Delhi Sultanate. During the British Colonial period, the British administration implemented the existing method used in preserving records, which has some loopholes that causing issues nowadays [1]. The current process and steps for purchasing or selling a plot of land create uncertain complexity for people with little knowledge. One of the main problems is the land management system has loopholes that are being exploited by many land sharks who prey on gullible people. Block chain technology will ensure the land management system is paperless, hassle-free, and secure.

Figure 1: Traditional Land Management

1.2 Problem Statement and Analysis

People utilize physical documents to show ownership, such as Sales Deeds/ Bontonnama, Porchas/Khatiyan, and Mutations, however, these documents can be fabricated or changed. Corruption in government agencies and even the legal system exacerbates the problem, resulting in numerous unsolved disputes. The serious issue of land grabs and fake mutations is becoming more common. Individuals with links to high-ranking officials at land registration agencies, allowing them to alter land records to their benefit, frequently fuel this unpleasant situation.

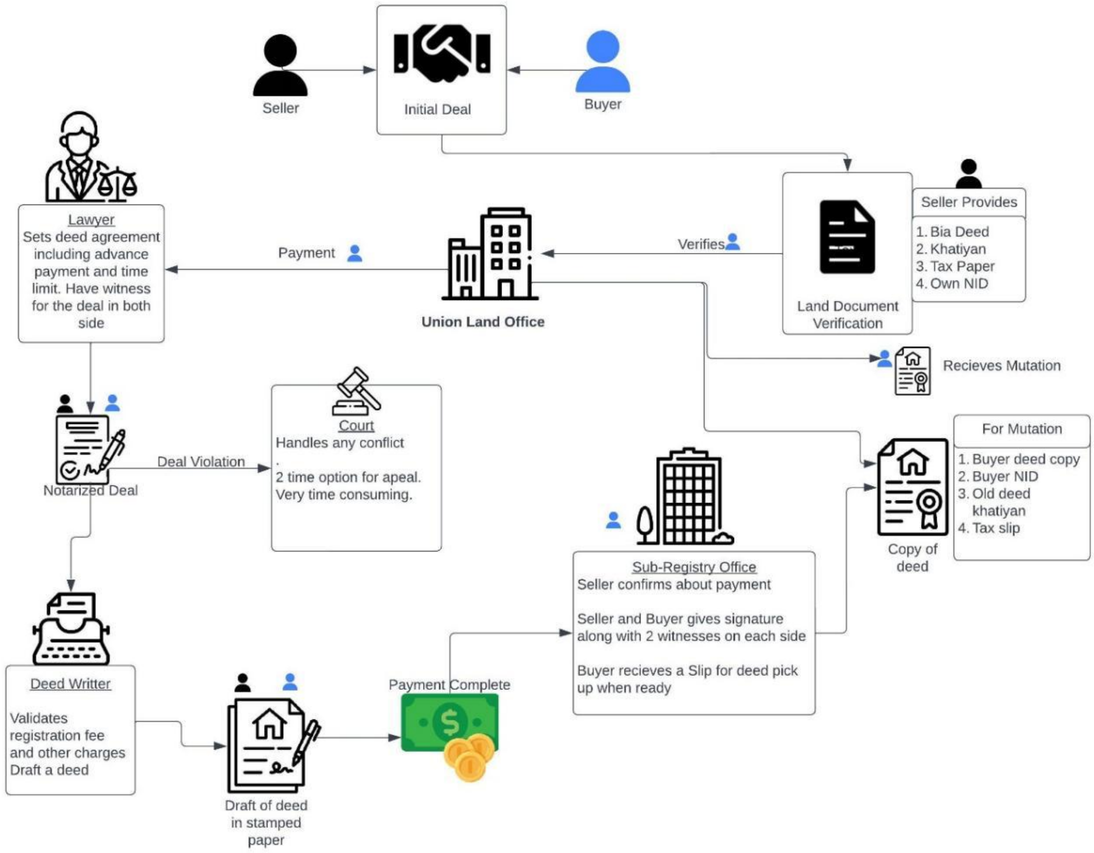

Figure 2: Traditional Land Management Breakdown

Unfortunately, such methods have grown all too widespread in recent years. Furthermore, defective mutation mechanisms compound the situation. Due to the National Property Revenue Board's ineffective management of mutations, dual ownership records have been created, creating the potential for property encroachment. In this chaotic atmosphere, the original landowners are frequently embroiled in land disputes, with little clarity regarding the underlying value of their land. The lack of transparency in land prices has spawned syndication among real estate sellers, further complicating matters. With no historical knowledge of a land's previous price, anyone can announce a selling price of their choice, greatly complicating land transactions. The way we manage land records is currently in disarray. Information is dispersed across several government offices, and people can cheat to modify papers. Attempting to solve this with a single central system will fail because people can still cheat.

1.3 Project Objectives

We have come up with a solution to these issues. We intend to use Block chain, a computer system that maintains secure and transparent records. Once something is recorded on Block chain, it is incredibly difficult to modify it, therefore no one can cheat. It's similar to a chain of blocks, with each block keeping note of who owns what land. Smart Contact will substantially enhance the land management system of Bangladesh by introducing transparency, efficiency, and security in the process. Furthermore, everyone connected to this system may see the records, making it incredibly open.

Replacing traditional land management systems with the implementation of block chain gives rise to several challenges.

1.How can we combine new technologies with our current computer-use efforts?
2.What factors contribute to open and trustworthy land transactions?
3.Can new technologies such as Block chain assist us in resolving land record issues?
4.How can smart contracts help us enhance land management in Bangladesh?

We also intend to employ Block chain in stages. Initially, anyone with computer skills can assist in keeping the records. Later, trusted organizations can also assist, and everyone has access to the records. Finally, the government can take control and expand the system. We discuss how difficult it is to manage land in Bangladesh due to outdated practices and corruption. We believe that utilizing new technology such as Block chain can be beneficial. It’s like constructing a strong home with immovable blocks. We’re also considering adopting smart contracts. This would improve land record organization, reduce cheating, and improve people’s lives in Bangladesh.

As the table below describes, we have compared six criteria between traditional and our proposed land management model regarding stakeholders, traceability, transparency, fair pricing, security, and quality assurance.

Criteria	Traditional System	Proposed System
Stakeholders	Stakeholders rely on centralized authorities while facing limited access and bureaucratic processes.	Stakeholders are offered decentralized control with direct access, and automated, transparent transactions.
Traceability	Relies on a paper-based process thus making traceability prone to error.	Ensures a transparent tamper-proof ledger that enables seamless traceability of land transactions.
Transparency	Centralized control lacks transparency due to limiting stakeholder visibility into land records.	Decentralizing data gives full transparency, a tamper-proof ledger with real-time access for all stakeholders.
Fair pricing	Opaque pricing or some intermediaries could contribute to hidden costs and pricing inefficiency.	Intermediaries are not required due to smart contracts, automating processes ensures fair pricing through predefined rules.

Security	Centralized databases are susceptible to breaches and fraud and the reliance on manual paperwork exposes land records to unauthorized alterations.	Cryptographic techniques and decentralization enhance security, making it resistant to unauthorized access and tampering.
Quality assurance	Offers complex, paper-based documentation and manual processes that can make a stakeholder face challenges through legal procedures.	Offers user-friendly interface and accessibility via digital platform provides stakeholders more intuitive and efficient experience.

Table 1: Traditional land management model vs. proposed model.

Chapter 2

Related Works

2.1 Survey of the State-of-the-art

We have identified a few features that are essential for a block chain based Land management. They are Price Control, Transparency, Privacy, Smart Contact, Security, Dapps, Validation. Here we did an extensive analysis on the related works based on these features:

The subject of the proposed article is Pakistan's use of blockchain technology to set up a system for managing land records. The system aims to provide a secure and immutable ledger for the management of land records through the use of smart contracts and the integration of numerous databases and systems. However, there are some problems with the viability and efficiency of the suggested system. Because the article lacks technical information and empirical evidence, it is challenging to evaluate how well the system works. The proposed system's limited scope is a result of the fact that it only addresses land records while ignoring important problems like corruption or land disputes. The system's implementation costs, and stakeholder involvement are also not given enough thought.

A number of recommendations are made to make the suggested system more effective. More testing and evaluation should be conducted to identify any potential problems or areas for improvement before the system is expanded. To accommodate a large number of users and transactions, scalability issues must be resolved. Feedback from end users should be gathered to make sure the system satisfies their needs and is simple to use. To guarantee that the law is being followed, legal and regulatory issues must be considered. To familiarize users with blockchain technology and realize its full potential, education and training should be made available.

The purpose of the proposal is to demonstrate the viability of integrating blockchain technology into Pakistan's land management system. The advantages of blockchain's scalability, interoperability, and security are emphasized. The proposal envisions enterprise-level software that will be funded by the government and will incorporate geospatial technologies, citizen engagement, sustainability issues, and capacity development. Future system versions will be developed with a focus on lowering costs and enhancing functionality from a Pakistani perspective, informed by feedback from real-world deployments. Before blockchain technology is widely used in land management, more investigation is required to address scalability issues.[1]

In this paper, a land administration system (LAS) solution is put forth that takes three major issues into account: LAS characteristics, stakeholders, and blockchain technology assets. To manage land transactions and modifications, the system uses blocks and nodes. Nodes are in charge of making requests for changes and approving transactions, whereas blocks store crucial information like seller ID, buyer ID, land ID, transaction money, prior hash, and special hash. By using a blockchain-based consensus mechanism to verify and add blocks to the distributed ledger, the system ensures secure and efficient land administration. The solution does, however, have some drawbacks, such as scalability issues brought on by consensus algorithms and data storage needs, potential delays in information updating brought on by the verification process, and privacy issues in the event that the private key is compromised.

The recommended strategy suggests a number of improvements to get around these drawbacks. First, implementing sharing is advised to increase scalability and decrease storage needs. Second, it is recommended to use an exact and automated verification process to cut down on wait time when updating information. Thirdly, the use of advanced encryption methods and two-factor authentication strengthens security and addresses issues with private key vulnerabilities. The solution also entails the creation of a block containing transfer-related data, its examination for compatibility with the existing blockchain through a consensus algorithm, and the digital submission of applications by both parties using their private keys. The goals of these changes are to make ownership transfers and data updates related to land accurate, swift, and secure.

The study mainly focuses on applying blockchain technology for updating land-related data, with a focus on ownership transfer and mutation submission. The proposed framework's effectiveness in real-time transactions hasn't been tested; instead, it is assessed through simulations. Future work will focus on evaluating the system's effectiveness in developing a secure, dependable, and efficient land administration system based on the proposed framework by testing its performance in real-time scenarios.[2]

A thorough review of the literature looked at the problems with land registration in developing nations like Bangladesh as well as the potential of Blockchain technology to provide a fix. Bangladesh-relevant information was obtained from a comparative analysis of Blockchain-based land record systems in various nations, including Sweden, Georgia, Ghana, and Dubai. A proposed framework for implementing Blockchain in Bangladesh's land registration process was created in light of these findings. With a decentralized ledger, smart contracts for automation, digital identity verification, consensus mechanisms for authentication, and data privacy protections, the framework emphasizes transparency, security, and efficiency. Interfaces that are simple to use may improve accessibility. However, it was acknowledged that data reliability had its limits, and that implementation might be difficult.

Challenges include obtaining trustworthy land-related data for the genesis blocks of the Blockchain system while addressing privacy issues. Population growth may cause scalability problems, necessitating multiple Blockchains. To prevent disputes, updating land information must be simple, especially in areas vulnerable to disasters. Government notifications and legal requirements should be taken into account. It is advised that the proposed Blockchain system be combined with artificial intelligence and machine learning to enhance the land management system.

The suggested framework has benefits for security and transparency, but it needs more work to address privacy issues, accurate data collection, scalability, updates, and legal requirements. Integrating new technologies can improve responsiveness, security, and efficiency.[3]

The proposed research aims to implement a blockchain-based solution to enhance the land titling procedure in Bangladesh. The solution involves gradually integrating two levels of hybrid blockchain and smart contracts on a public blockchain ledger. Data synchronization, transparency, accessibility, and immutable record management are its main goals. By contrasting the proposed solution with the current land titling procedure in Bangladesh, the effectiveness of the proposed solution is assessed. A number of factors are taken into account, including the number of required travels, the overall cost of information processing, and the ease of access to crucial information. To glean insights from the data, the research employs both qualitative and quantitative data analysis techniques.

There are a number of restrictions and difficulties to take into account, though. The research might be constrained by its small sample size, and its conclusions might only be applicable to Bangladesh's particular situation. The effectiveness and viability of the suggested blockchain- based solution could be impacted by technical issues with scalability, interoperability, and security. In addition, adoption barriers like a lack of knowledge or opposition from stakeholders may restrict the use and impact of the solution. Particularly when dealing with sensitive land ownership and management information, ethical considerations regarding data privacy, confidentiality, and ownership must also be taken into account.

In conclusion, the study suggests a blockchain-based system with a focus on advantages like data synchronization, transparency, accessibility, and immutable record management to enhance the land titling procedure in Bangladesh. A prototype system built on the Ethereum blockchain is used to assess the solution's efficacy in comparison to the current procedure. The study aims to support Bangladesh's efforts to digitize land titling while also identifying the potential advantages, constraints, and difficulties of the country's adoption of blockchain technology.[4]

In this article, a private Hyperledger blockchain network-based system for land ownership transfers is described. The system is made up of a Client-Server, Land Office Server, and Bank Server in a three-node architecture. The Land Registry Office (LRO), which confirms buyer, seller, and land information, and the banks for financial transactions are the main points of attention. Users can register as buyers or sellers, upload or search for land information, and negotiate contracts. The LRO verifies the data and increases taxes and fees. The bank supervises financial transactions, transfers ownership using smart contracts, and adds a new block to the blockchain. The system aims to solve problems like unverified land ownership data, sluggish transfer procedures, expensive transaction fees, potential for fraudulent information, and coordination difficulties.

The proposed system uses blockchain technology to store and transfer land ownership information in order to achieve secure land ownership transfer. The transfer procedure is automated by smart contracts, and nodes are verified and authenticated by a membership service provider. Before putting ownership information in the blockchain, the Land Registry Office verifies and checks it. Cash collection and tax payments are handled by an authorized bank node, and ownership transfers are handled by smart contracts. Using specialized message and notification servers, the system also simplifies node communication and verifies user data.

The proposed system enables users to sign up as buyers or sellers, upload land data, search for available lands, negotiate deals, verify information, add taxes and fees, send payment information to the bank, and complete the transaction by adding a new block to the blockchain. Beyond land exchanges, the study considers other potential use cases with the goals of enhancing authenticity, lowering fraud, enhancing communication efficiency, and facilitating seamless network transactions. It is also taken into account whether the system is applicable to other asset classes and transaction types, such as stock, IP rights, or vehicles. Overall, the system aims to provide a safe, open, and effective method for managing land ownership, benefiting people, the nation, and safeguarding land rights. Future directions include implementing artificial intelligence, creating smart contracts, and ensuring resistance to cyberattacks.[5]

The paper introduces LANDCHAIN, a land administration system for Bangladesh based on blockchain. In order to overcome the shortcomings of the nation's current paper-based system, the authors suggest a hybrid blockchain model. The system has been evaluated and contrasted with existing blockchain-based solutions and paper-based systems, proving its superiority in terms of efficiency and cost-effectiveness. A flowchart diagram of the entire land administration process is provided, along with a description of the system's architecture. Future research directions include carrying out practical implementations and prototypes as well as incorporating remote sensor data into the e-Deed. The main goals of the suggested approach are to streamline the current procedure, reduce document fraud, make it easier to access data about public properties, make it possible to collect taxes from landowners, and eradicate corruption from Bangladesh's land management system.

There are some restrictions to take into account, despite the fact that the suggested system has many benefits. A multi-ownership transfer efficiency test is missing from one Ethereum-based blockchain solution and using the Ethereum Virtual Machine (EVM) for testing may compromise scalability and performance in large-scale applications. The paper also lacks a thorough examination of the difficulties and restrictions that might arise when applying the system in a practical setting. It is crucial to acknowledge that, as is typical with new technologies, implementation may encounter unforeseen difficulties. The adoption of the system by users and government support, for example, are key success factors.

In conclusion, the paper introduces LANDCHAIN, a Bangladesh-specific lightweight and effective blockchain-based land administration system. It aims to use the transparency and decentralization offered by blockchain technology to get around the difficulties and problems of the current paper-based system. Comparing the proposed system to conventional database management systems, it demonstrates its dependability, security, efficiency, and scalability. Although there are some restrictions and issues to be resolved, the research offers a basis for further research and practical application. The integration of sensor data and machine learning techniques, as well as extensive testing and analysis in real-world environments, may be the focus of future work.[6]

With a focus on Bangladesh, a blockchain-based verification system for land registration is suggested. The Land Office (LO), Bank, and Sub-Registry Office (SRO) are key nodes in the system. It uses a pre-agreement title contract that includes signatures, names, a sale identification number, and payment information. With money obtained by the bank, the contract is digitally signed by the client and encrypted using RSA. In order to validate a block hash sent to all nodes by the SRO, a Proof of Work (PoW) procedure requiring a 66% consensus is used. The system's objectives include cost reduction, immutable ledger upkeep, and land ownership tracking. It's intended to create a prototype using the Ethereum blockchain.

Technical limitations, adoption barriers, legal and regulatory compliance, privacy and security issues, cost considerations, and user acceptance are all problems, though. The PoW consensus algorithm may require a lot of resources, and the system's usability might be restricted to a single country. It might be difficult to persuade governmental organizations and land registry offices to adopt the system. Along with ensuring data privacy and security, legal and regulatory frameworks for blockchain technology need to be addressed. Blockchain technology and digital signatures cost implications and user adoption present additional difficulties.

In spite of these challenges, blockchain technology has advantages like increased security, transparency, and reduced fraud. Land registration in Bangladesh could be revolutionized by implementing a blockchain-based system because it would do away with middlemen, increase transparency, and streamline the procedure. The proposed system aims to improve land registration through the integration of cutting-edge technologies like AI, machine learning, and IoT as well as taking into account smart contracts and DeFi solutions. In general, the adoption of blockchain has the potential to greatly enhance Bangladesh's land registration procedure.[7]

The paper explores the development of a hybrid blockchain for land registry in the

Republic of Georgia, aiming to improve land titling processes, enhance transparency, and reduce fraud. The project involved implementing a blockchain-based timestamping layer on top of the existing digital land registry system. However, the paper has limitations. Firstly, its conclusions may be limited to the Republic of Georgia due to its unique legislative frameworks, land management systems, and socioeconomic conditions. Secondly, being a pilot project, it may not encompass all the complexities that could arise during large-scale implementation of a blockchain-based land titling system. Additionally, the article may not delve fully into technical aspects like consensus algorithms and security measures, which are crucial for success in certain situations. It may also lack extensive comparisons with other projects or alternative technologies in the field.

In a different context, a proposed solution involves building a complete blockchain-based land registry platform adaptable to different situations. However, the focus is specifically on using blockchain to facilitate land purchases for infrastructure and development projects. The solution incorporates smart contracts to automate transactions, ensure compliance, and enable real-time tracking of land purchases. While the proposed solution aims to improve land administration globally, the discussed project addresses challenges specific to acquiring land for large-scale projects, streamlining the process and providing accurate information.

Both projects share the goal of leveraging blockchain's transformative potential to enhance land management systems, restore public trust, and improve efficiency, security, and clarity. The success of the Georgian project was attributed to education and high-quality data. Stakeholders were educated about blockchain, while the availability of accurate data ensured project validity. It highlights that blockchain can secure information but cannot replace institutional infrastructure and data quality in government solutions.[8]

The idea of creating a decentralized land registry system in India using a permissioned blockchain is discussed in the article. This system aims to guarantee that only authorized parties can access and modify land records, promoting the security, clarity, and immutability of ownership information while lowering fraud and disputes. The system automates title registrations and land transfers through the use of smart contracts, resulting in quicker transactions and lessening the administrative burden on the state. The paper suggests that implementing this approach could revolutionize land management practices in India by highlighting potential advantages like enhanced record accuracy, increased transparency, decreased fraud, and streamlined governmental processes.

But there are issues with the study's limitations that need to be resolved. It limits the generalizability of its findings to nations with different legal systems and socioeconomic contexts by concentrating solely on the Indian land administration system. Furthermore, the technical aspects of the suggested blockchain solution are not fully covered, raising questions about its adaptability in various scenarios. The study fails to adequately take into account social and cultural factors and ignores implementation-related complexities like interagency coordination and the digitization of records. The authors suggest extending the research to include nations with various systems, delving more deeply into technical issues, addressing implementation issues, and conducting thorough analyses of social and cultural factors to get around these constraints.[9]

The limitations of the current paper-based systems are addressed by the text by suggesting a blockchain-based Land Record Management System (LRMS). The proposed system aims to improve land record availability, data privacy, and data integrity. It uses an asymmetric cryptosystem to improve data privacy and stores records on the blockchain to guarantee their integrity. Additionally, the LRMS offers a trading platform that streamlines the acquisition and sale of land. Additionally, compared to the conventional ASCII table, the C2I table introduced in this paper lowers the overhead of text to integer conversion, increasing the system's effectiveness. Experimental findings and comparisons with cutting-edge systems are used to support the effectiveness of the proposed LRMS.

Adoption of this blockchain-based LRMS, however, is not without its difficulties and limitations. When managing a high volume of land records and transactions, the system's scalability may become a problem. The adoption process might demand a lot of time, money, and infrastructure, which can be difficult in some nations or regions. Although the paper emphasizes the system's privacy, integrity, and security features, it is important to address any potential security flaws and guarantee the system's overall robustness. Furthermore, the proposed LRMS and C2I table may only be applicable under certain conditions, which could limit its generalizability and applicability, potentially limiting its use in other contexts or domains.

Finally, by digitizing land records, ensuring privacy and integrity, supplying a trading platform, and accelerating ownership transfers, the proposed blockchain-based LRMS offers a number of advantages over current systems. But scalability, adoption, security, and generalizability issues need to be carefully considered. Through experimental analysis and comparisons with cutting- edge systems, the paper emphasizes the effectiveness of the proposed system. Future plans call for more advancements and a practical application of the LRMS.[10]

In the paper, a framework for using Blockchain technology to reduce fraud in land authentication is proposed. To understand the current state of Blockchain-based land authentication systems and to pinpoint problems, the authors conducted qualitative research that included literature reviews, case studies, and stakeholder surveys.

To deal with these difficulties, the authors offered some suggestions. They suggested educational initiatives to raise the technical competence and familiarity of stakeholders with blockchain technology. It was suggested to standardize protocols and guidelines to increase interoperability. Measures for privacy and security were suggested, such as encryption and access controls. Partnerships between stakeholders and changes to laws and regulations to accommodate Blockchain technology were emphasized.

The paper focuses on a blockchain-based model for reducing fraudulent activities in land authentication in Sri Lanka. The suggested system reduces transaction validation time and fraud by addressing transparency and authentication complexity. By eliminating vulnerabilities and integrating with other land-based service providers, the digitalized system streamlines procedures and gets rid of middlemen.

The overall goal of the paper is to increase efficiency, reduce fraud, and provide a framework and prototype for a Blockchain-based land authentication system in Sri Lanka.[11]

The research paper suggests building a decentralized land registry and title management system in India using blockchain technology and smart contracts. India's land registry system currently has issues with lengthy procedures, middlemen's involvement, and the possibility of fraud. The paper reviews the body of research on blockchain and smart contracts in land registry systems and suggests a fix for the problems found.

The system under consideration aims to digitize land records, store them on a blockchain for immutability, transparency, and verifiability, and use a permissioned blockchain network to mimic the distributed nature of various departments involved in land administration. The paper offers a thorough system design that covers the architecture, attributes, and capabilities of the suggested system.

The paper assesses the system's efficacy in digitizing land records and compares its performance to that of existing systems in terms of efficiency, safety, and scalability. A prototype of the system is implemented using the Hyperledger Fabric framework. The findings are summarized, and future research directions are suggested in the paper's conclusion.

This paper does have some drawbacks, though. The success of the system depends on the cooperation of all parties involved in land administration, and the proposed system has yet to be put into practice and tested extensively. Moreover, smaller land administration organizations might not be able to afford the significant infrastructure and training investments necessary for the system's adoption. Furthermore, other aspects of land administration may need to be addressed because the proposed system only addresses land registry and title management.The overall goal of the suggested solution is to improve the transparency, security, and efficiency of India's land registry and title management system by utilizing blockchain and smart contracts technology.[12]

This study investigates the application of blockchain technology to land registration in India's National Capital Region. Interviews with participants in the study are conducted, and official sources and international research are reviewed. It aims to comprehend the elements affecting the adoption of blockchain for land registration.

The study focuses on a variety of stakeholders, such as users of the land registry, banks, police forces, governmental agencies, civic personas, and technologists. It is restricted to the NCR area and is supported by qualitative interview data.

The paper presents findings and suggestions that highlight the advantages of blockchain for safe and open land records. The regional focus, small sample size, lack of quantitative data, and technological considerations are, however, limitations.

The study places a strong emphasis on stakeholder cooperation for effective implementation. It suggests conducting additional research with more participants, improving the methodology, demonstrating connections, and creating an adoption framework.[13]

The study examines the potential for Ghana's land management to use blockchain technology. Interviews with subject-matter experts are combined with secondary data analysis in this study. The study examines the use of land, acquisition of land, and implementation of blockchain technology in Ghana. The study employs a systematic methodology, gathering pertinent literature and conducting in-depth reviews to spot connections and gaps. Specialist consultations add to the analysis. To create improvement strategies, the strengths, weaknesses, opportunities, and threats of Ghana's land management system are examined. The study recommends carrying out a systematic review to address this issue, despite the fact that the integrative review technique might be unreliable. A detailed technical blueprint is missing from the suggested framework and should be created in additional study. Despite the study's emphasis on the Ghanaian context, it is encouraged that other African nations also investigate the framework's applicability. In particular, in pluralistic land tenure systems like Ghana's, more research is required to fully comprehend blockchain applications for land management.[14]

The studies that have already been done on blockchain technology and land registry systems were thoroughly reviewed by the authors. Using blockchain technology, they created a framework for the land registry system that incorporates a pre-agreement algorithm and smart contract architecture. Case studies were used to assess the framework's security, dependability, transparency, and usability.

The text also identifies difficulties in putting the framework into practice, including the slow uptake of blockchain technology, technical complexity, high costs, security risks, ethical dilemmas, and resistance to change. The authors propose approaches like a multi-layered blockchain network, a consensus algorithm with reduced energy consumption,

interoperability through standardization protocols, and legal frameworks that support blockchain implementation to deal with these issues.
The article contrasts the suggested framework with a different undertaking that compared the acquisition of land for substantial projects. Both initiatives use blockchain to enhance land administration procedures, but they have different features. While the other project streamlines land acquisition with integrated payment systems and automated due diligence checks, the Blockchain-based framework focuses on land registry procedures.
The proposed framework and the other project, according to the paper's conclusion, both show the potential of blockchain technology to enhance land management in Bangladesh. It emphasizes the importance of taking into account the distinctive qualities and focal points of each solution when addressing the problems with the current land administration system.[15]
In order to increase transparency, the paper suggests a Blockchain-based land registry solution that uses a Delegated Proof of Stake consensus mechanism. It concentrates on seamless integration, collaboration, cost-effectiveness, and capacity-building and aims to integrate with existing land registry systems. The authors draw comparisons between their project and a land registry system resembling that in Bangladesh and intend to use concepts from the paper to address challenging problems in land transactions. They stress the usefulness of blockchain technology in actual land transactions and the significance of learning best practices. In order to address implementation issues, the paper examines hybrid solutions that combine smart contract technologies with already-in-place infrastructure and offers case studies from Sweden, Australia, and Canada.
The hybrid strategy is meant to be the first step toward scaled implementation. However, more study is required to address interdisciplinary issues like stakeholder awareness, institutional trust, legal considerations, sustainable business models, and data decentralization and security. To enable scaled implementation and development, the findings point to the need for a wider perspective and a reexamination of concepts.[16]
The article "Hybrid Approaches for Smart Contracts in Land Administration: Lessons from Three Blockchain Proofs-of-Concept" investigates the use of smart contracts in land administration and suggests a framework for assessing blockchain proofs-of-concept. Scalability, interoperability, governance, and adoption are among the issues mentioned by the authors. They offer solutions like hybrid blockchain models, uniform interoperability standards, unambiguous governance policies, and strengthened stakeholder capacity. The author's project centers on blockchain-based smart contracts for land acquisition, while the paper focuses on hybrid approaches. The results show that hybrid solutions are compatible with the requirements of the land sector, but more study is needed to address implementation, policy, trust, and security issues.[17]
Only when a new technology can solve problems that cannot be solved in other ways should it be implemented. Lack of transparency and drawn-out ownership transactions are examples of deficiencies. However, there isn't a clear risk of a breach of trust in the current circumstance. The procedure for transferring ownership is already standardized, and the cadastral administration plays no direct part in the transfer itself. Leading institutions like the notary and land registry would play a different role if blockchain were used to speed up transfers.
Blockchain technology offers the potential for safe and automated administrative processes, but it also poses difficulties that call for regulatory frameworks and internal guidelines for quality control. Complexity, immutability, power consumption, process redesign, liability concerns, and a lack of clear legal standards are all difficulties. If blockchain is to be used for more than just the land registry, these issues must be solved. Authorities in surveying and mapping play no active role in this area at the moment.

Although blockchain can help with digitization, there is no immediate cause for concern. In Germany, the centralized approach to land registries works well, and blockchain does not completely replace governmental actions. No loss or breach of trust necessitating a tamper-proof system is apparent in the German cadastre. Although it would be ideal, the main objective of cadastral administration is not to streamline administrative processes. They are capable of providing technology.

Even with an electronic land register already in place, using blockchain has advantages. It can be used in conjunction with other technologies to streamline ownership transactions and aid in the digitization of public services.[18]

The use of blockchain technology in land registration and its potential economic effects are examined in the study. The authors analyze current blockchain-based systems using a literature review and survey, citing examples from various nations. They list problems with land registration and suggest fixes, including hybrid systems, anti-corruption measures, better data accessibility, uniform data standards, and smart contracts. The study recommends working with specialists to investigate blockchain's potential in the legal domains and utilizing open blockchains for transparency. To incorporate blockchain into property registration, legislative changes might be required. The authors also mention a different project that uses blockchain technology to acquire land for large-scale projects.

The study highlights how blockchain can improve governance, sustainability, and efficiency in land administration. The study highlights the value of blockchain for property registration and its potential to advance public policies and good governance in general.[19]

Using a Delegated Proof of Stake consensus structure to ensure computational efficiency and security against attacks, the paper suggests a Blockchain-based solution for land registry. To strengthen the consensus mechanism and get rid of lobbying votes, it adds a Council Protocol. To maintain transparency and avoid centralized control, financial institutions are involved. The system does not serve as a medium of exchange and integrates with conventional land registry systems.

However, integrating the suggested method with the current land registry systems could present difficulties. Collaboration with governmental agencies and financial institutions is essential for its success. Infrastructure and significant financial investment may be needed for the solution. The authors propose a comprehensive strategy that focuses on seamless integration, stakeholder collaboration, cost-effectiveness, scalability, and capacity-building initiatives in order to address these issues. Public-private partnerships may be able to supply the funding and knowledge required. A stable, safe, and effective land management system can be achieved by putting these measures into practice.

The proposed blockchain-based land registry system is connected by the authors to their own project, which involves land acquisition. The common goal of both initiatives is to use blockchain technology to streamline land administration procedures and increase the efficiency, transparency, and security of transactions. Their project aims to address issues with land transactions and learn from Bangladesh blockchain-based land registry system by incorporating the concepts from the suggested solution. Their project can also demonstrate how blockchain technology is used in real-world land transactions, such as buying, selling, and acquiring land for substantial development projects.

They hope to identify best practices and creative solutions for various land management scenarios by contrasting and comparing the two projects. The proposed system discussed in the paper needs to be further developed because it lacks seller- related functionalities. The mutation procedure has been made simpler and will be developed further in the future.[20]

Paper Name / Features	A Smart Contract Approach in Pakistan Using Blockchain for Land Management [1]	A Novel Framework for Implementation of Land Registration and Ownership Management via Blockchain in Bangladesh [3]	A Blockchain-based Land Title Management System for Bangladesh [4]	A Blockchain Based Land Registration and Ownership Management System for Bangladesh [5]	LANDCHAIN: A Blockchain-Based Lightweight Land Administration System for Bangladesh [6]	Land records on Blockchain for implementation of Land Titling in India [9]	Advancing Land Management in Bangladesh: A Comprehensive Blockchain-Based System for Efficient, Transparent, and Secure Land Transactions
Price Control	Y	✕	Y	Y	Y	✕	Y
Transparency	Y	Y	Y	Y	Y	Y	Y
Privacy	Y	Y	Y	Y	Y	Y	Y
Smart Contact	✕	Y	Y	Y	✕	Y	Y
Security	Y	Y	Y	Y	Y	Y	Y
Dapps	Y	✕	✕	✕	Y	Y	Y

Table 2: Features Comparison with other approaches

2.2 Key Challenges

Traditional land management system issues have become crucial nowadays. Because in the present time the world has been going through a big crisis, there are so many fraud issues. Most common people have been rigged by powerful people. Whoever is a corruption scammer, they did this for some money without any hesitation. The following are some of the primary obstacles in the current land management system:

- Insufficiency of Data and Information: Most often, thorough data records and contemporary data collection methods are absent from traditional land management systems. This shortcoming makes it difficult to accurately document land ownership, boundaries, and use.
- Legal Complexity: Traditional land transactions frequently take place outside of established legal systems, which can result in uncertainty and potential legal conflicts about land titles and property rights.

- Reliability Issues: Traditional processes are frequently informal and prone to errors, which makes it difficult to build trust and reliability in land transactions.
- Authentication of True Owners: Due to informal paperwork and inadequate methods of verification, confirming the legitimacy of landowners can be challenging.
- Protracted Processes: Traditional land purchases take a lot of time from both the buyer and the seller due to lengthy procedures, negotiations, and conflicts.
- Land Tenure Insecurity: Landowners are at danger for eviction, land encroachment, and conflicts with powerful groups when official land titles and tenure security are absent.

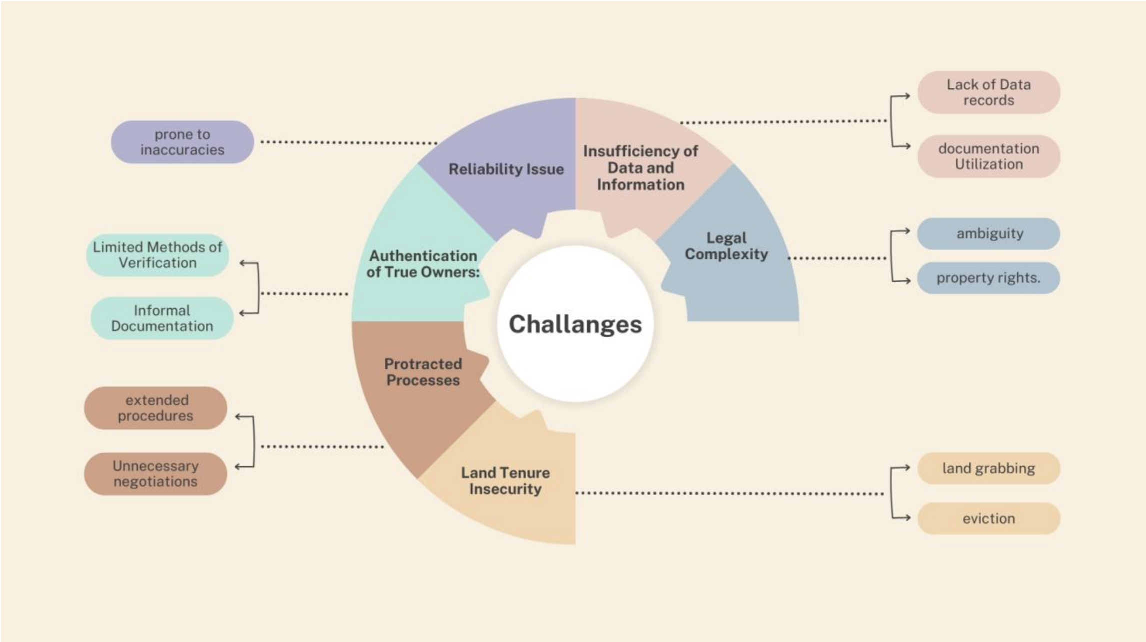

Figure 3: Challenges in traditional Land Management

2.3 Summary

The traditional system has its problems. It is harder to trace the documents regarding a plot of land in a traditional system. There is also a problem with transparency. Since it uses a central system, there are also security issues along with the possibility of corruption. Overall, traditional systems can be a problem with people who want to purchase a plot without any hassle. This is why the blockchain method is introduced for rapidly creating and adapting generic Ethereum-based smart contracts for land management administration and ensuring that code and modules may be reused to reduce development time while retaining security and dependability. While Ethereum is now the platform, future work will broaden the approach’s use to other administrations. The researchers’ goal in this work is to develop a system that can store every data regarding land management in the blockchain network ensuring a future of paperless land management system.

Chapter 3

Method

3.1.1 Proposed Model

Our proposed land registry system uses modern blockchain technology to streamline how land is registered and transferred. At its core is a smart contract that acts like a digital ledger, recording every transaction and land detail securely.The system is managed by a SuperAdmin, who oversees everything and can appoint Admins. These Admins are responsible for adding new land records to the system, making sure all the details like location, size, and ownership are correctly entered.

Landowners in this system can easily put their land up for sale. They just mark their property as available, much like putting a "For Sale" sign up. Potential buyers can then browse through these listings and express interest in properties they like.

When a landowner agrees to sell their land to a buyer, the system smoothly transfers ownership. This process is all recorded in the blockchain, ensuring that everything is done fairly and transparently.

Everyone using the system, from landowners to buyers, can set up their own profiles with their personal details. This makes it easy to keep track of who owns what and who's buying.

1. Key Components:
    - **SuperAdmin:** Has overarching control over the system, primarily responsible for adding and managing admins.
    - **Admins:** Authorized to register and manage land details within the system.
    - **Landowners:** Own land and can mark their properties as available for sale.
    - **Buyers:** Interested in purchasing available land.
    - **Smart Contract (Registry):** Central to the system, it processes and stores all transactions, land details, and user profiles.
2. Core Functionalities:
    - **Admin Management:** SuperAdmin adds or manages Admins who are responsible for land registration.
    - **Land Registration:** Admins register new lands with details like location, value, and owner.
    - **User Profile Management:** All users can create and update their profiles with personal and contact information.
    - **Property Listing for Sale:** Landowners mark their land as available for sale.
    - **Purchase Requests:** Buyers express interest in available properties.
    - **Transfer of Ownership:** Upon acceptance of a purchase request, the property ownership is transferred from the seller (landowner) to the buyer.
3. System Workflow:
    1. **Initialization:** SuperAdmin is set up upon contract deployment.
    2. **Admin Registration:** SuperAdmin adds Admins who can register lands.
    3. **Land Registration Workflow:**
        - Admins add new land records through the **registerLand()** function.
        - Each land record contains details specified by the Admin.
    4. **User Interaction:**
        - Users set up or update their profiles via **setUserProfile()**.
        - Landowners mark properties as available for sale.

- Buyers browse available properties and make purchase requests.

5. **Sales Process:**
    - Landowners review purchase requests.
    - Acceptance of a request leads to a transfer of ownership, handled by the contract.
6. **Information Access:**
    - All users can access land and user information through various getter functions.

4. Data Management:
- Land details, user profiles, and transaction records are securely managed and stored within the blockchain through the smart contract. This ensures transparency, security, and immutability.

5. User Interface (Potential):
- A user-friendly interface can be developed for interacting with the smart contract, enabling users to easily register properties, view available lands, and initiate transactions.

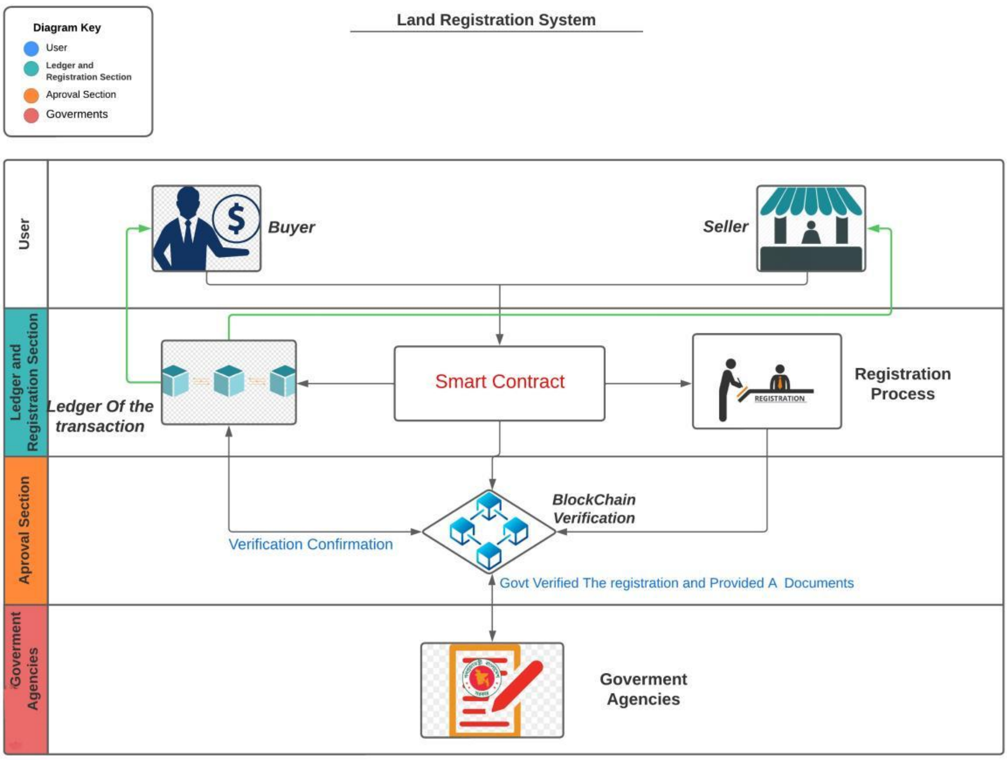

Figure 4: Proposed Model.

For our convenience, we have created a data flow, workflow, and use case model to understand the progress and the workflow of our project.

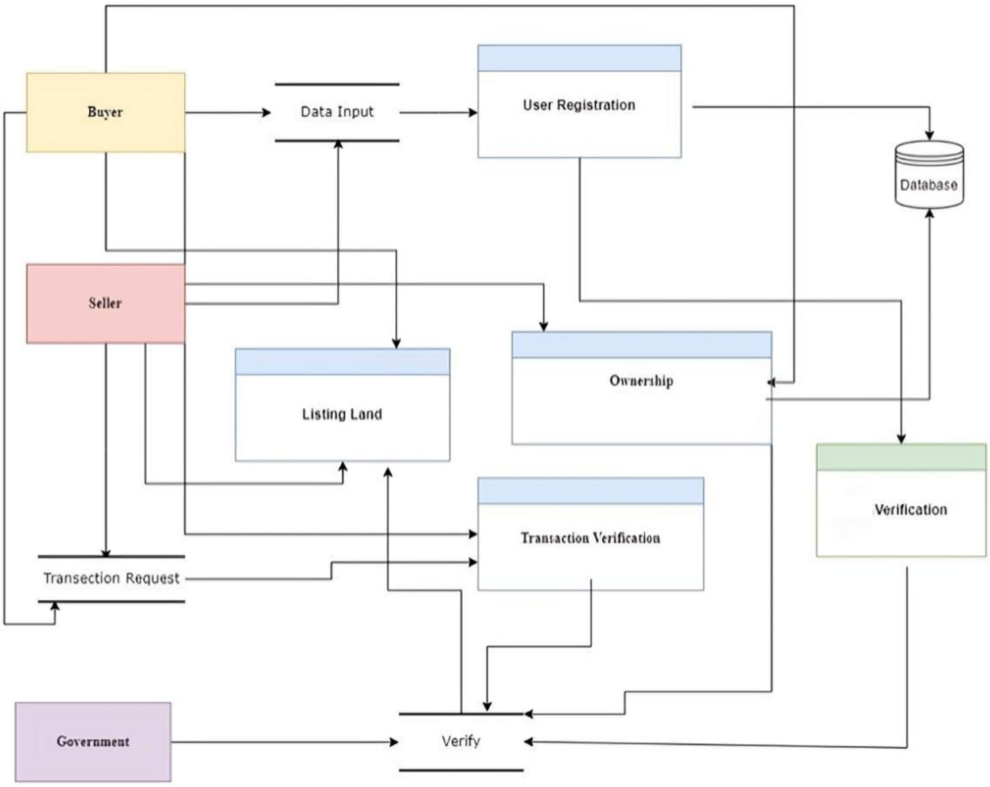

Figure 5: Data flow Model

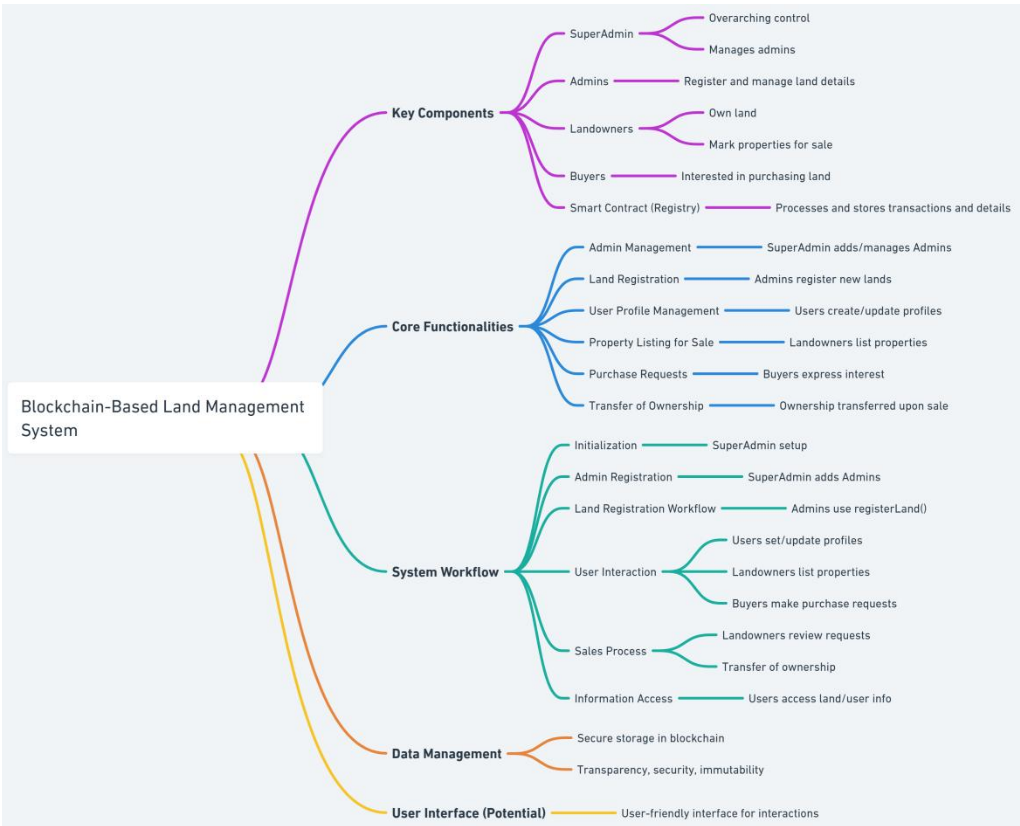

Figure 6: Workflow Model

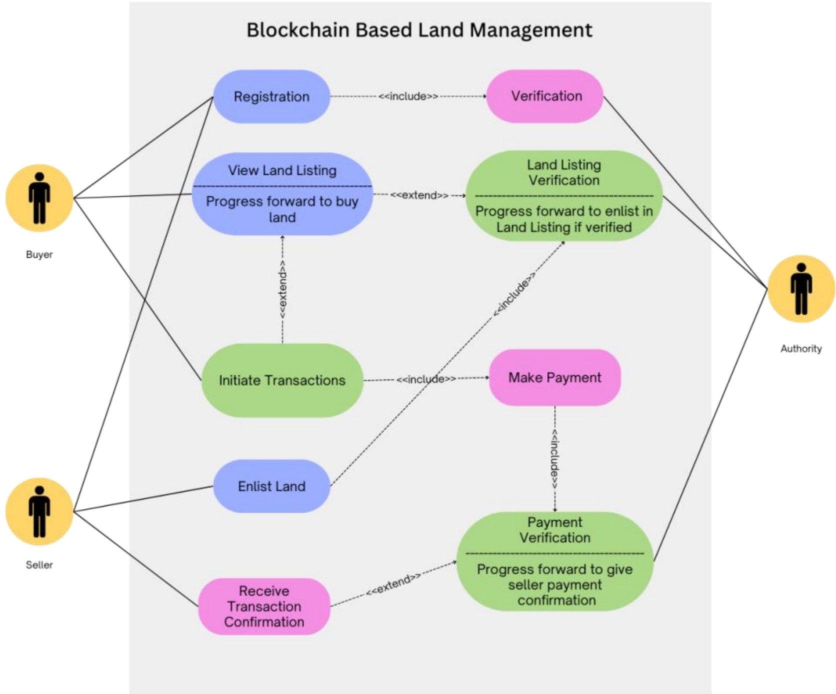

Figure 7: Use case Model.

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3.1.2. System Architecture

Our proposed model incorporates a blockchain-based land acquisition system with multiple critical components, each of which plays a significant role in maintaining the system's structural integrity. Here is a brief architectural summary:

- **Users (Buyers and Sellers):** Users (sellers and buyers) engage with the system through user interfaces, which allow sellers to advertise properties for sale, buyers to see and choose properties, and both to complete transactions.
- **User Interface:** The front-end component of the system where users interact with the application is called the user interface. It might be a mobile or web-based application.
- **Application Layer:** This layer is responsible for managing the business logic for tasks such user registration, land listing and purchase, and transaction management. This is the location of the processes shown in the data flow diagram.
- **Blockchain Network:** All transactions are recorded in a decentralized ledger on the blockchain network. Data transparency and immutability are guaranteed by the network. It is made up of nodes maintained by numerous organizations, including in this case the government organization. The immutability of blockchain can facilitate the resolution of disputes. Since all transactions are permanent and immutable once added to the blockchain, it provides a trustworthy and unbiased record in the event of land transaction disputes.

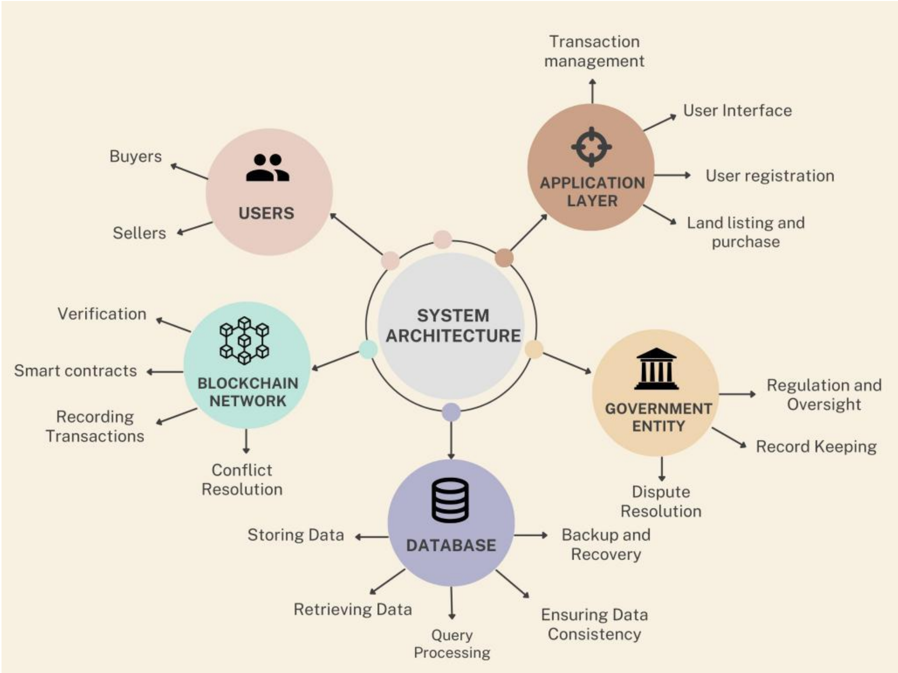

Figure 8: System Architecture.

- **Smart contracts:** On the blockchain network, smart contracts automate transactions. Once the requirements outlined in the contract are satisfied, they will automatically execute transactions and contain business rules. For instance, the ownership of the land might be immediately transferred when a buyer makes a payment.
- **Database:** The database supports several key functions. It stores KYC data, land records, transaction history, and potential user communication. The database allows users to quickly retrieve transaction histories and land specifics. Importantly, it provides data integrity across all interactions, reflecting user information changes throughout the system. All user information gathered during this procedure will be stored safely in the platform's database, ensuring protection from unauthorized access.
- **Government Entity:** The government entity checks the transactions to make sure they are legal and that all rules are being followed. They may be equipped with a unique interface to communicate with the blockchain and application layers, allowing them to validate user registrations, land listings, and transactions. In the event of land transaction disputes, the government entity may be required to intervene. This process can be aided by the blockchain immutable record of transactions, which provides an objective history of what transpired.
- **Regulation and Oversight:** The governing body will supervise and regulate all land transactions conducted on the blockchain network. This involves ensuring that all land transactions are legal and in accordance with national regulations.

3.1.3. Framework

The framework of the land registry system is akin to a well-organized and secure digital ledger designed explicitly for managing land ownership and transactions. At the core of this system is the role of the SuperAdmin, comparable to a government authority, who has the authority to appoint administrators (or admins). These admins are entrusted with adding new land records to the system, ensuring that each new entry is accurately documented with details like ownership, location, value, and size.For individuals interacting with this system, the first step is to set up a personal profile, akin to filling out a detailed membership form. This profile includes essential information such as their name, contact details, and address. Landowners within this system have a unique capability – they can flag their properties as available for sale, much like putting up a 'For Sale' sign on physical land. This action makes their land visible to potential buyers within the system.

When it comes to buying land, interested parties can easily browse through available properties and place a request to purchase specific parcels. This process is similar to placing a bid in an auction. Upon receiving such requests, the current landowner has the discretion to accept any of them, effectively agreeing to transfer the ownership of the land to the buyer, much like finalizing a deal with a handshake. The system is also equipped with a variety of inquiry functions. Anyone can access detailed information about each land parcel, like checking a comprehensive, interactive map. This includes checking if a land is up for sale, finding out how many people have shown interest in a property, and even delving into the specifics of each purchase request.

Moreover, users can view lists of all the properties they own or have expressed an interest in buying, providing a clear and transparent overview of their land-related activities. Lastly, there's a feature to check whether a user has already made a purchase request for a particular land, ensuring no duplication or confusion in the bidding process.

In summary, this framework functions as a digital, transparent, and secure system for land registry, streamlining the process of land ownership registration, sale, and purchase. It's designed to be user-friendly while maintaining strict control over who can modify records, ensuring accuracy and reliability in land transactions.

Function Name	**Workflow**
addAdmin()	**Register a new administrator in the blockchain network.** SuperAdmin registers new admins, granting them rights to register land.
isAdmin()	**Check if a user is an admin.**Verify if the calling user has admin privileges.
registerLand()	Register a new parcel of land.An admin registers land details, including owner, survey number, and market value.
setUserProfile()	Set or update a user's profile.Any user sets their personal details such as name, contact, and residential address.
markMyPropertyAvailable()	Mark a property as available for sale.A landowner marks their land as available for purchase.
RequestForBuy()	Request to buy a land. Interested buyers request to purchase land marked as available.
AcceptRequest()	Accept a purchase request and transfer ownership.The current landowner accepts a buy request, transferring ownership to the requester.
getLandDetails()	Retrieve details of a specific land.View details of a land parcel, including owner and market value.

getRequestCnt_propId()	Get the number of requests and property ID for a specific land. Retrieve the total number of purchase requests for a land and its property ID.
getRequesterDetail()	Get details of a particular request for a land.Access details of a specific purchase request for a land.
isAvailable()	Check if a land is marked as available.Determine whether a specific land is available for sale.
getOwnerOwns()	Retrieve lands owned by a user.List all land parcels owned by a specific user.
getRequestedLands()	Retrieve lands requested by a user.Show all lands that a user has expressed interest in buying.
getUserProfile()	Get the profile of a user.Access the personal profile details of a user.
getIndices()	Get indices related to land ownership and requests.Retrieve total indices of lands owned and requested by a user.
didIRequested()	Check if a user has requested a specific land.Determine if the calling user has already made a purchase request for a given land.

Table 3: Smart Contract's functions' overview.

3.1.4. Algorithm/Model Formulation

Algorithm 1:
Register Land This algorithm is like the process of recording a new piece of land in an official registry. When an admin (think of them as a trusted official) wants to add a new land record, they fill in all the important details like which area (division, district, city) the land is in, its unique ID (property ID and survey number), who owns it, its market value, and size in square feet. This info is packaged into a 'LandDetails' structure, almost like a digital file, and added to the registry. But, only an authorized admin can do this, ensuring that not just anyone can add new land records.

Algorithm 1: Register Land
1: **Procedure** registerLand(...params)
2: *params[0] ← _division*
3: *params[1] ← _district*
4: *params[2] ← _city*
5: *params[3] ← _propertyId*
6: *params[4] ← _surveyNo*
7: *params[5] ← _owner*
8: *params[6] ← _marketValue*
9: *params[7] ← _sqft*
10: **struct** LandDetails

```
    $owner: address
    $admin: address
    $propertyId: uint256
    $surveyNumber: uint
    $index: uint
    $registered: bool
    $marketValue: uint
    $markAvailable: bool
    $requests: mapping(uint => RequestDetails)
    $noOfRequests: uint
    $sqft: uint
  end struct
  LandDetails ← newLandDetails
  if msg.sender == AuthorizedAdmin then
    newLandDetails[$owner] ← params[5]
    newLandDetails[$admin] ← msg.sender
    newLandDetails[$propertyId] ← params[3]
    newLandDetails[$surveyNumber] ← params[4]
    newLandDetails[$index] ← userProfile[params[5]].totalIndices
    newLandDetails[$registered] ← true
    newLandDetails[$marketValue] ← params[6]
    newLandDetails[$markAvailable] ← false
    newLandDetails[$sqft] ← params[7]
  end If
  landDetalsMap[params[0]][params[1]][params[2]][params[4]] ← newLandDetails
end Procedure
```

Algorithm 2:

Mark Property Available In this step, a landowner can mark their land as available for sale. It's like putting up a "For Sale" sign. They do this by selecting the land they own (using an index number) and changing its status to 'available.' However, they can only do this if the land isn't already marked for sale, preventing any confusion about the land's availability.

Algorithm 2: Mark Property Available

```
Procedure markMyPropertyAvailable(...params)
  params[0] ← indexNo
  landDetail = landDetalsMap[ownerMapsProperty[msg.sender][params[0]].division][ownerMapsProperty[msg.sender][params[0]].district][ownerMapsProperty[msg.sender][params[0]].city][ownerMapsProperty[msg.sender][params[0]].surveyNumber]
  Require: landDetail.markAvailable ≠ true
  if msg.sender == landDetail.owner then
      landDetail.markAvailable = true
  end if
end Procedure
```

Algorithm 3:

Request to Buy Land This is where potential buyers can express their interest in a piece of land that's up for sale. They specify which land they're interested in by its location and survey number. The system checks if the land is indeed available and that the interested buyer hasn't already made a request for it. If all is clear, the buyer's request is noted down, almost like adding their name to a waitlist.

Algorithm 3: Request to Buy Land

```
Procedure requestToBuyLand(...params)
  params[0] ← _division
  params[1] ← _district
  params[2] ← _city
  params[3] ← _surveyNo
  landDetail = landDetalsMap[params[0]][params[1]][params[2]][params[3]]
  Require: landDetail.markAvailable = true && !didIRequested(params[0], params[1], params[2], params[3])
  if msg.sender ≠ landDetail.owner then
     reqDetails = new RequestDetails(msg.sender, userProfile[msg.sender].requestIndices)
     landDetail.requests[landDetail.noOfRequests++] = reqDetails
     userProfile[msg.sender].requestIndices++
  end if
end Procedure
```

Algorithm 4:

Accept Buy Request When a landowner decides to sell their land to one of the interested buyers, this algorithm comes into play. The landowner picks a particular request (using indices) and approves it. This is a bit like saying, "Yes, I agree to sell my land to this person." The system then updates all its records: it clears all other purchase requests for that land and updates the ownership details to reflect the new owner. It's like updating the land's title deed to the new owner's name.

Helper Functions for Algorithm 4:

1. Clearing All Requests: This function removes all pending purchase requests for the land once it's sold, ensuring the records are clean and current.
2. Transferring Ownership: This changes the registered owner of the land in the system to the new buyer, making it official that the land has changed hands.
3. Updating Owner Properties: This updates the new owner's records to include their newly purchased land, like adding a new title to their list of properties.

Algorithm 4: Accept Buy Request

```
Procedure acceptRequest(...params)
  params[0] ← _index
  params[1] ← _reqNo
  ownerOwns = ownerMapsProperty[msg.sender][params[0]]
  landDetail = landDetalsMap[ownerOwns.division][ownerOwns.district][ownerOwns.city][ownerOwns.surveyNumber]
  Require: landDetail.registered = true && landDetail.noOfRequests > params[1]
  if msg.sender == landDetail.owner then
     newOwner = landDetail.requests[params[1]].whoRequested
     clearAllRequests(landDetail)
     transferOwnership(landDetail, newOwner)
```

updateOwnerProperties(newOwner, ownerOwns)
end If
end Procedure

Helper Functions for Algorithm 4:

1. *clearAllRequests(landDetail): Clears all pending requests for the land.*
2. *transferOwnership(landDetail, newOwner): Transfers the ownership of the land to the new owner.*
3. *updateOwnerProperties(newOwner, ownerOwns): Updates the properties list for the new owner.*

Algorithm 5:

User Set Profile This is a simple yet crucial part of the system where users (landowners, buyers, admins) can set up or update their personal profiles. They provide their full name, gender, email, contact number, and residential address. This is important for keeping track of who's who in the system and ensuring that all transactions can be traced back to real people, adding a layer of security and accountability to the whole process.

Algorithm 5: User Set Profile

Procedure setUserProfile(...params)
params[0] ← _fullName
params[1] ← _gender
params[2] ← _email
params[3] ← _contact
params[4] ← _residentialAddr
userProfile[msg.sender].fullName = params[0]
userProfile[msg.sender].gender = params[1]
userProfile[msg.sender].email = params[2]
userProfile[msg.sender].contact = params[3]
userProfile[msg.sender].residentialAddr = params[4]
end Procedure

3.1.5. Summary

In this section, we have tried to visualize our proposed model which will have a complete structure and become easier to implement. According to our model of the Application, we have implemented five algorithms for deploying the functions into our application. These algorithms further helped us in deploying the blockchain based application.

Chapter 4

Results and Discussion

4.1 Smart Contract Test in Remix

We utilized Remix, an effective open-source program enabling the writing of Solidity contracts directly from browsers, to test our Solidity code in smart contracts. Every successful transaction in our smart contract simultaneously updates both the smart contract and the web application. The overall procedures for creating a contract to facilitate transactions between stakeholders run seamlessly through a chain.

Following the successful execution of the "AcceptRequest" function in the provided smart contract, the land registration process becomes crucial for maintaining an accurate and updated property registry. The "AcceptRequest" function triggers the update of ownership details and marks the property as unavailable, as mentioned earlier. It's important to note that the property being transferred should have undergone the land registration process, involving the "registerLand" function. Before reaching the "AcceptRequest" function, the seller ("User_1") should have previously registered the land using the "registerLand" function. This function records details such as state, district, city, property ID, survey number, owner's address, market value, and square footage of the land. The successful execution of "registerLand" sets up the initial registration of the property, rendering it eligible for subsequent transactions. In summary, the workflow entails the initial land registration by "User_1" using the "registerLand" function, followed by the "AcceptRequest" function, which facilitates the transfer of ownership and updates the property's status. Together, these functions ensure a comprehensive and accurate property ownership transition within the smart contract. [Fig-10]

A SuperAdmin or Admin initiates the contract setup by executing the "addAdmin" function to register a new admin. The admin subsequently uses the "registerLand" function to register a new piece of land, providing details such as state, district, city, property ID, survey number, owner's address, market value, and square footage. The land details are stored in the contract, and the property is marked as registered. To check if an owner possesses any land, the "getOwnerOwns" function is employed. The "getRequestedLands" function reveals the requested owner index and property ID. The "getRequesterDetail" function identifies the user who requested to buy the land. The "isAdmin" function validates whether the address signing is an admin. Additionally, the "isAvailable" function is instrumental in determining the availability of a land.[Fig-11]

In the final phase depicted in Fig-12 of the smart contract, the "landDetailMaps" showcase all details of the land, including ownership and administrative information. The "totalAdmin" function provides insight into the number of admins registered by the super admin. User profiles can be queried using the provided address. The smart contract also reveals the super admin's address and displays requests for land.

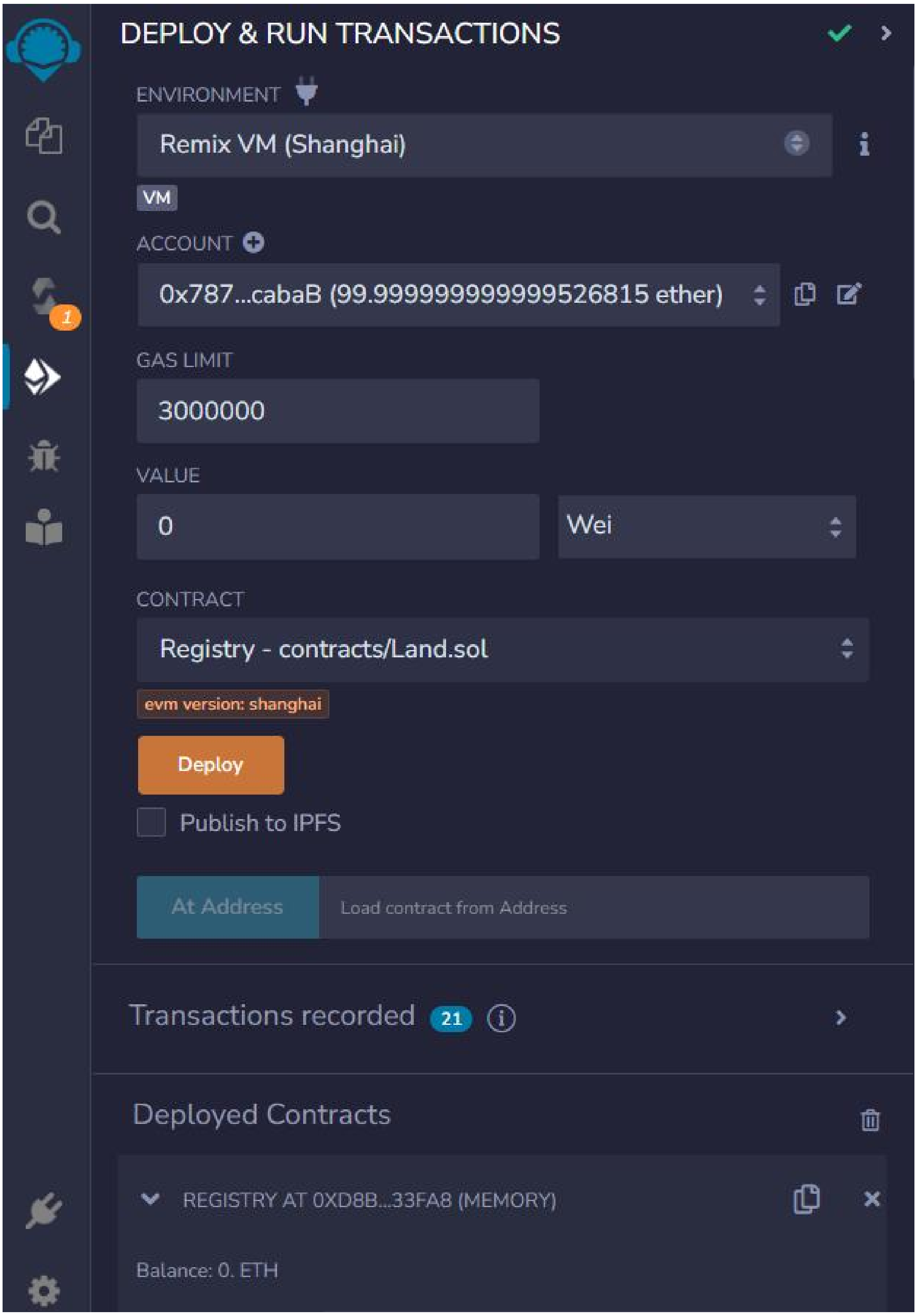

Figure 9: Deployed Contract.

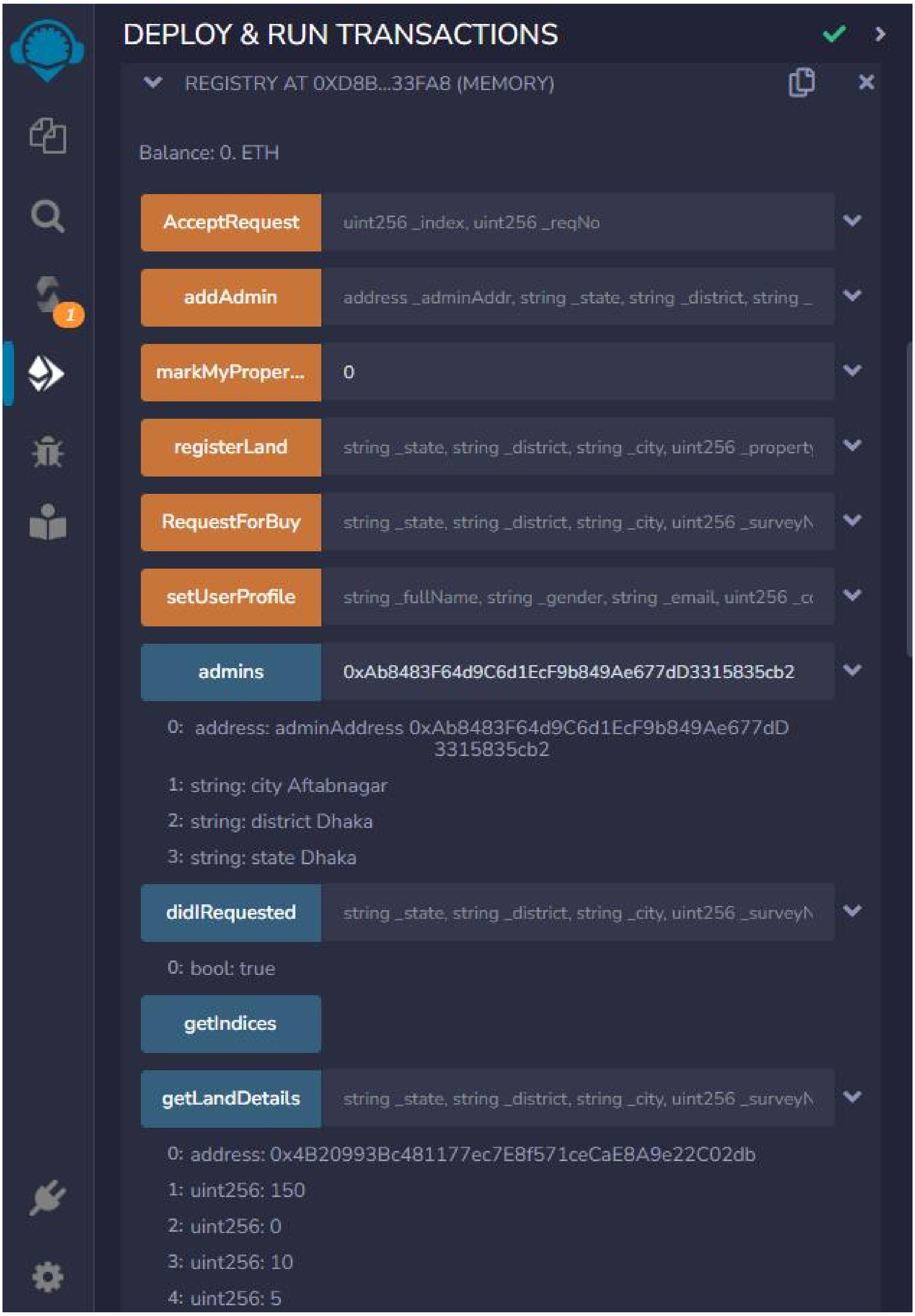

Figure 10: Land Registered, Request for buy applied and the details of Admin, Land also requested value.

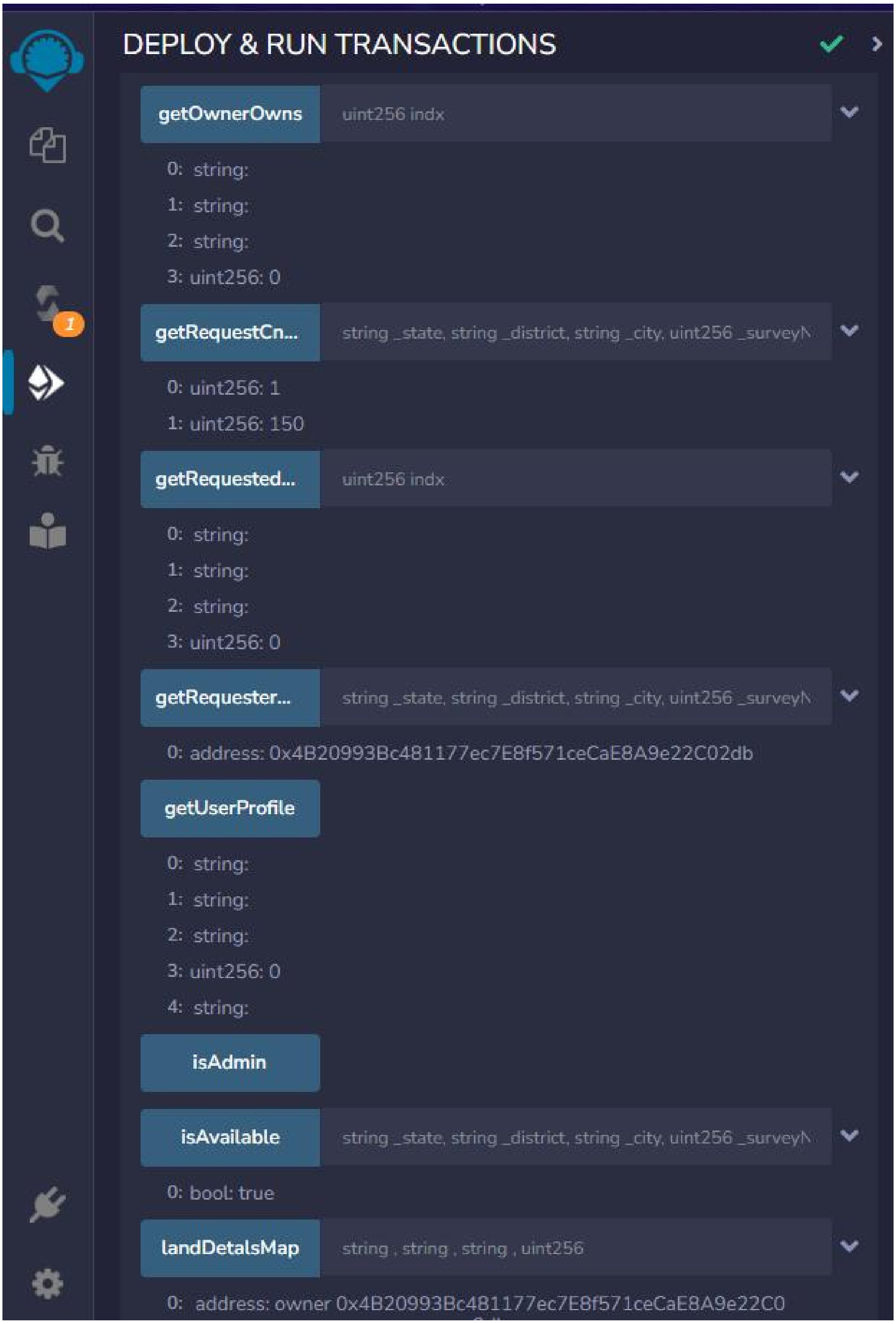

Figure 11: Details of user and property id

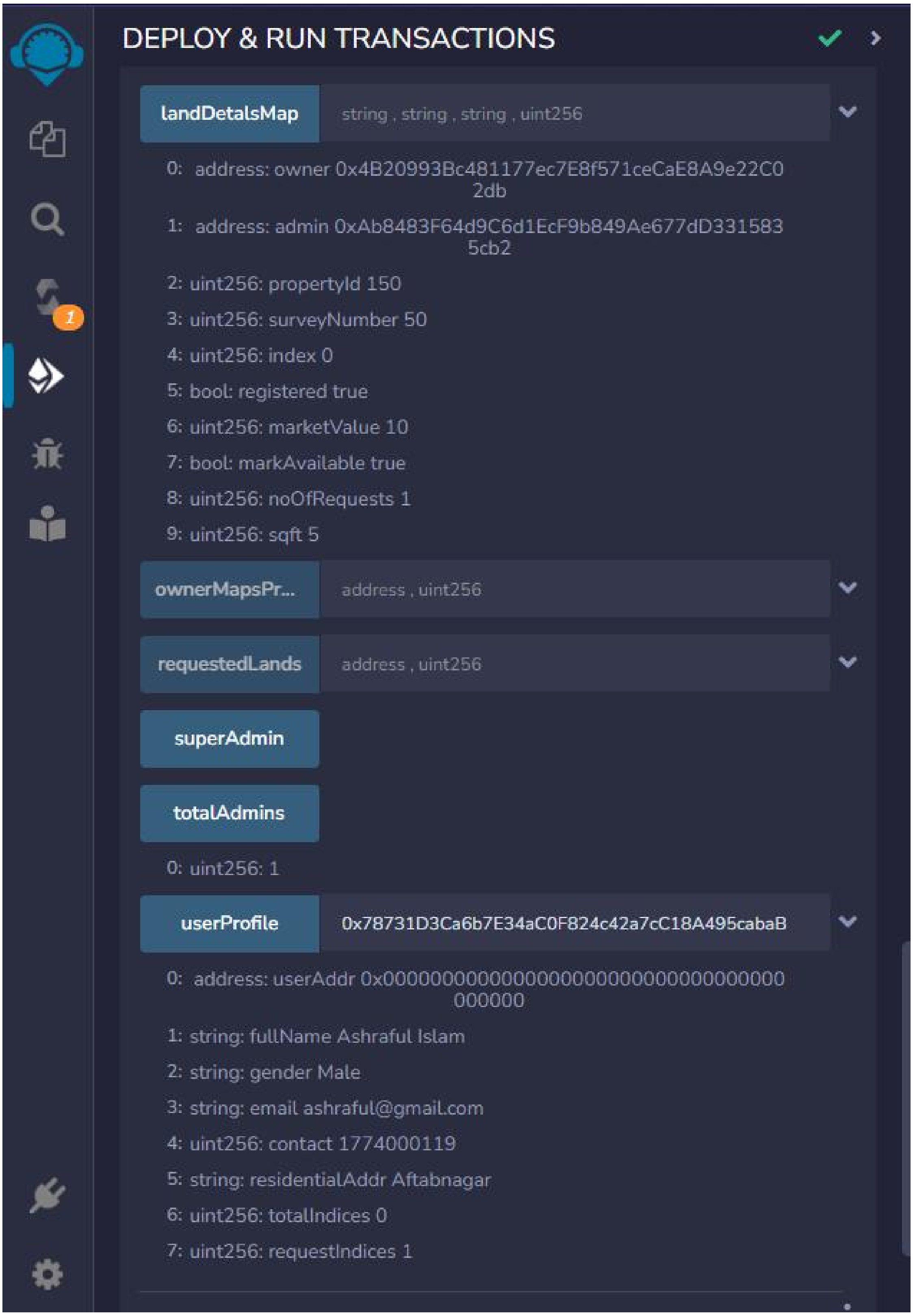

Figure 12: Maps of land and User Profile Data and Admins Count

4.2 Deployed Blockchain Based Web application

The system's end users have to communicate and create a network through an application. Hence, we have designed our front end with React JS and other JavaScript libraries, and for the back end, we have used Node JS. For the simulation, the open-source blockchain platform Ethereum is used. We have compiled the contract code into the solidity compiler. After collecting the code, we received byte codes and JavaScript ABI. From the byte codes, we deployed it to Ethereum, the test network we chose, Ganache Local Test Net. From our React Application, a user can access the test network through the web3 JS network and modify it as the web3 JS portal also accesses the solidity functions.

We have used ganache and MetaMask extension as a wallet to make the transaction smoother. Our designed application has different profiles for different users, and the accessibility also differs from user to user. The Super admin will add an Admin for a city to investigate and register land for a land owner with the land owner's address. So, Here we kept the trust issue on available land for buyers. Seller means the Owner of the land can update their profile there. They will charge some gas costs to complete this. Then, Any user means buyers from different addresses can see if the land is for sale. If the Owner of this land makes it marked available, then the buyer can request a buy request from the Owner. So, the Owner will find this request in the Request section in the navbar we provide. The Owner can accept the request and confirm that the MetaMask Owner will sell the land to the buyer. Then, if the buyer Goes to the Land Feature, they will see they have acquired the land with their address of block. Also, buyers can see which land they requested to buy in the Requested Feature. Anyone can see the land of anyone using the Survey No of land and details using the Explore Feature.

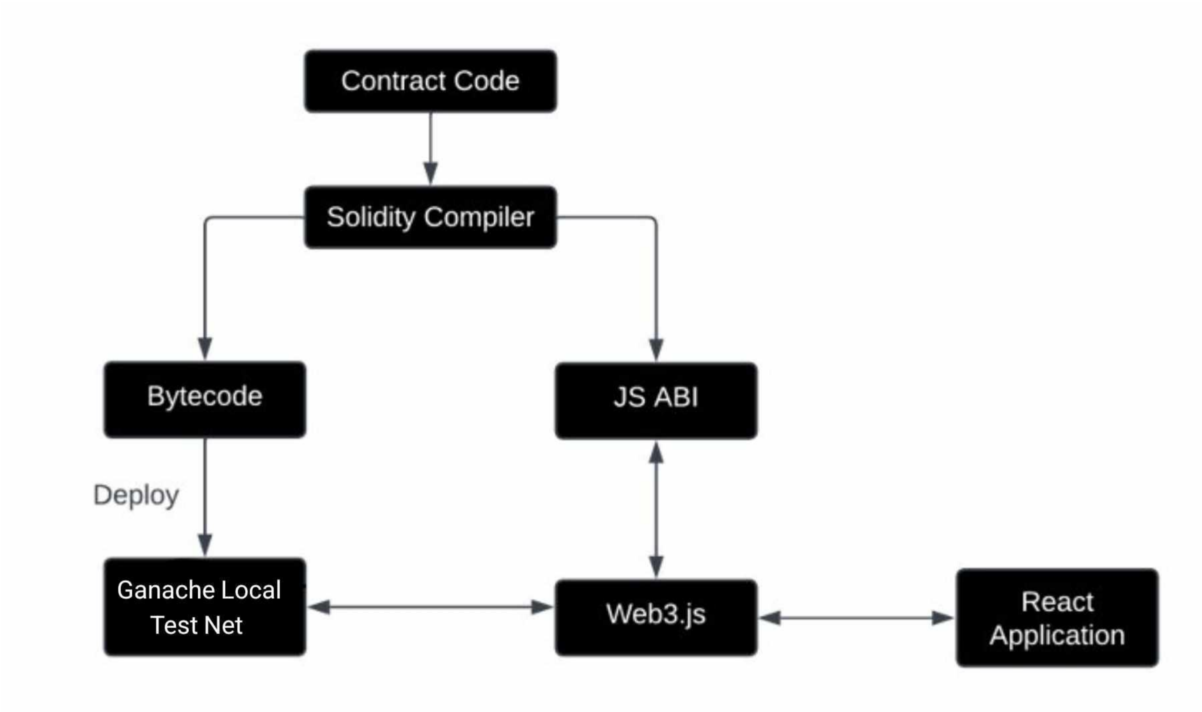

Figure 13: The path of connecting solidity with JS.

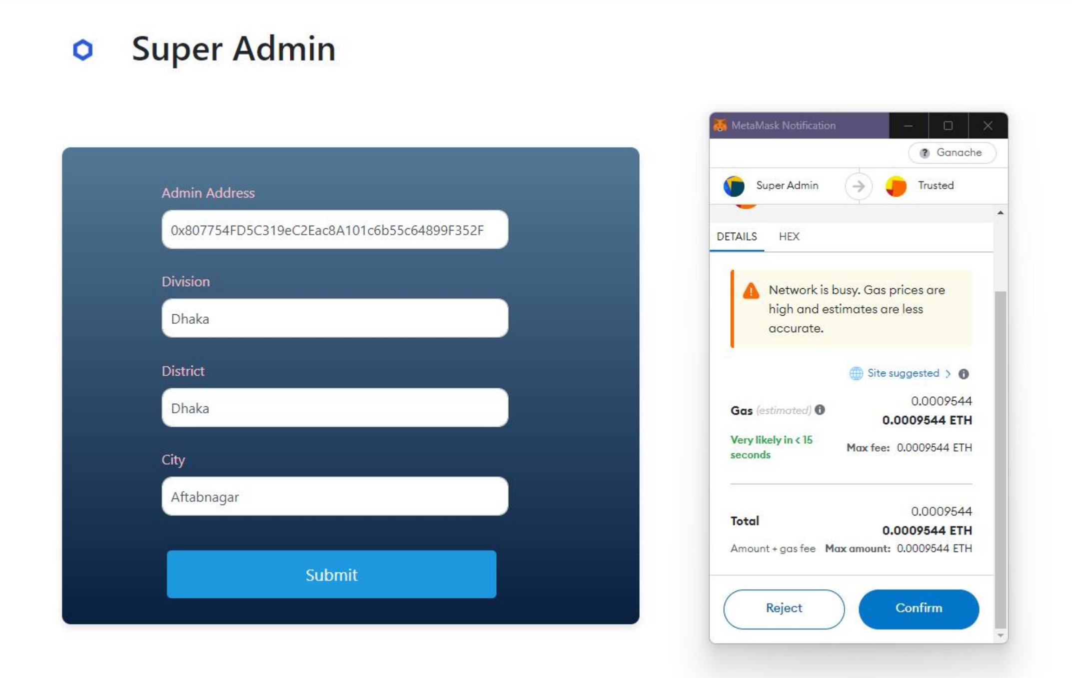

Figure 14: Create Admin

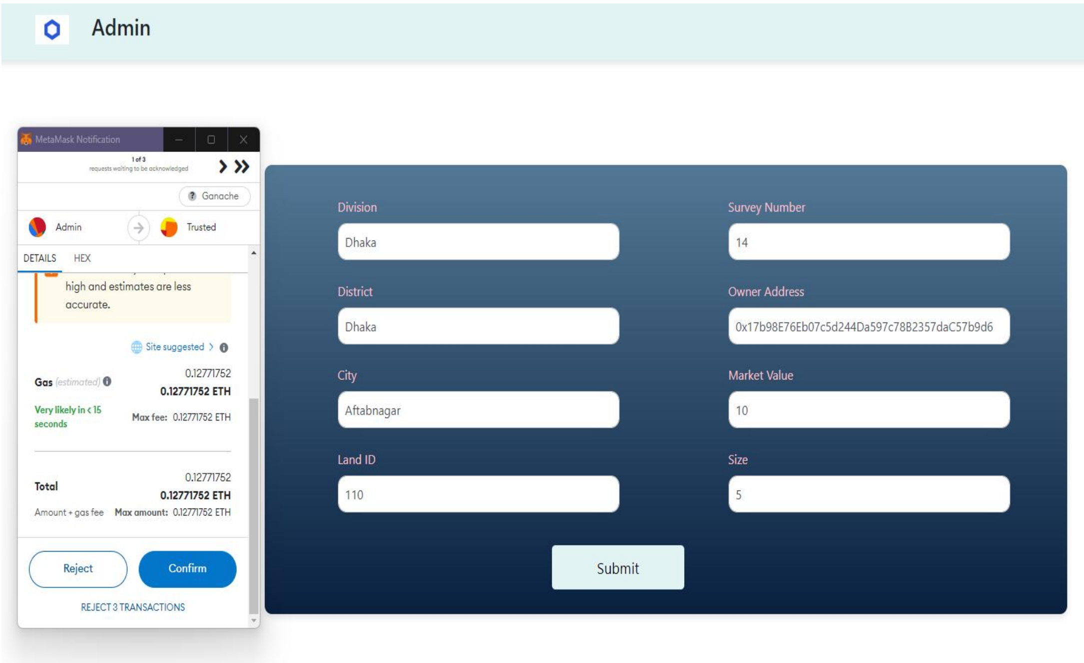

Figure 15: Register New Land.

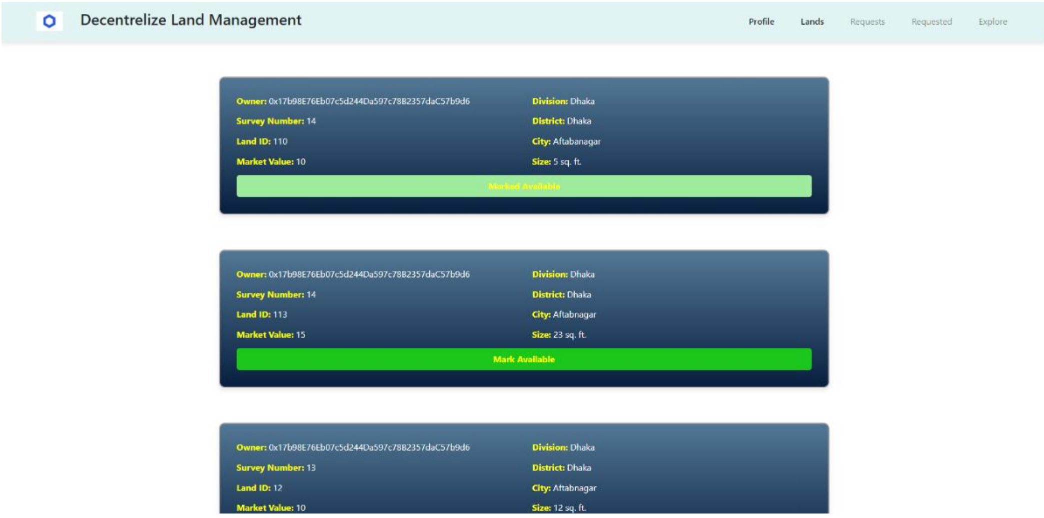

Figure 16: Lands of User-1.

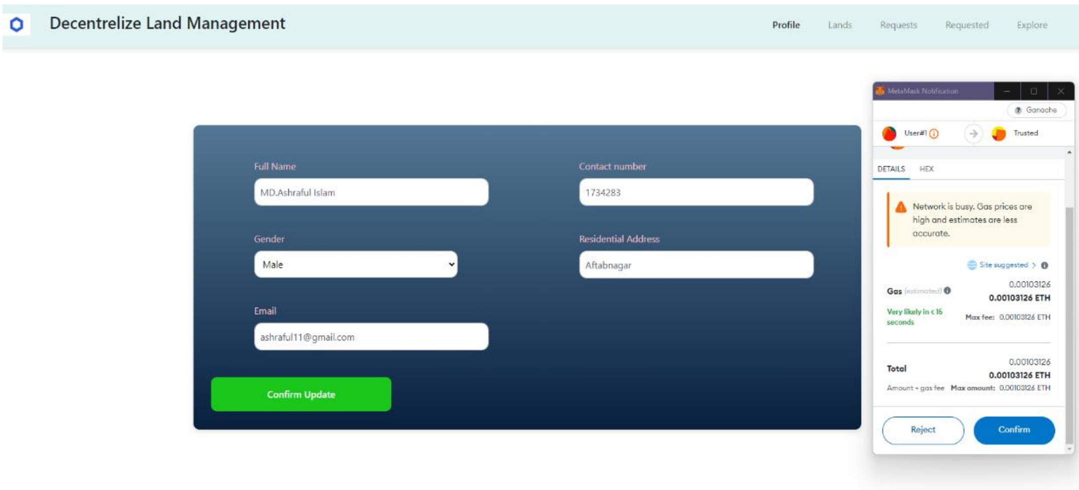

Figure 17: Profile Update by Land Owner.

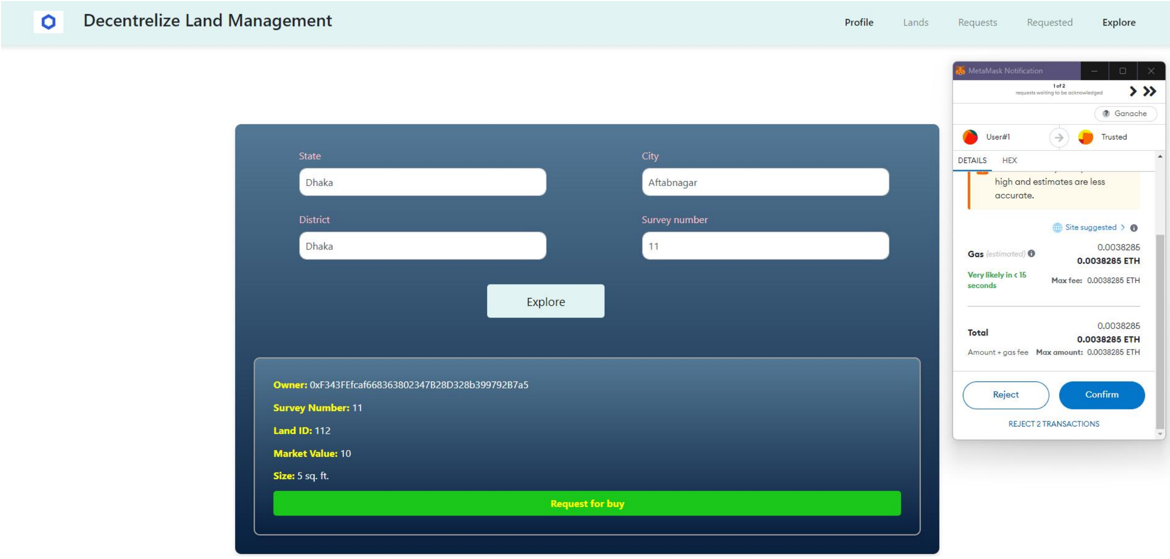

Figure 18: User Request to buy To the land owner.

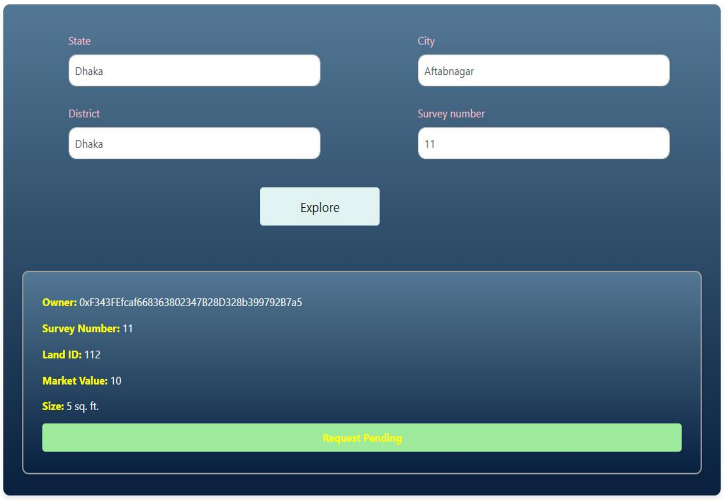

Figure-19: Request Pending in Explore

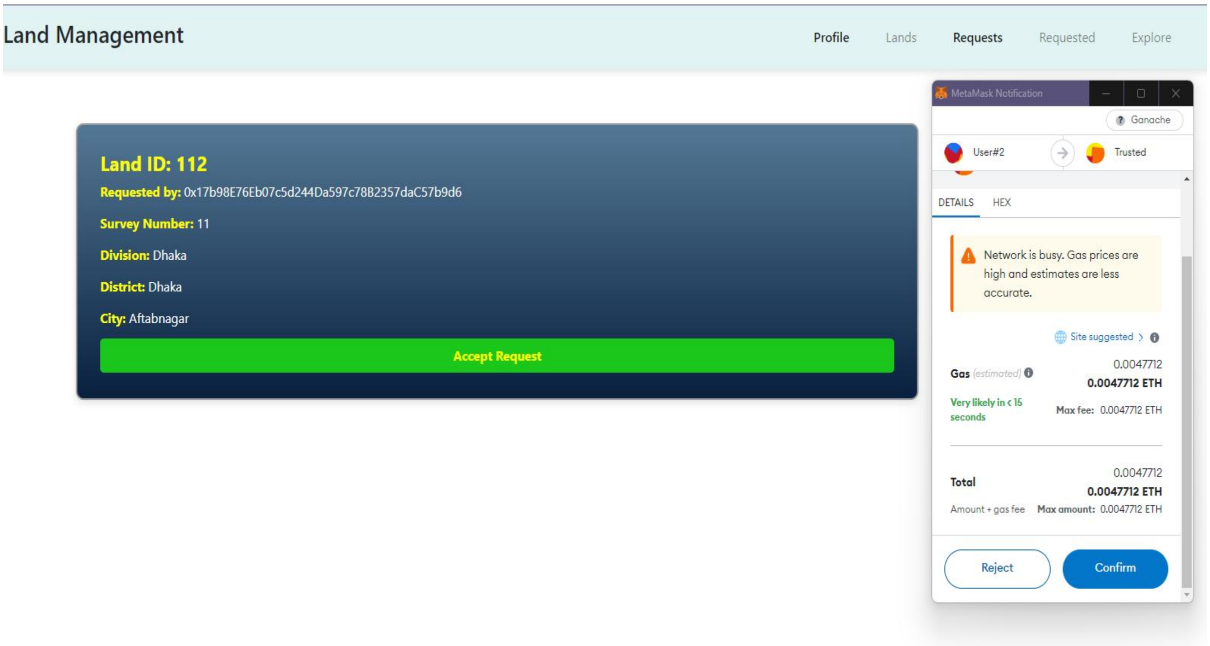

Figure-20: Accept The Request by land owner.

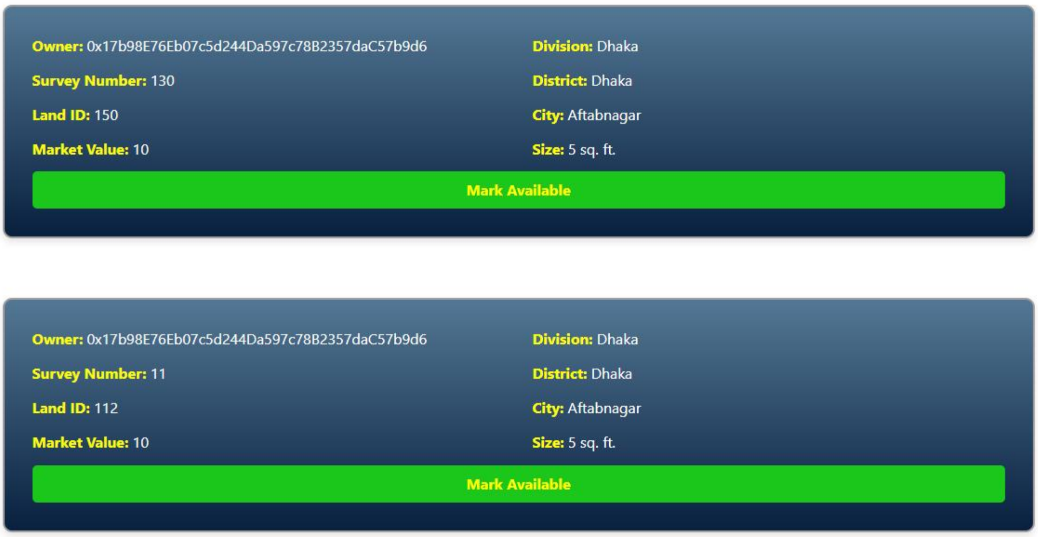

Figure-21: New Owner Of the Land

Figure-22: User Can See the pending Request.

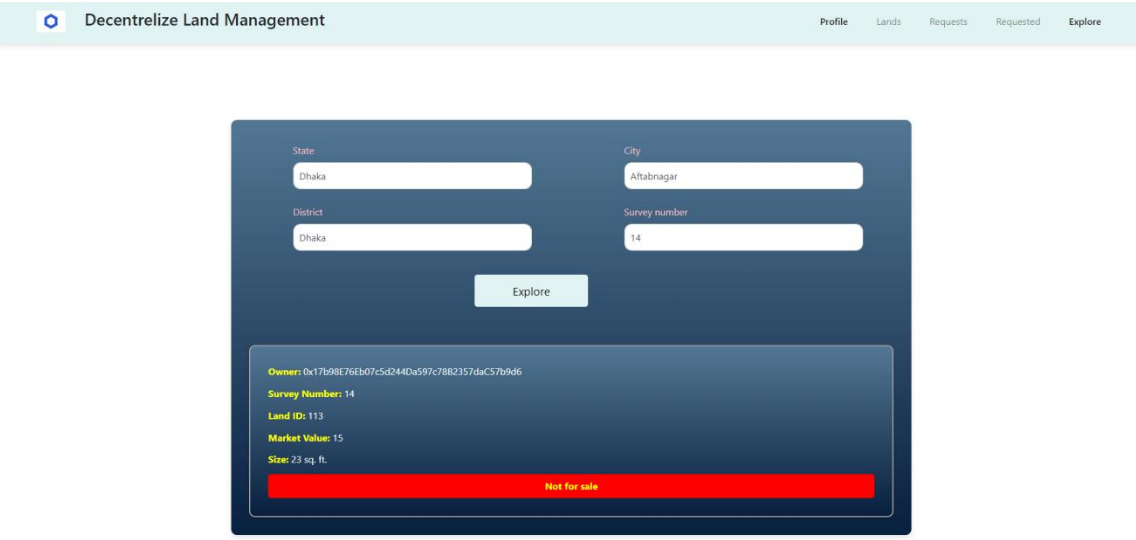

Figure-23: Owner did not listed to sale

4.3 Performance Evaluation

The performance of our application is mainly measured in terms of gas consumption and required time. For this simulation and performance analysis, we used Ganache to deploy the smart contract and make transactions.The configuration of the machine used in testing are intel core i7 11^{th} Gen (3.5 GHz processor), 8 GB 3200 Mhz RAM, 512GB M.2 nvme SSD. The parameters we have used for testing are as follows:

• Gas consumption of the smart contracts.

• Gas consumption against the input parameter size.

• Amount of time spent against the input parameter size.

Table 3, shows the gas price for each transaction on the contract. The gas price to create new requests is higher than others as expected. Here it is also mentioned that The cost for deploying the smart contract over the test network is 0.014521624 Ether or 17.49 USD.

Transaction name	deployed gas	Cost in Ether	Cost in USD
SetUserProfile	151559	0.005153	$13.19
RegisterLand	314146	0.010680964	$27.35
Request For Buy	191425	0.00650845	$16.66
Accept Request	167290	0.00568786	$14.56
Marked Property Available	58294	0.001981996	$5.08
Add admin	137646	0.004679964	$11.98

ation of smart contract (gas price = 34Gwei, 1 ether = 2560.52 USD , 1 ether= 1 billion gwei).

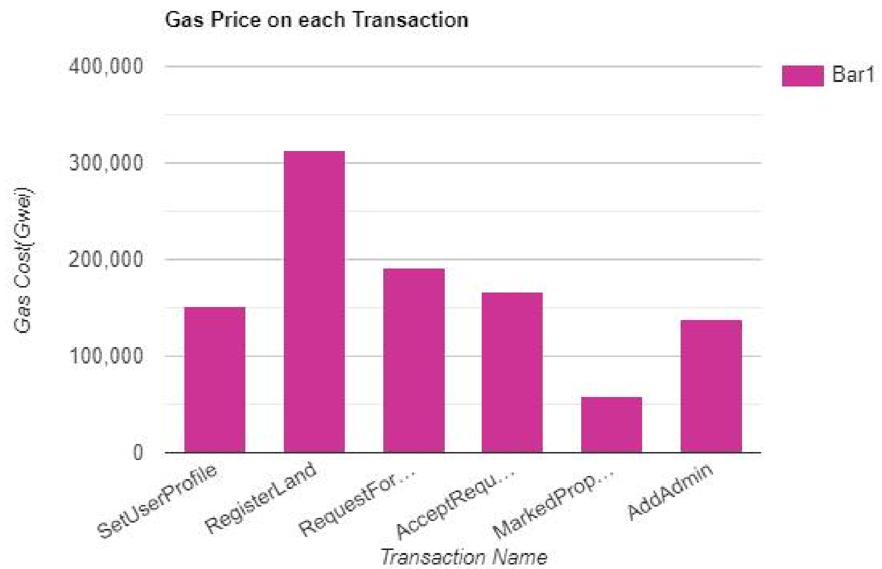

Figure 23: Gas Price on each Transaction.

In figure, to generate Register Land we provided different lengths of inputs and then estimated the cost. For longer input sizes, the gas price was also higher than the previous. So, we can make a statement that a longer input size will cost more than the shorter one.

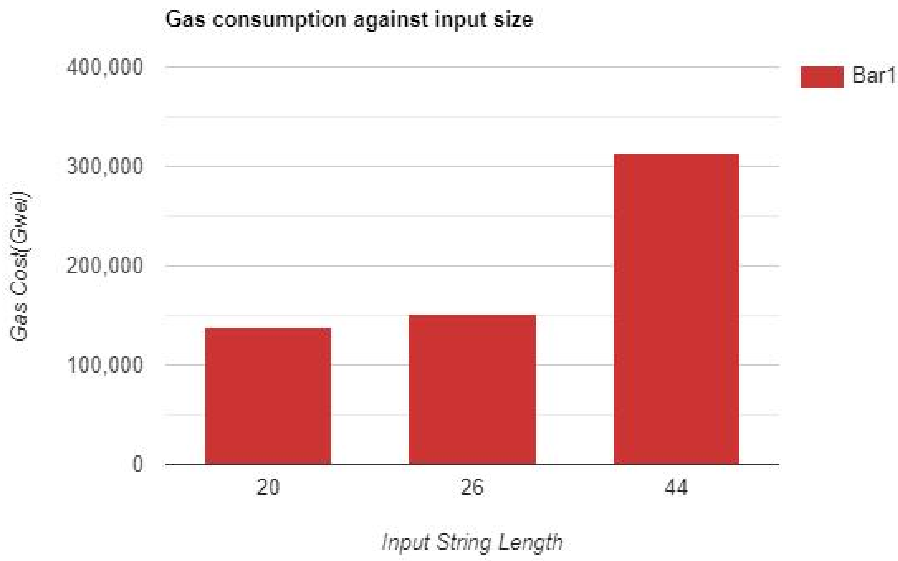

Figure 24: Gas consumption against input size

Next, we tried to estimate the time spent for different sizes of the input. But it is observed that the length of input does not make any difference to the transaction time. In some cases, longer input takes less time than shorter input. However, the connection was stable and smooth during the evaluation process. An unstable network connection can affect the result as well.

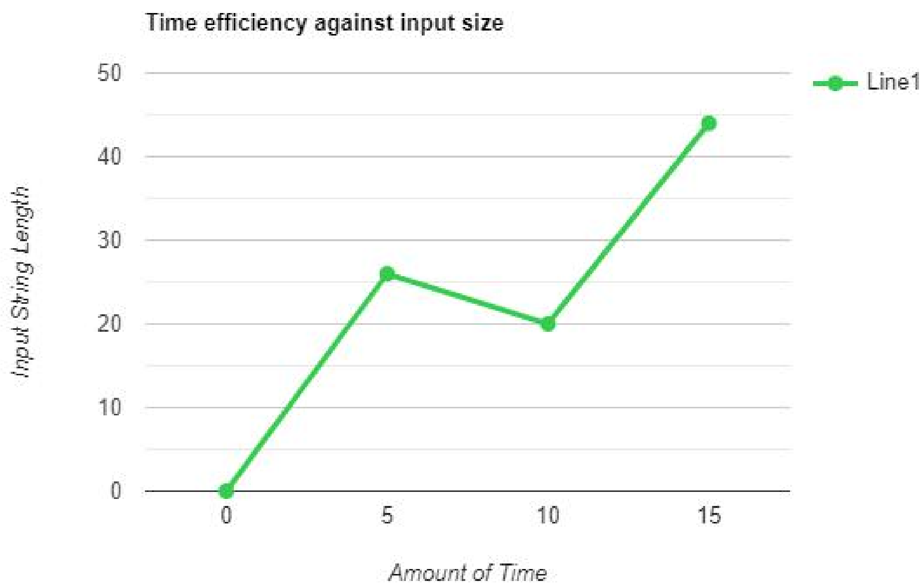

Figure 25: Time efficiency against input size

Chapter 5

Conclusion

5.1 Overall Contributions

We anticipate significant results from putting our model for blockchain-based land transactions into practice. First, smart contracts will make it possible to automate and streamline the process, increasing productivity and reducing the time needed to complete real estate transactions. Both landowners and buyers will profit from the faster ownership transfers and title registrations made possible by this. Second, stakeholder trust and belief in the accuracy and validity of land transaction data will be increased by the immutability and openness of the blockchain ledger. By offering a safe and impenetrable record of transactions, it will lessen the likelihood of fraudulent behavior. It will also improve overall transactional integrity and compliance with regulatory requirements to include governmental and legal organizations in validating the validity and legality of property transactions. By building a transparent, effective, and secure system, our suggested scenario aims to alter land management practices, improve governance, and increase economic activity in the real estate market.

5.2 Limitations and Future Works

In the future, we want to implement NFT for more secure ownership transfer. The NFT generates a unique element that will help to authenticate the owner's claim more precisely. Furthermore, the blockchain nodes can be updated to hold plot locations and images of the land. With the endorsement of the Government, we will try to implement the system on a bigger scale. The proposed framework's effectiveness in real-time transactions hasn't been tested. instead, it is assessed through simulations. Future work will focus on evaluating the system's effectiveness in developing a secure, dependable, and efficient land administration system based on the proposed framework by testing its performance in real-time scenarios.

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Appendix A

Mapping of Course and Program Outcomes

CSE400A

CO	K	EP
CO1	i) K1: To ensure Land authenticity and validity we need to apply ZKP, and we can also do manual validation through city corporation Ameen. K2: Digital Signature method of Ethereum uses ECDSA Algorithm which is Elliptic curve cryptography that uses high computational power based on a complex projective plane is a part of advanced geometry. K3: Software Development Life Cycle and software scheduling.	i)K3: Software Development Life Cycle and software scheduling. K4: Blockchain architecture followed by consensus mechanisms like Ethereum. K5: Information design and system analysis. K8: Literature Paper review on current Land Management Scenario of Bangladesh. ii) Research questions/problem statements [EP6] Integration of different stakeholders : Landowners ,Buyers ,Government Agencies, Legal Authorities
CO2	i)Related works[K8] · Literature paper review on current Land management and exchange system of Bangladesh. · Paper review on smart contract deployment on the blockchain-based Land management. · Literature review in Land management based on blockchain ensuring traceability and transparency.	i)Related works [EP1] K5: BPMN Design. K6: Simulation-Based Blockchain Deployment. ii) Objectives [EP2, EP6,EP7] EP2: Blockchain is power consuming and expensive technology. So, the most efficient algorithm should be followed. EP6: Integration of different stakeholders. Landowners ,Buyers ,Government Agencies, Legal Authorities EP7: · Central server § Decentralized distributed nodes. · Central application § Web application

		§ Mobile Application · Transactions § Bank to Bank § Cryptocurrency iii) Planned Methodology [EP2, EP6] EP2: Blockchain is power consuming and expensive technology. So, the most efficient algorithm should be followed. EP6: Integration of different stakeholders. Landowners ,Buyers ,Government Agencies, Legal Authorities

CSE400B

CO	CO Descriptions	K	EP
CO1	**Analyze** various aspects of the objectives for designing a solution for the capstone project.	i)Problem Analysis [K1, K2, K3, K4] **K1:** To ensure Land authenticity and validity we need to apply ZKP, and we can also do manual validation through city corporation Ameen. **K2:** Digital Signature method of Ethereum uses ECDSA Algorithm which is Elliptic	(i) Problem Analysis [EP1, EP2, EP3, EP6, EP7] **EP1:** ***K5:*** System Architecture Design, UML, Level-1 data flow diagram, traceability chain. ***K6*****:** Simulation-Based Blockchain Deployment.

		curve cryptography that uses high computational power based on a complex projective plane is a part of advanced geometry. **K3:** Web Application Development Life Cycle and software scheduling. **K4:** Blockchain architecture followed by consensus mechanisms like Ethereum. Using Remix to write Solidity contracts straight from the browser.	**EP2:** Blockchain is power-consuming and expensive technology. So, the most efficient algorithm which is Ethereum is followed. **EP3:** For taking all of the stakeholders into one platform while ensuring the integrity and confidentiality of the data was quite challenging. Moreover, deploying using Ethereum while they switched from proof of work (PoW) to proof of stake(PoS) without acknowledging any previous guidelines. **EP6:** Integration of different stakeholders. . Buyers · Sellers · Authority **EP7:** · Central server ➢ Decentralized distributed nodes. · Central application ➢Web application · Transactions ➢Delivery

			➤Automated payments
CO4	**Design** and **develop** solutions for the capstone project that meet public health and safety, cultural, societal, and environmental considerations.	(i) Design and Implementation [K5] For visualizing the blockchain-based land management model, system architecture and workflow process figures were designed. As part of the conceptual approaches, the UML use case diagram, Traceability chain, and Level 1 Data flow diagram were designed to visualize the transactions process between stakeholders.	**EP1:** ***K5:*** System Architecture Design, UML, Level-1 data flow diagram, traceability chain. ***K6*****:** Simulation-Based Blockchain Deployment.(deploying the smart contract architecture) **EP2:** Blockchain is power-consuming and expensive technology. So, the most efficient algorithm which is Ethereum is followed. **EP4:** Connecting the solidity contract code with the JavaScript application and connecting the live transaction at the same time is one of the challenges that have been overcome. **EP5:** Throughout this model, we have tried to maintain a standard coding protocol and tested our codes to some extent. The variables in our codes are declared considering the

			functionality hence it is simple yet understandable. We have tried to implement an efficient data structure as well. **EP6:** Integration of different stakeholders. . Buyers · Sellers · Authority **EP7:** · Central server ➢ Decentralized distributed nodes. · Central application ➢Web application · Transactions ➢Delivery ➢Automated payments
CO5	**Identify** and **apply** modern engineering and IT tools for the design and development of the capstone project.	Materials and Devices [K6] The blockchain-based web application is built with the help of JavaScript and React JS. For storing and tracking the	Materials and Devices [EP1, EP2, EP4, EP5] **EP1:** ***K5:*** System Architecture Design, UML, Level-1 data flow diagram, traceability chain. ***K6*:** Simulation-Based

		transaction of the data MongoDB and Node JS have been used. For completing the Know your customer (KYC) protocol firebase has been used. Solidity is used for deploying a smart contract, and an open-source wallet Metamask was used for doing transactions among stakeholders on test networks. Web3 library has been used for connecting Metamask to the web application.	Blockchain Deployment. (Blockchain-based Web Application) **EP2:** Blockchain is power-consuming and expensive technology. So, the most efficient algorithm which is Ethereum is followed. **EP4:** Connecting the solidity contract code with the JavaScript application and connecting the live transaction at the same time is one of the challenges that have been overcome. **EP5:** Throughout this model, we have tried to maintain a standard coding protocol and tested our codes to some extent. The variables in our codes are declared considering the functionality hence it is simple yet understandable. We have tried to implement an efficient data structure as well.
CO6	**Assess** and **address** societal, health, safety, legal, and	**Social and Environmental**	Social and Environmental Impact of Engineering [EP2,

	cultural aspects related to the implementation of the capstone project considering the relevant professional and engineering practices and solutions.	**Impact of Engineering [K7]** This model was developed with the motive of helping one of the most significant contributors to the economy of the country. This model tried to solve one of the alarming problems of society which is price disparity. By implementing this model, the quality of the products will be assured. Moreover, socioeconomic growth will be spread out among all levels of society, which would help in upgrading the living standard of people to some extent.	EP5, EP6] **EP2:** Blockchain is power-consuming and expensive technology. So, the most efficient algorithm which is Ethereum is followed. **EP5:** Throughout this model, we have tried to maintain a standard coding protocol and tested our codes to some extent. The variables in our codes are declared considering the functionality hence it is simple yet understandable. We have tried to implement an efficient data structure as well. **EP6:** Highest avails and fair pricing among different stakeholders. . Buyers · Sellers · Authority

CSE400C

CO	K	EP
CO7	This blockchain based application was built with the motivation of solving land management model of Bangladesh. ➢ To add value chain in model. ➢ Keep everything transparent. ➢ Reduce the unauthorized activities. ➢ create societal peace and harmony among the stakeholders of the Land management application.	**EP5:** In this application the number of intermediaries in the Land management is reduced and implementing the model using blockchain, creating smart contracts and making the whole transaction process transparent was not easy to do. **EP6:** In this applications there are diverse number of stakeholders available: Buyers Sellers Authorities
CO8	This application was built by abiding all professional and societal ethical rules and regulations. The application was built using blockchain but the transaction method that we would be applying was mobile banking as cryptocurrency is prohibited in Bangladesh. While conducting this project no societal issues or problems occured. The application contains a consensus algorithm hence there is no possibility for tempering the user's given information.	**EP2:** Blockchain is power consuming and expensive technology. So, the most efficient algorithm should be followed. ***EP6:*** Integration of different stakeholders. . Buyers . Sellers . Authorities
CO9	This application was designed, built and implemented by all of the team members. Each one of us worked dedicatedly to deploy this application.This project efficiently guided us	**EP5:** Throughout this model, we have tried to maintain a standard coding protocol and tested our codes to some extent. The variables in our

	to work in a professional environment.	codes are declared considering the functionality hence it is simple yet understandable. We have tried to implement an efficient data structure as well.
CO10	This application has it's own documentations, designs and structure before it was deployed. This application also abides by the life-cycle of a software product and it has performance evaluation analysis regarding the costing of using the application.	**EA1**: Throughout this implementation of this application, we have used materials and resources. We have used documentation regarding Ethereum and solidity. To built smart contracts we used online platform like Remix. **EA2:** The main challenge while deploying this project was to connect smart contracts with our web application and make it responsive in every device possible. **EA3:** The idea of implementing this application was innovative as there is so far no application built with merging smart contracts in a web application. Also, Ethereum moved from Proof-of-Work to Proof-of-Stake while we were about to implement the application. Hence, there are not numerous projects built after ethereum moved to proof-of-stake. **EA4:** If this application is deployed in society this will bring socio-economic development in the economy. This application will also reduce the use of vehicles as the shipment process will be minimal. **EA5:** There were certainly

		some challenges across while conducting the implementation phase of the application. Merging the smart contract updates in corresponding UI of the web application was one of them.
CO11	As per the economic analysis, this application will definitely bring positive change to the economic region of Bangladesh. The fair price of the lands will bring ease among the producers to the consumer chain. Every stakeholder of this application will not face any discrimination or unauthorized activity while doing transactions between the stakeholders. As the system will be transparent and it will ensure accountability and reliability as well. The cost estimation of MetaMask platform requires the gas prices. Here gas price = 13 Gwei, and 1 ether =1204.24 USD has been used. This application will be used by the stakeholders, and it will be maintained by the team members of this project.	**EP2:** Blockchain is power consuming and expensive technology. So, the most efficient algorithm should be followed. **EP5:** In this application the number of intermediaries in the blockchain based land management is reduced and implementing the model using blockchain, creating smart contracts and making the whole transaction process transparent was not easy to do. **EP6:** In this applications there are diverse number of stakeholders available: . Buyers . Sellers . Authorities
CO12	This project has taught us the environment of working in the professional phase as developers.	**EA1**: Throughout this implementation of this application, we have used materials and resources. We have used documentation regarding Ethereum and solidity. To built smart contracts we used online platform like Remix. **EA2:** The main challenge while deploying this project was to connect smart

		contracts with our web application and make it responsive in every device possible. **EA3:** The idea of implementing this application was innovative as there is so far no application built with merging smart contracts in a web application. Also, Ethereum moved from Proof-of-Work to Proof-of-Stake while we were about to implement the application. Hence, there are not numerous projects built after ethereum moved to proof-of-stake. **EA4:** If this application is deployed in society this will bring socio-economic development in the economy. This application will also reduce the use of vehicles as the shipment process will be minimal. **EA5:** There were certainly some challenges across while conducting the implementation phase of the application. Merging the smart contract updates in corresponding UI of the web application was one of them.