Addis Ababa Institute of Technology

School of Electrical and Computer Engineering

COMPUTER STREAM

Final Year Project Proposal

TITLE: Blockchain-Based Land Management System

GROUP MEMBERS:

1. Bisrat Berhanu UGR/6935/13
2. Yonatan Tizazu UGR/5812/13

ADVISOR: Mr. Kinde Mekuria

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Abstract

This paper investigates the application of blockchain technology to enhance transparency and accountability in land governance. We explore how blockchain can improve the efficiency, data management, and transparency of land administration systems. By leveraging blockchain’s key features—such as decentralized data storage, transparency, and immutability—we demonstrate how it addresses the limitations of traditional, paper-based land records. Conventional systems require extensive manual processing, which is time-consuming and labor-intensive. Additionally, land ownership data in these systems is susceptible to tampering, loss, and physical damage. Blockchain's architecture facilitates fast data retrieval and robust protection against forgery by preventing unauthorized modifications of sensitive information. Our study also addresses potential challenges in implementing blockchain for land governance, including the need for supportive government policies and the ongoing development of blockchain technology.

CONTENTS

Introduction

Land is a critical natural resource essential for housing, agriculture, and infrastructure development, playing a key role in driving economic growth. Effective land management is necessary to ensure its optimal use, yet traditional land management systems face challenges that can hinder economic progress. These systems often rely on paper-based records and manual processes, which are inefficient and susceptible to corruption.

In today's technology-driven world, various sectors are embracing digital advancements to improve operations, and land management is no exception. Among emerging technologies, blockchain stands out as a promising solution, providing a transparent, decentralized, and tamper-proof method for data storage. Blockchain technology can address the inefficiencies and vulnerabilities of traditional land management by offering secure and transparent mechanisms for recording land transactions and ownership data.

Blockchain’s attributes reduce many challenges of traditional data handling. Specifically, it enables secure, transparent recording of land transactions, real-time tracking, and builds trust among stakeholders by reducing the risk of corruption. Consequently, a blockchain-based approach to land management presents benefits for both government entities and citizens, enhancing transparency and accountability.

However, blockchain’s adoption in land management remains limited, necessitating more comprehensive research and practical implementations to realize its full potential. This research explores the specific application of blockchain technology in land governance, analyzing its foundational principles, mechanisms, and anticipated benefits.

Statement of the Problem

In the traditional land management system, data is mainly stored in a paper based approach. This is highly exposed to unauthorized modification, leading to significant issues . Such kind of issues happen due to lack of proper data organization or deliberate alteration of data for one's gain.

In recent times we are hearing cases where more than one owner claims the same land and both parties seem to have legal data which verifies that they own the land. The existence of such a scenario in the current data handling of land management systems, given the importance of land, has initiated the need for developing a blockchain assisted approach to transparent and accountable land governance. The nature of blockchain technology offers a decentralized, transparent, and immutable platform for recording land transactions and ownership information which opens the door for ensuring that all parties that are involved have access to the same accurate information.

Literature Review

Two literature papers have been investigated for analyzing the problem at hand. The papers were chosen to have a diversified view and also touch different aspects of land governance issues around the world.

Purpose and Scope

The study of the literature aims to demonstrate our comprehension of the state of the art in blockchain-based land governance studies. Our objective is to look into any potential barriers to the implementation of such a system. We will also look at several blockchain technologies that may be applied to land governance. This review will draw attention to the gaps in the literature, highlight any disagreements, and stress the importance of more research in this field.

[1] A Blockchain-based Land Title Management System for Bangladesh

Critical problems with Bangladesh's current land titling procedures are highlighted in the research on blockchain-based land management systems. The issues include document fabrication, a high rate of civil disputes, administrative complexity, and a lack of integrity and security. Anisha Tasnim, Aysha Akther, Kazi Masudul Alam, and J.M. Ashfiqur Rahman suggest a progressive implementation of blockchain for land title management in Bangladesh. Their solution, which eventually switches to a hybrid paradigm, incorporates a public blockchain for data synchronization and transparency. They investigate techniques that enable effective data handling and economical transactions, such as byte32 storage and JavaScript-based Keccak256 hashing. Blockchain is a mechanism for immutable, synced records, which might simplify the current disjointed system and stop fraud, according to major popular hypotheses. The Ethereum implementation of the authors' prototype acts as a proof-of-concept and illustrates the system’s ability to reduce administrative delays and improve access to land records.

The literature's primary concerns include how blockchain might resolve data integrity problems, how decentralized solutions could expedite administrative procedures, and what obstacles can stand in the way of blockchain's widespread practical implementation in a nation with a weak digital infrastructure. The authors' methodology is in line with the phased approach, which starts with a public ledger and progresses to hybrid blockchain models. Their exploration of blockchain's potential to handle high

transaction costs and disputes is successful thanks to their usage of smart contracts on Ethereum test networks. The study supports the idea that blockchain technology has potential for digitizing land records and might be used as a template for other countries dealing with comparable administrative challenges.

In conclusion, this work demonstrates that a carefully phased blockchain approach can significantly benefit land title management in Bangladesh by enhancing transparency, security, and efficiency.

[2] Securing Land Registration using Blockchain

This paper argues that traditional land registration systems are inefficient and prone to fraud. It proposes blockchain technology as a solution to these problems. Blockchain offers a secure, transparent, and efficient way to record land ownership information.

Cryptographic techniques like SHA256 hashing, elliptic curve cryptography (ECC), and Merkle Trees are used to ensure data integrity and security. Real-world applications of blockchain in other sectors, such as real estate and education, demonstrate its potential for land registration.

The paper suggests we should use Proof-of-Work as a consensus mechanism. However, implementing a full-scale blockchain system with Proof-of-Work consensus for land registration is not practical. Proof-of-Work requires significant computational power and energy consumption, making it expensive and environmentally unsustainable.

Research Questions and Hypothesis

Research Questions

Here are the key questions that we will address in this research

1. How the implementation of a blockchain based land management system improves transparency and accountability of land administrators?
2. In what ways the deployment of blockchain technology impacts the accuracy and reliability of land ownership and transaction records?
3. How will the use of blockchain technology reduce corruption and unauthorized modification of data related to land ownership and transactions?
4. What are the potential challenges and difficulties that we might encounter during the implementation of blockchain for land management and administration?

Hypothesis

These are the corresponding hypotheses, covering all important areas of the project:

1. The integration of blockchain technology in land management will enhance transparency and accountability in land transactions, making it easier to track changes and verify ownership by using blockchains' decentralized nature.
2. Implementing a blockchain-based land management system will significantly improve the accuracy and reliability of land ownership records by providing a secure and immutable record keeping mechanism.
3. Using blockchain for recording land transactions will reduce corruption since it prevents unauthorized modification or abuse of data, for once gain, by providing an immutable and transparent mechanism.
4. We expect some challenges which will affect the implementation of blockchain on the ground. The challenges that we might encounter include technical integration issues, high initial costs, government policies and resistance to change from all parties who are involved in the process.

Conceptual framework

This study's conceptual framework focuses on how blockchain technology might enhance land governance's transparency and accountability. To give readers a clear grasp of the research background, this framework lists the important variables and explains the way they relate to one another. An input-process-output model is used to structure the analysis.

Input Variables

Blockchain Infrastructure: This includes the setup of blockchain nodes, smart contracts, and decentralized ledger protocols. It measures the availability and scalability of blockchain technology, such as Ethereum or Hyperledger.

Data Entry Accuracy: Accuracy of initial land records, user IDs, plot information, and ownership percentages entered into the blockchain. Measured by the correctness and completeness of data.

User Accessibility and Technical Literacy: Evaluates users' ability to access and interact with the blockchain-based system, especially for those with limited digital skills. This may include measuring system usability and user support needs.

Cost of Transactions and Storage: Considers gas fees, storage costs, and overall financial expenditure required to maintain and operate the blockchain network. This input assesses financial feasibility for large-scale adoption.

Regulatory and Legal Compliance: Measures the system's alignment with national land laws, property rights regulations, and data privacy standards.

Processes

Data Hashing and Encryption: This involves using cryptographic algorithms, to secure and verify data entries in the blockchain, ensuring immutability and integrity.

Smart Contract Execution: Smart contracts automate ownership transfers, record updates, and property disputes, providing a transparent, tamper-proof transaction history. Processed automatically based on predefined rules.

Record Storage and Retrieval: Involves efficient data storage, optimized using byte32 format or other data minimization methods, and retrieval through unique hashes (Khatiyan IDs) for individual land plots.

User Interface and Accessibility Tools: Interface design allows easy data entry and retrieval for users, including government entities, landowners, and potential buyers, possibly through a user-friendly graphical interface.

Output Variables

Data Integrity and Security: Measures the system's ability to prevent tampering, duplication, and unauthorized access to records. Indicators include frequency of data breaches, error rates in data retrieval, and user trust levels.

Administrative Efficiency: Measured by the reduction in processing time for land title verification, transfer, and dispute resolution. Metrics include transaction speed, time saved, and reduced government bureaucracy.

Cost Efficiency: Assesses the reduction in costs related to land title management, including operational expenses and user transaction fees. Lower gas fees and streamlined processes result in measurable cost savings.

User Satisfaction and Accessibility: Evaluates user ease of access and satisfaction with the blockchain system. Collected through user surveys, system usage data, and feedback on user interface functionality.

Legal and Regulatory Compliance: Ensures the blockchain system adheres to property rights laws and data privacy regulations, reducing potential legal conflicts. Measured by the system’s compliance with national policies and regulations over time.

Objective

General Objective

The primary objective of this research is to assess and use a blockchain-based approach to improve land management's efficiency, accountability, and transparency while investigating its potential application in government operations.

Specific Objectives

1. To examine the present issues with land governance's accountability and transparency, paying particular attention to the effects of technology shortcomings.
2. To pinpoint possible applications of blockchain technology in government operations, particularly with regard to land management.
3. To examine different usage and strategies for blockchain technology in order to solve the problems of transparency and accountability in land governance.
4. To evaluate the potential advantages and disadvantages of integrating blockchain technology into the current land governance systems.
5. To offer suggestions to lawmakers on how to use blockchain technology to improve land administration's accountability and transparency.

Research Methods, Materials and Procedures

Study Area

The selection process of the location of the research took the following factors into consideration:

- The existence and form of land records
- Modernity of existing infrastructures
- Easy adaptability to new processes and technology
- Scope of the research

After taking the above considerations, the research scope will reside in Addis Ababa, Arada Sub City.

Methods of Data Collection

- Document analysis: Reviewing existing land registry records, legal documents related to land ownership and transactions, and relevant government policies on land management.
- Interviews and Questionnaires: Conducted on stakeholders like land registry, legal professionals, technology experts to gain insight into the challenges in the existing land management system and the challenges and perspectives on implementing blockchain systems.

One of the key steps to be taken in the data collection phase is the process of digitizing land records. In the traditional land management system, key documents such as ownership certificates, sale/transfer records and other similar documents exist in paper form. Moving forward to implementing blockchain in a modern land management system, converting these documents into digital form is of crucial importance.

Description of Variables

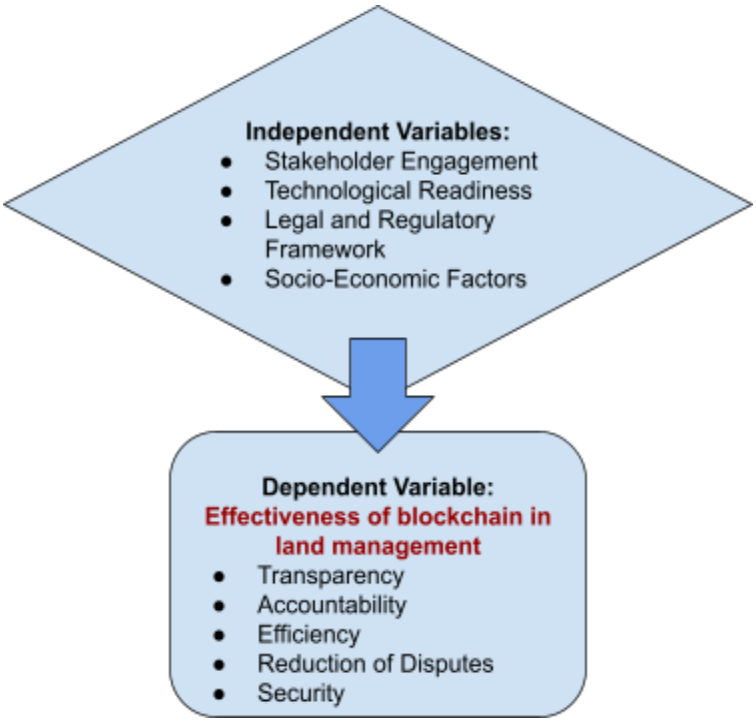

Fig: Outline of dependent and independent variables of the research

The control variables that have been identified are the following:

- Diversity of existing records
- Level of existing digital infrastructures

Activities

1. Select a suitable blockchain platform

This step will prove crucial to the rest of the research as the entirety of the proposed modern land management system will fully reside on the platform of choice. The following factors have been taken into consideration while an appropriate platform was chosen:

- **Scalability:** Ability to handle a high volume of land transactions efficiently.
- **Security:** Robust cryptographic protocols to ensure data immutability and prevent unauthorized access.
- **Privacy:** Mechanisms to protect sensitive land ownership information while maintaining transparency.
- **Regulatory compliance**
- **Cost**

Potential platforms for land management include Hyperledger Fabric, Ethereum, and Coda.

2. System Design

The blockchain layer consists of two essential modules. The first one being a digital ledger. A blockchain digital ledger is a distributed and decentralized database that maintains records of transactions which are linked and secured using cryptographic techniques. The setup of this digital ledger is inherent to the blockchain platform of choice. The other module is smart contracts. This depends on the specific application the blockchain platform is used for, hence it will require design attention.

❖ Smart Contracts

This process is primarily concerned with setting up a land Registry Smart Contract. A smart contract is a self-executing contract deployed on the blockchain that governs the core functionalities of the land management system. The contract will be programmed to handle land registration, transfer, and sale processes in a secure and transparent manner. The smart contract is expected to define the following:

- ➔ **A Data Structure for Land Records:** This specifies the type and format of data stored on the blockchain. It might include essential details like:
  - Owner identity
  - Plot location
  - Land size and type
- ➔ **Access Control Mechanisms:** The smart contract will enforce rules around who can perform specific actions on land records. This could involve different user roles with varying permissions such as:
  - Landowner: View their land records, initiate transaction requests.
  - Land Registry Official: Process registration applications, approve land transfers, arbitrate disputes.

❖ Identity Management Layer

A secure mechanism for user authentication and authorization is crucial in the system. This can be fulfilled with the provision of digital certificates issued by a trusted third

party. The current initiative of an all inclusive national digital ID in Ethiopia could also prove to be useful for this once it is implemented on a broader scale.

❖ Application Layer

A) Land Owner Portal
   This will be a secure web application designed specifically for landowners to access and manage their land records. It will require login credentials to grant access. The functionalities may include:
   - View information about their registered land parcels including ownership history, plot boundaries and associated documents.
   - Manage profile information
   - Initiate land transfer requests to other users
   - Track the progress of land transfer applications

B) Administrative Portal
   This is a secure platform for land management officials to manage land records, monitor and process transactions and resolve disputes.

C) Public Portal
   This will be a portal accessible to the general public without the need of any credentials. This will give basic, non sensitive information about the registered land records and transactions. This can be of important use for important issues of the likes of research and urban planning.

❖ Off-Chain Data Storage

Aside from the sensitive and valuable information that is decentralized and stored in the blockchain ledger, we can store non-critical land record data like large maps, historical documents in and off-chain storage for cost-efficiency. This will also enable the public portal to directly access all non sensitive information directly from this off-chain storage without the need of authentication.

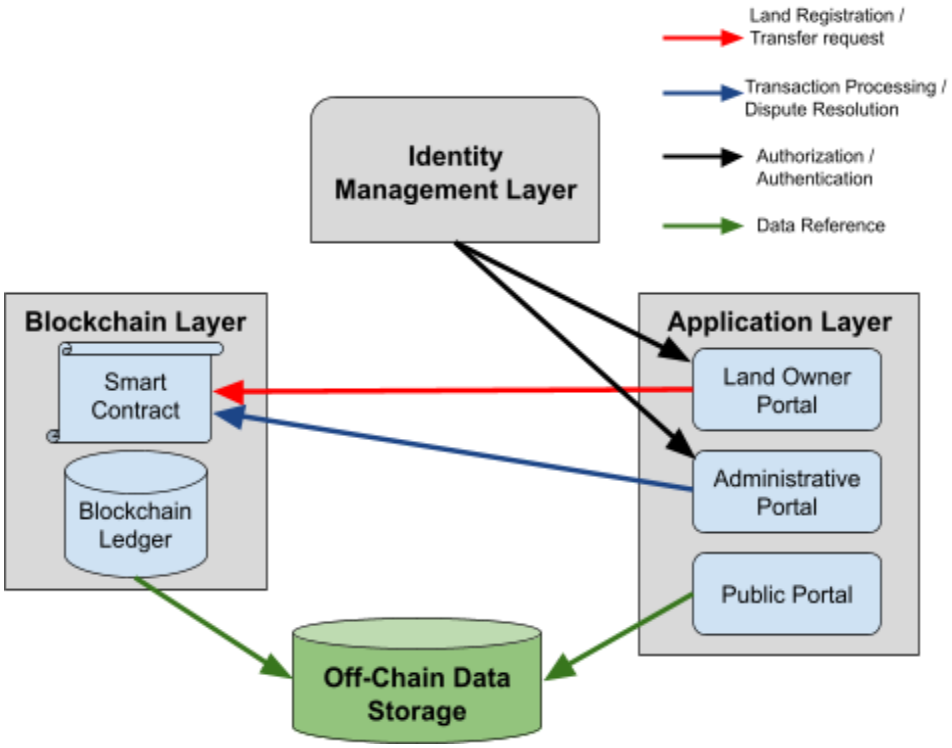

Fig: Outline of the Proposed System Architecture

Operational Definitions:

- **BlockChain Technology:** A decentralized digital ledger that records transactions across multiple digital devices in a way that ensures the data is secure, transparent, and untampered
- **Land Management:** The process of managing the use and development of land resources in a sustainable and efficient manner.
- **Transparency:** The degree to which information about land transactions and ownership is openly accessible.
- **Land Disputes:** Conflicts arising from competing claims over land ownership or use.
- **Smart Contract:** A self-executing contract deployed on blockchain platforms that governs transactions between two parties,
- **Digital Ledger:** A distributed and decentralized database that maintains records of transactions which are linked and secured.

Work Plan For The Research

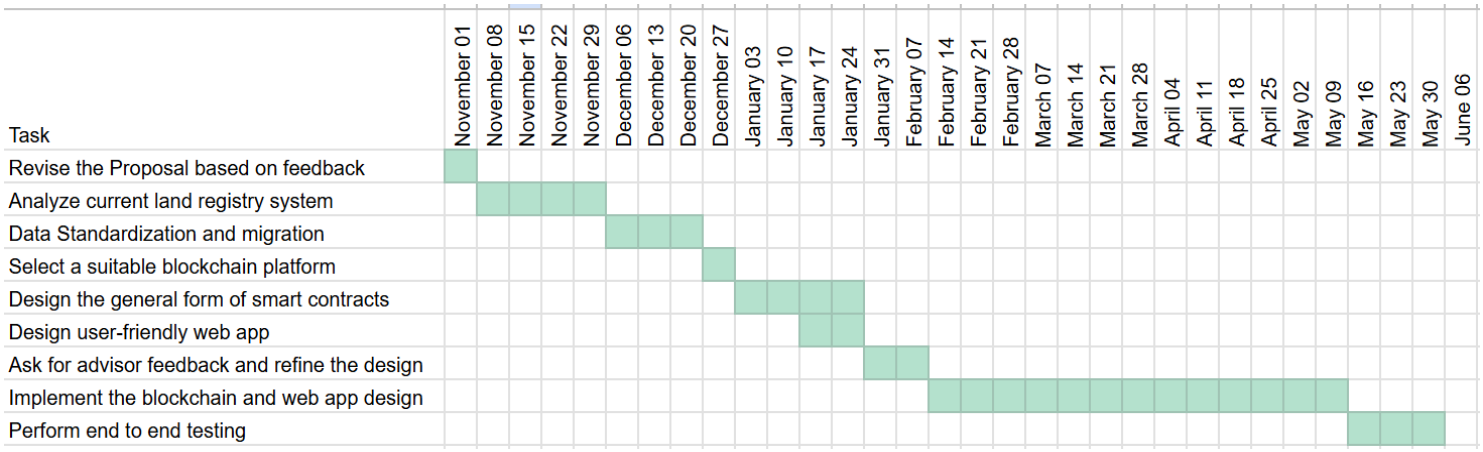

Fig: Gantt Chart For The Work Plan

Budget

Activities	Budget
1. Transportation	2000 - 3000 Birr
2. Contingency fund	3000 Birr

The researchers will primarily use their own PCs to conduct the project, minimizing equipment costs. Transportation expenses are necessary to collect data from government offices, ensuring accurate and relevant information. For hosting the platform and blockchain components, free-tier versions of the required technologies will be utilized.

References

[1] Aysha Akther,Anisha Tasnim,J.M. Ashfiqur Rahman and Kazi Masudul Alam “A Blockchain-based Land Title Management System for Bangladesh”,Available: https://www.sciencedirect.com/science/article/pii/S1319157820304912?ref=pdf_download&fr=RR-2&rr=8d92f7da9adf5458

[2] Krishnapriya S, Greeshma Sarath “*Blockchain-Based Land Record System”*. Available: https://www.sciencedirect.com/science/article/pii/S1877050920311649