Exploration of the Potentials of Blockchain in Helping Assure Public Trust in the Registration of Eligible Citizens and Transfer of Ownership of Public-Funded Houses in Ethiopia

Fesseha Zemenu
fzemenu@gmail.com

Taye Abdulkadir
HiLCoE School of Computer Science and Technology
tabdulkadir@ieee.org

Abstract

As a concept, "trust" is abstract and generally subjective. When there is mistrust between two entities, a third party trusted by both entities is usually involved to build the bridge of trust. This paper [8] sets out to explore the possibility of adapting blockchain technology to serve as the "trusted third party" between untrusting entities. As a case for study, there exists an issue of mistrust between the Ethiopian government (specifically Addis Ababa City Government) and the constituent public in the transparency of the process of registration of eligible city residents and transfer of ownership of public-funded condominium houses for registered, lucky lottery winners in successive rounds. In order to address this problem, the paper expounds the concept of trust first and goes on to explore blockchain technology in relation to its fundamental work in bitcoin. It compares four blockchain platforms, namely, Bitcoin, Ethereum, Hyperledger Fabric, and Multichain, and selects one for prototype implementation based on pre-defined evaluating metrics. The metrics used for the comparison are the platform's customizability, maturity, performance / scalability, security, consensus algorithm, and relevance to the problem under study. The selected blockchain platform is then used for a prototype Proof of Concept (PoC) demo implementation to serve as the main element for assuring public trust in the transparency of the process for registration of residents and transfer of ownership for Addis Ababa Housing Project. Based on the results of the exploratory and comparative analysis, Multichain blockchain platform is selected and the Trust Assurance application prototype system is implemented in the cloud on AWS (Amazon Web Services). The Multichain-based PoC demo showed that the Housing Project data records can be made available publicly, that the system can't be taken offline without turning off all nodes in the distributed peer-to-peer blockchain computing network, that the project data can't be deleted or modified at will, that timestamps are an inherent part of every record, including who published them, and that the chronology of records can't be altered. With the full consent of a Citizen's Board and the Government's goodwill in cooperating with the Board, the results of the PoC demo indicate that the public could trust the Housing Project data records if an enterprise-grade blockchain system is implemented in accordance with the procedures set out in this paper.

Keywords: Trust, Blockchain, Multichain, Addis Ababa Housing Project

1. Introduction

There are certain abstract human issues that technology may not directly address and solve, such as the issue of trust (or rather the lack of trust) that ordinary citizens may have on the activities of their government. A research article [1] from Deloitte outlines that a citizen's trust in government can be defined as citizens' confidence in the actions of a government to do what is right and perceived fair. The research suggests that governments can build and sustain citizen trust by focusing on four areas: humanity, transparency, capability, and reliability.[1] A key finding from Deloitte's research is the capacity of technology and innovation to drive change and to play a key role in trust transformations. Taking transparency as one of the four pillars in building trust between governments and their constituencies, ICT can play a significant role in bridging the trust gap.

One of the areas citizens have big questions of trust in the case of Ethiopia is in the conduct of government-led housing projects. The issue of transparency in this area has been a concern for a long time. Advances in information technology, particularly in innovative applications of blockchain concepts, have shown that technology can help assure citizens on the factual accuracy of verifiable government activities and records that cannot be easily tampered with. Government-led housing projects, in the case of Ethiopia and particularly that of Addis Ababa, are usually surrounded by suspicions and controversies. The public in general has a number of doubts and complaints about the conduct of the projects from registration of eligible citizens up to ownership transfer of housing units to citizens. Although the allocation of houses is done through a publicized lottery scheme, people still have doubts whether all houses are indeed transferred only to those who have been properly registered and only to those who have been lucky winners in successive rounds of lottery draws. It is this issue of lack of trust that this paper tries to address and suggest a mutually acceptable technological solution for the recording of the registration of eligible citizens for condominium houses and the subsequent ownership transfer of houses, that's secure, unchangeable, undeletable, incorruptible, and accessible by all parties for unequivocal verification of the whole process.

The following research questions (RQ) are formulated to address the above stated problems.

- RQ1: Can blockchain technology be used to record basic data about users registered for condominium houses, data about the housing units, and data about the results of successive rounds of lottery draws? If so, can the data thus recorded be kept tamper-free, unchangeable, and stored for perpetuity as promised by blockchain technology?
- RQ2: Is it possible to provide the immutable recorded information related to registered users, condominium houses, and corresponding lottery results accessible for public scrutiny?
- RQ3: How could blockchain technology help in earning the trust of the public and that the public gets assured "beyond any reasonable doubt" that the government-provided record of the housing projects is genuine, and that it couldn't be modified by anyone, even by technical and non-technical people in government authority, and that the information remains available and visible for anyone at any time?

2. Related Works

A research paper entitled "Secure Notarization using Blockchain for the FDRE Document Authentication and Registration Agency (DARA)" by Ashenafi Zena and Mesfin Kifle [3]

investigates the expediting of authenticating notarized documents using blockchain. The paper states that consumers of notarized documents (financial and civil service institutions) resort to authenticating notarized documents against registered copies at the notary as a measure of security. The researchers say such a lengthy security measure leads to delayed service delivery and customer dissatisfaction. Automating this key process has been slow for a long time due to the difficulty of creating efficient and effective digital trust relationship between transacting parties. In the paper, the researchers compare blockchain with similar technologies and adapt it for the purpose of notarization. Their proposed solution is a notarization, registration, and verification system based on an open source blockchain infrastructure. They hypothesized that, blockchain can deliver a secure, open and efficient solution to notarization. The researchers claim to show that development in distributed trust relationships with the advent of blockchain technology is a viable solution to many problems, such as, trusted third-party computation model, single point of failure and the related scalability and availability issues. The proposed solution promises instantaneous and independent verification for consumers of notarization services, providing an expedited service to end consumers, and immediate dissemination of authentication revocation, thereby closing a potential security vulnerability. In another case, academics from Ghana have written a paper [4] with the aim of exploring the potential application of blockchain technology in land acquisition and title registration processes. They say their paper contributes to the existing literature by formally documenting land acquisition procedures, title registration, and potential integration with blockchain technology. The study focuses on improving land acquisition and title registration process by leveraging on blockchain technology as a platform for recording and managing land transactions to achieve certainty of title and security of ownership. They say that as blockchain technology is a new platform, there is no available evidence of how such a novel technology could be leveraged for use in lands acquisition and title registration process in Ghana. [4]. Two other works, one from India [7] on "Securing Land Registration Using Blockchain" and another from the Republic of Georgia, "Integration of Blockchain Technology into a Land Registration System for Immutable Traceability – A Case Study of Georgia" published by Springer from the BPM (Business Process Management) 2019 Blockchain and CEE (Central and Eastern Europe) Forum Vienna, Austria and authored by Lazuashvili et al says, "…critical issues for land are traceability of records, hazards of document forgery as well as vulnerability to various errors...". The authors say that the case study has ascertained to them how blockchain technology resolves certain issues related to land management. [5].

What this paper tries to do is take the relevant points from the different conceptual discussions of the related works and attempt to make a prototype implementation for immutably storing of Addis Ababa's publicly funded condominium housing project registration and ownership transfer data.

3. Exploratory and Comparative Analysis

The methodology used for this paper follows design science research process, particularly the process recommended by Takeda et al, as summarized by Offerman et al [2] in their paper entitled "Outline of a Design Science Research Process". The process follows a phased approach, namely, the enumeration of problems at first (problem identification phase), followed by suggestion of possible solutions (solution design phase), a decision on a solution to be

adopted (evaluation phase), and then arriving at the production of an artefact as proof of concept.

The solution design phase involves exploratory literature research of available solutions and making a comparative analysis of the findings for suitability to the problem under study. Out of the dozens of blockchain platforms available for analysis, four have been selected for the purposes of the paper based on maturity, adaptability, and built-in features. They are Bitcoin, Ethereum, Hyperledger Fabric, and Multichain. Comparison metrics are used to assess the blockchain platforms selected for the study: Accessibility, Maturity, Performance / Scalability, Security, Consensus, and Relevance.

Accessibility metric refers to the "Platform's Accessibility for Customization", that is, the ease of programming the generic blockchain solution for particular use-cases. Maturity metric looks into "Maturity, Documentation, and Community Activity" for the platform under evaluation. It assesses how long the blockchain solution has been active in the industry, the variety of available documentation, and the community of practice. "Performance and Scalability" metric analyzes the transaction processing throughput and the network's ability to adapt to operational capacity needs. "Security" metric refers to the privacy and confidentiality of each of the platforms. Consensus metric refers to the "Consensus Algorithm" or the mining method for the blockchain platform. It is a software algorithm that consists of an automated procedure through which all participants reach a common agreement about the present state of the blockchain network. Relevance metric weighs the "Relevance to the problem under study" in terms of the platform's practicality in assuring trust for the public-funded housing project under case study.

4. The Proposed Solution

4.1 The Proposed Blockchain Platform

Table 1 Comparison of Blockchain Platforms

	Bitcoin	Ethereum	HyperLedger	Multichain
Accessibility / Customization	• GUI, CLI, API • Stack-based scripting	• GUI, CLI, API • High-level programming	• GUI, CLI, API • High-level programming	• GUI, CLI, API • In-built database
Maturity / Community	• The oldest • Rich documentation	• Second oldest • Ranks top for 'Adoption' empirically	• Benefits from the experience of Linux Foundation	• Inherited a mature codebase from Bitcoin
Performance / Scalability	• Limited performance and scalability	• Performs better and is scalable with PoS algorithm	• Performance / scalability addressed by design	• Performance / scalability addressed by design
Consensus Algorithm	• PoW	• PoW / PoS	• Plug-and-Play of choice	• PoW / Mining Diversity
Security	• Highly secured, never breached	• Breached once but rectified	• Operated by vetted participants	• Secured by diversity parameter
Relevance	• Costly, time taking for case	• Big and costly for case	• Oversized, complicated for prototype	• Adaptable for case

Narative analysis put HyperLedger on the leading edge for enterprise level implementation of blockchain applications, this study recommends Multichain for implementation based on the

appropriateness strategy followed in the methodology while avoiding costly and complicated undertaking for a basic prototype implementation of the case study.

MultiChain deals with problems related to performance and scale by using its design features of being able to control the block size and other parameters of the blockchain.

MultiChain has two options to reach consensus, either PoW (Proof-of-Work) or Mining Diversity (round-robin type). Enterprises usually use the round-robin type since participants in a MultiChain network are known and that there is no need for an expensive consensus mechanism such as PoW. The basic premise is that as the participants within a private blockchain network, such as Multichain, are already "trusted" to some extent because they are identifiable entities, there is no need for the computationally expensive PoW algorithm to be used on such private networks. With this understanding amongst private blockchain participants (usually established businesses or other organizations), Mining Diversity protocol in Multichain can securely provide consensus to provide continuity to the chain.

MultiChain is secure enough as it allows users to configure parameters including the permissions to access the network, the privacy of the chain, the maximum block size, and the mining incentive. Multichain has a strong and active community of developers and a full-fledged documentation that is progressively updated. Its Github page is also rich with additional utility software for GUI applications and an online explorer.

As the main objective of this study is to help assure public trust with the use of blockchain technology in the conduct of government business in registering and allocating of houses, data is recorded permanently and immutably for the following items:

- Registrant name
- Date of registration
- Unique identification for each housing unit
- Results of lottery draws
- Date lottery was drawn
- Date house was transferred to registrant

It is expected that the prototype implementation will be a foundation for helping assure public trust in the project data that the system provides. The system is built in such a way that all the data on record is openly viewable and verifiable. The security and integrity of the system will be verified by checking the data against the existing, publicly available data of the project that has successively been published in rounds on the City Government's official Gazette for more than a decade. The data on the Gazette has actually been the basis for the transfer of individual housing units to lucky winners of successive rounds of lottery draws.

The Trust Assurance system provides the public with an easy-to-remember website address to check all data related to registrants, lottery results, and transfer of houses to individuals with basic search functionality.

4.2 Data Structure Design

The Addis Ababa Houses Project data (records) can ideally fit into a large single table with no need for other related tables. The number of records and the data in each record grows as the project progresses and as new data is collected.

The storage and querying of this kind of massively growing data fits best in a key-value, non-relational (NoSQL) database. All of the data in such key-value databases consists of an indexed key and a value. Key/value databases are highly optimized for applications performing simple lookups using the value of the key, or by a range of keys. [6]

Every entity (record) in this kind of databases is a set of key/value pairs. A key has multiple components, specified as an ordered list. The major key identifies the record and consists of the leading components of the key. The subsequent components are called minor keys.

The main data fields (keys) for Addis Ababa Condominium Houses Project are:

- The housing unit identification
- The name of an eligible city resident
- The registration ID of an eligible city resident
- The date of registration
- The lottery round
- The date the housing unit was transferred to the lucky winner

From the data fields (keys) listed above, the mandatory one(s) for a record is/are "the housing unit identification" OR "the name, registration ID, and date of registration of an eligible city resident". The other fields are optional and can be added as they become available. Additional fields may also be part of any record as needed, such as "Remarks" and "the date the lottery results were published on the official gazette".

In most cases, the major key is "the housing unit identification" following the nomenclature, **NameOfSite_BuildingNo_FloorNoApartmentNo**, such as Kolfe_Bldg4_103 – Name of Site: Kolfe; Building No:4; Floor No: 1; Apartment No.:03

The minor keys may include:

- RegName — Registrant's name
- RegID — Registrant's unique ID of registration
- RegDate — Date of registration
- LottoRound — The round number of the lottery draw
- LottoDate — Date the lottery was drawn
- GazetteDate — Date the lottery result was published on the official paper
- TransferDate — Date the house was transferred to lucky registrant
- Remarks — Any comment as needed for the specific record

For a new registrant who has not yet won the lottery, the major key for the record is the "registrant's unique ID of registration" and the minor keys are the "registrant's name" and the "date of registration.

4.3 Proof of Concept (PoC) Demo

The system implements a peer-to-peer (P2P) distributed computing architecture where all nodes are equal. MultiChain Community Edition open source blockchain platform is selected for the prototype PoC demo, along with related utilities such as Multichain Command Line Interface for direct access to all APIs, Multichain WebDemo for the GUI interface, and Multichain Explorer for drilling down the data in finer detail. The in-built NoSQL non-

relational database of Multichain called “Stream” is used to store the key:value pair project data.

The PoC demo system is installed in the cloud on Amazon Web Services (AWS) EC2 (Elastic Compute Cloud) for ease of use, affordability, availability, and scalability. It is separately installed on two virtual machines (nodes) in line with the distributed and decentralized nature of the application with no single point of failure (SPOF).

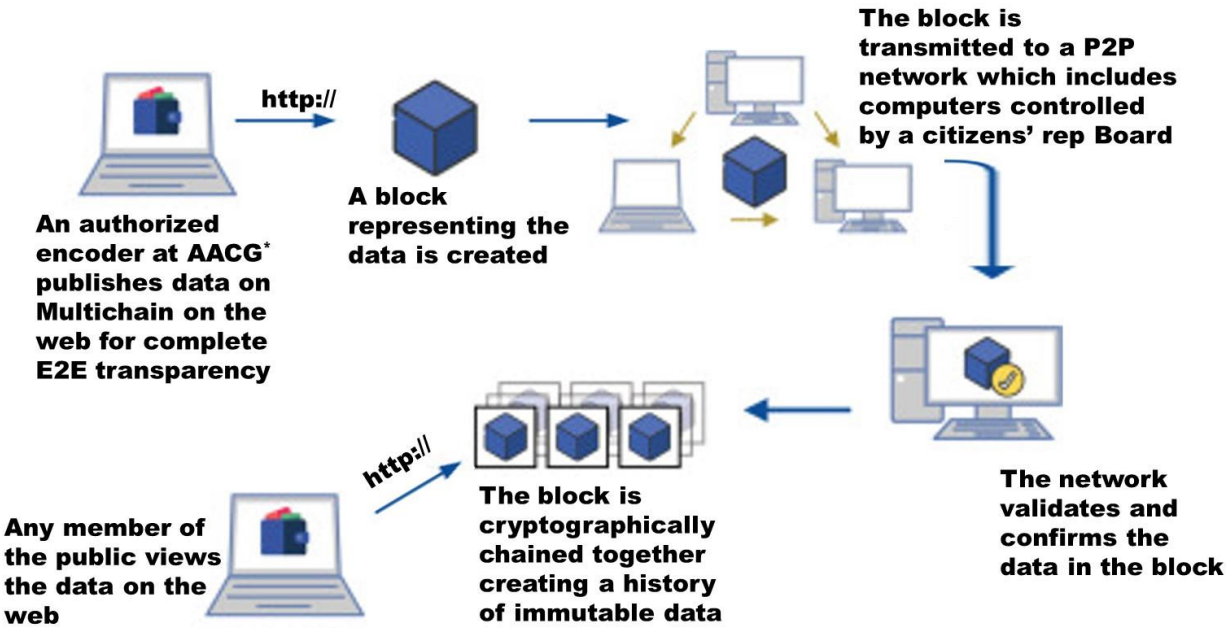
Amazon Linux is the underlying operating system, Apache is used for the web server, PHP for the front-end, and Python for some high-level scripting as recommended by Multichain.

Arbitrary representative data for the housing project is entered into the prototype PoC demo record by record. For large size implementation the data can be imported from a text file in JSON format.

In case of data entry error, an additional record has to be inserted with identical keys and indicating the error in the value of the “Remarks” key since any data once committed to the blockchain cannot be updated or deleted.

A super admin manages all permissions for the system, but cannot modify or delete any project data. A data uploader simply uploads publicly available project data into the blockchain system in a pre-defined JSON format.

The public is provided with a website address to view all data related to registrants, lottery results, and transfer of houses to individuals with some basic search functionality.



*Addis Ababa City Government

Figure 1: End-to-End Multichain Solution for Trust Assurance

The features below are objectively considered for the evaluation:

- Reliability – Accuracy of Search Results_: how the results of searches closely match anticipated outputs
- Versatility – Multiple-Key Selection : whether the prototype allows categorization of data with multiple major keys
- Security – Un-deletability of Data : whether there's any possibility of removing data from the system once it's entered
- Security – Un-modifiability / Immutability of Data : whether there's any possibility of changing data values once they are entered into the system
- Auditability – Traceability of Data : whether the system provides ways to trace "who" entered a record and "when" exactly it was entered
- Chronology – Sequentiality (Keeping of Data Entry Chronology) : whether the system preserves the order of data entry without any possibility of rearrangement

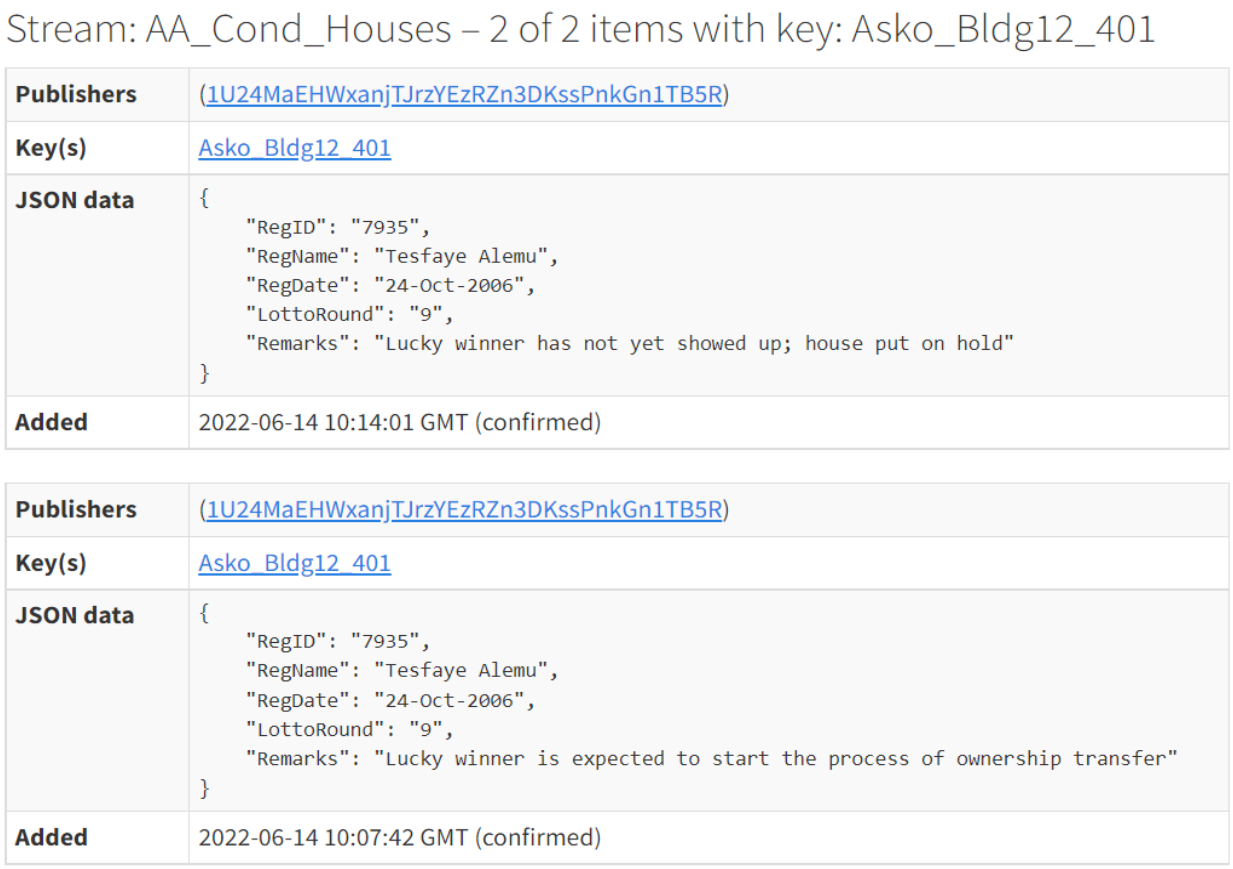


Figure 2: Querying by HouseID Returns the History of that House

5. Assessment Using the Evaluation Features

• Reliability – Accuracy of Search Results:
The search results returned exactly what was intended unless the search text was mistyped or not fully typed.
• Versatility – Multiple-Key Selection:
It was possible to use multiple major keys for data record categorization, such as HouseID and LottoRound.

- Security – Un-deletability of Data :

There was no way during the testing of the prototype to delete data once it was entered into the system, either from the back-end or front interface.

- Security – Un-modifiability / Immutability of Data :

There was no way during the testing of the prototype to change data values once they were entered into the system, either from the back-end or front interface.

- Auditability – Traceability of Data :

The prototype system readily provides the "Publisher" (the *who*) for every record and the unalterable system "timestamp" (the *when)* the record was published.

- Chronology – Sequentiality (Keeping of Data Entry Sequence) : In line with the system timestamp, the history of a certain house was shown from when it was ready for lottery draw until it was transferred to the lucky winner. There was no possibility of changing the sequence of events as and when they happened

6. Conclusions and Recommendations

The outcomes for the research questions are outlined below:

- The first question (RQ#1) asked whether blockchain technology can be used to record basic data about users registered for condominium houses, data about the housing units, and data about the results of successive rounds of lottery draws, and if so, whether the data thus recorded can be kept tamper-free, unchangeable, and stored for perpetuity. The PoC demo appropriately showed the answer is a clear "Yes".
- The second question (RQ#2) asked whether it is possible to provide the immutable recorded information related to registered users, condominium houses, and corresponding lottery results accessible for public scrutiny. Again, the answer is "Yes" and the "how" has clearly been demonstrated by the PoC demo.
- The third question (RQ#3) asked how blockchain technology could help the public to trust the government-provided record of the housing project "beyond any reasonable doubt". This is the core investigative quest of the thesis and answering it in the affirmative requires both technological solutions and public-awareness-creation approaches. A Citizen's Board can play a crucial role in assuring the public that the technology offers an unforgeable platform for everyone to trust, which can easily and always be cross-checked with publicly available data and events since the inception of the housing project.

The following are recommended for future work.

- A full-fledged system for Trust Assurance for Addis Ababa Housing Project be implemented on an enterprise-grade blockchain platform, taking into account additional scenarios that are captured during the system analysis phase that involves representative stakeholders from the government and the residents of the City.
- The lottery allocation needs to be implemented using smart contracts on the enterprise-grade implementation, avoiding any manual interference.
- The enterprise implementation should include flexible ad-hoc queries that can go deep down into key:value pairs of minor keys for advanced querying functionality.
- It's also recommended that the City Administration adopts the use of blockchain technology for internal audit purposes for regulatory and compliance inspections for the Housing Project.

References

[1] W. Eggers, “Rebuilding Trust in Government -- Four signals that can help ıprove citizen trust and engagement,” Deloitte, 9th March 2021. [Online]. ⁄ailable: https://www2.deloitte.com/us/en/insights/industry/public-ctor/building-trust-in-government.html . [Accessed 17th September 2021].

[2] P. Offermann, “Outline of a Design Science Research Process,” in oceedings of the 4th International Conference on Design Science Research in formation Systems and Technology, Pennsylvania, 2009.

[3] A. Zena, “Secure Notarization using Blockchain for the FDRE Document ıthentication and Registration Agency (DARA),” HiLCoE Journal of Computer ience and Technology, p. 9, 2018.

[4] K. Mintah, “Skin lands in Ghana and application of blockchain technology r acquisition and title registration,” Journal of Property Planning and ıvironmental Law, 12 May 2020. [Online]. Available: tps://www.emerald.com/insight/2514-9407.htm. [Accessed 27th November)21].

[5] Lazuashvili, “Integration of Blockchain Technology into a Land Registration ⁄stem for Immutable Traceability – A Case Study of Georgia,” in *BPM 2019 ockchain and CEE Forum Vienna, Austria, September 1–6, 2019 Proceedings*, enna, Austria, 2019.

[6] “What is NoSQL?,” DataStax, 01 01 2022. [Online]. Available: tps://www.datastax.com/what-is/nosql. [Accessed 08 06 2022].

[7] Krishnapriya, “Securing Land Registration using Blockchain,” 4th May 2020. ınline]. Available: tps://www.sciencedirect.com/science/article/pii/S1877050920311649. ccessed 22nd March 2021].

[8] F. Zemenu, Exploration of the Potentials of Blockchain in Helping Assure ıblic Trust in the Registration of Eligible Citizens and Transfer of Ownership of ıblic-Funded Houses in Ethiopia, Addis Ababa: HiLCoE - Master of Science ıesis, 2024.