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# IMPLEMENTING A SECURE TITLE DEED REGISTRATION MODEL FOR LAND TRANSACTIONS IN BLOCKCHAIN

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**Abstract**

The purpose of this study was to implement a secure title deed registration model for land transactions in blockchain. The non-existence of a universal National Land Information Management System in Kenya has generated inconsistencies in land transactions, thus creating a need for a secure title deed registration model for land transactions. The study adopted a proof of concept (PoC) methodology to demonstrate the concept of using blockchain technology to resolve existing challenges currently experienced in land transactions. The outcome of the PoC methodology was the design of a model that was later evaluated for implementation. The design architecture of the model was based on Ethereum, an open-source, decentralised blockchain platform used to establish a peer-to-peer network that securely executes and verifies an application code referred to as a smart contract that enables network users to execute land transactions amongst themselves with no trusted central authority. Selected users evaluated the designed model against the metrics set out by the study. Upon model evaluation, its results provided a trail of non–immutable and verifiable land transaction records visible to all the parties involved. The land transaction records were securely distributed across the peer-to-peer network, providing participants with visibility of all the transaction data. Therefore, the model implemented in the study demonstrated that blockchain technology has an immense potential of executing secure and transparent land transactions across Kenya. This study recommends that future research should explore implementation strategies and regulatory frameworks for integrating blockchain technology into land registration.

**Key terms:** Blockchain, decentralisation, immutable ledger, lands registry, transparency.

## 1.0 INTRODUCTION

Land registration plays a crucial role in property rights and economic development, but traditional systems often face challenges related to inefficiency, fraud, and lack of transparency (Ayalew et al., 2021). In Kenya, these issues have led to mistrust in land transactions and a weakened real estate market (Njoroge & Mwangi, 2022). The emergence of blockchain technology offers a promising solution to these challenges by providing a secure, decentralised ledger that can improve transparency and accountability in land registration systems (Anderson et al., 2020). Blockchain technology allows for immutable and transparent records, enabling real-time access to verified title deeds, which can significantly reduce fraudulent activities (Zhu & Shi, 2020). This is the same technology underlying Bitcoin, which is a type of Distributed Ledger Technology that has been defined as a "distributed, shared, encrypted database that serves as an irreversible and incorruptible repository of information" (Wright, 2015).

In November 2015, the Financial Times reported that the government of Honduras had approached a company called Factom, a Texas-based start-up, about the use of blockchain technology to address the recordkeeping problems associated with the Honduran Land registration system. Given the proposal to use blockchain technology to address recordkeeping issues in Honduras, it is worthwhile to consider how well the Factom Blockchain solution proposed for Honduras might work as a solution to the kinds of recordkeeping problems faced by Kenya (Wild et al., 2015).

This study, therefore, explored the technical implementation of blockchain in the Kenyan land registration system, with a focus on restoring public trust, improving security, and driving economic growth through increased real estate investment. By addressing the vulnerabilities in traditional systems, this blockchain-based model has the potential to transform land management and set a new standard for secure transactions. This article, therefore, proposes a blockchain-based secure title deed registration model that aims to streamline land transactions and enhance trust among stakeholders by implementing smart contracts and automated transaction processes (Smith & Garcia, 2021).

The land registration system in Kenya faces significant challenges, including inefficiencies, bureaucratic delays, and widespread fraud, which undermine its reliability and erode public trust. Issues such as title deed forgery and land grabbing create uncertainty for landowners and potential buyers, while outdated manual processes hinder timely access to information and increase the risk of disputes. To address these vulnerabilities, there is a critical need for a more secure, efficient, and transparent approach to land registration. This research aims to propose a secure title deed registration model leveraging blockchain technology to enhance the integrity of land records, restore stakeholder trust, and facilitate smoother land transactions, ultimately promoting economic growth.

## 2.0 LITERATURE REVIEW

Since independence, successive Kenyan governments have been trying to address land issues. Unfortunately, land has continued to remain an emotive issue that emerges in almost all civic and economic developments in the nation. As of today, very few influential people own expansive Lands while the majority live as squatters, even in their very own ancestral Land, unable to enjoy the socioeconomic benefits that come with Land ownership in a country whose economic backbone is agriculture. Such scenarios have time and again generated ferocious cycles of relentless struggles for Land, leading to endless tribal conflicts and loss of lives as well as property in many parts of Kenya. The Government of

Kenya, together with 11 other stakeholders, have made several efforts to address the Land issue through mechanisms such as Land legislation, demarcation, rationalisation and issuance of Land titles to the Landless with little allocation of resources going into the development of a National Land management information system (Mulaku, 2005).

The situation in Kenya is that we have many Land laws in place, some of which are incompatible or overlapping. This has resulted in a complex Land management and administration system with lots of disparities in Land registers. Furthermore, the lack of an efficient, transparent and secure Land management information system has created environmental, social, economic and political problems such as deterioration in Land quality, squatting and Landlessness, disinheritance of some groups and individuals, underutilisation and abandonment of agricultural Land, tenure insecurity and conflicts related to Land ownership (MoL, 2008). In Kenya, these challenges are particularly pronounced, with frequent cases of land grabbing and title deed forgery impacting economic stability and real estate investment (Kibera, 2020).

The government of Kenya, in 2021, launched an integrated National Lands Management Information System (NLMIS) called Ardhisasa, jointly developed by the Ministry of Lands and The Nation Lands Commission. The objective of Ardhisasa is to digitise land records, an ongoing process in the Land's registry in Nairobi. However, the process of digitising the records is hampered by an array of challenges in the Land's registry. The challenges relate to matters to do with overlapping institutional responsibilities, absence of proper documentation of Land records, missing Land records in the main registry, illegitimate and non-procedural Land transfers, more than double allocation of the same Land with multiple title deeds issued to it as well as corruption in Government (MoL, 2021).

All these challenges may not be exhaustively addressed by the NLMIS. The inadequacies in Land transactions, difficulties in proof of Land ownership that end up in endless court proceedings, lack of accountability and transparency in the issuance of Land title deeds among many other challenges relating to the administration and management of Land in Kenya seem to persist (UN Women Africa, 2021).

Recent studies have explored the potential of blockchain technology as a transformative solution for land registration. Blockchain's decentralised and immutable nature allows for secure, transparent, and real-time access to land ownership records (Zhang et al., 2019). By implementing blockchain, land registries can automate processes through smart contracts, significantly reducing administrative burdens and enhancing trust among stakeholders (Anderson et al., 2020).

Furthermore, research indicates that countries implementing blockchain in land registration have witnessed improvements in efficiency and reduced incidences of fraud (Njoroge & Mwangi, 2022). For example, jurisdictions that have adopted blockchain technology have reported faster transaction times and more secure ownership transfers (Smith & Garcia, 2021). Despite these promising developments, challenges remain regarding the integration of blockchain into existing systems, including legal, technological, and societal barriers that must be addressed for successful implementation (Ayalew et al., 2021).

The literature on land registration systems highlights various challenges and inefficiencies that hinder the effective management and governance of land resources. Traditional land registries often face issues such

as bureaucratic delays, fraud, and lack of transparency, which contribute to public distrust (Deininger, 2003; Fitzpatrick, 2006). Thus, the review underscores the necessity of adopting innovative solutions like blockchain to reform land registration systems. By addressing current inefficiencies and restoring trust, blockchain technology has the potential to revolutionise land management in Kenya and beyond.

**Proposed Conceptual Model**

The proposed model utilises a decentralised blockchain network to securely store title deed information as digital tokens, enhancing transparency and reliability. It features an automated verification process for ownership authentication, incorporates smart contracts to streamline transactions, and employs role-based access controls for security. Effectiveness will be evaluated through key performance indicators, such as transaction speed and user satisfaction, to demonstrate its impact on land registration in Kenya.

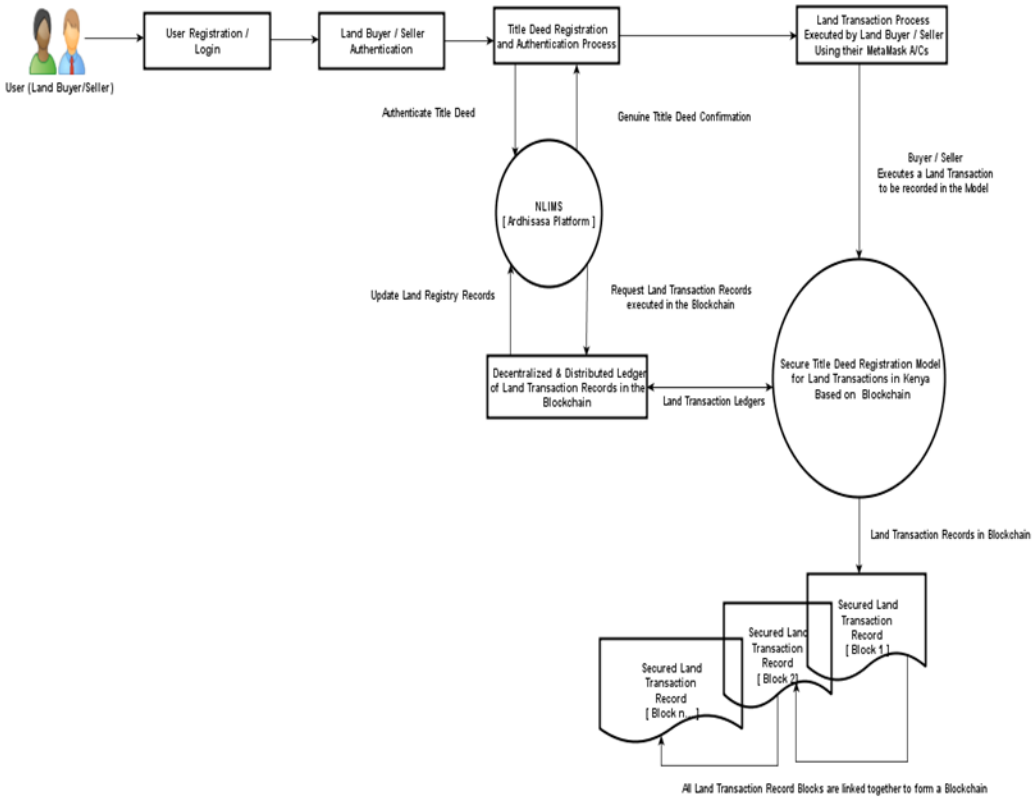


**Figure 1: Conceptual Framework**

## 3.0 METHODOLOGY

The model authenticated land ownership in the blockchain-based title deed registration model. Selected users submitted their title deeds and supporting documents, which were validated against predefined criteria and cross-referenced with existing land registry records. Discrepancies prompt alerts for investigation, ensuring only verified information is recorded, thereby enhancing trust and efficiency in land transactions.

## 4.0 RESULTS AND DISCUSSION

### Proof of Concept

A prototype was developed to implement the blockchain-based model for secure title deed registration. The system was created using a combination of React.js for the front-end interface and Node.js with MongoDB as the back-end for data management. React.js is a flexible, efficient, declarative open-source JavaScript library used to build creative user interfaces and components for the client-side JavaScript framework. Node.js provides a robust server-side platform, while MongoDB is an open-source document database. The prototype effectively demonstrates the functionality of user authentication, document submission, and automated verification processes, showcasing how land ownership details can be securely recorded and managed on the Blockchain Model.

### User Authentication

The user commences by entering the registration details as shown in Figure 2 below:

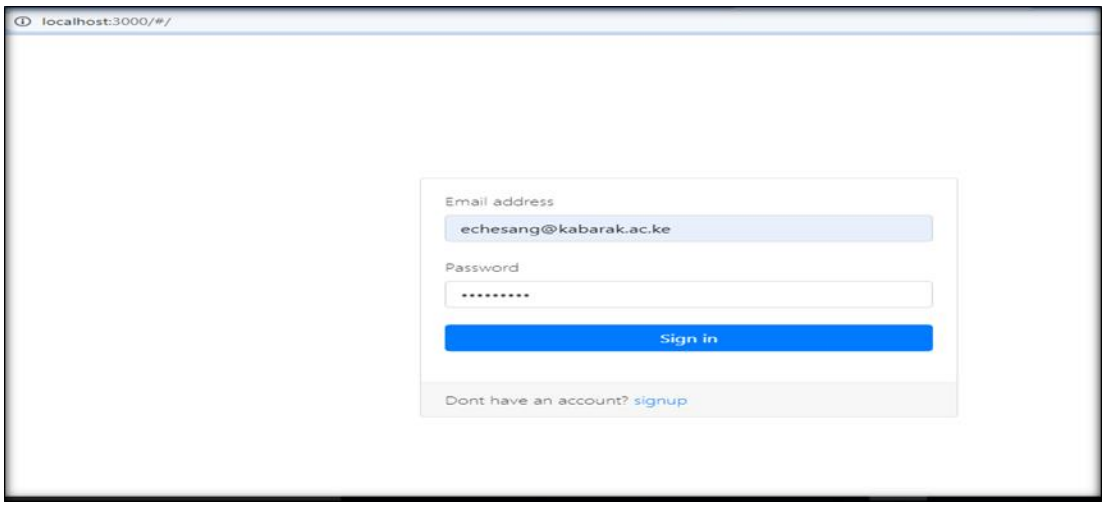


**Figure 2: User Login Interface**

User authentication initiates access to the system, requiring users to register with personal identification and documentation. After registration, they receive unique cryptographic keys and must undergo two-factor authentication (2FA) to enhance security. This multi-layered approach significantly mitigates unauthorised access risks.

**Document Submission**

Document Submission is shown in Figure 3 below:

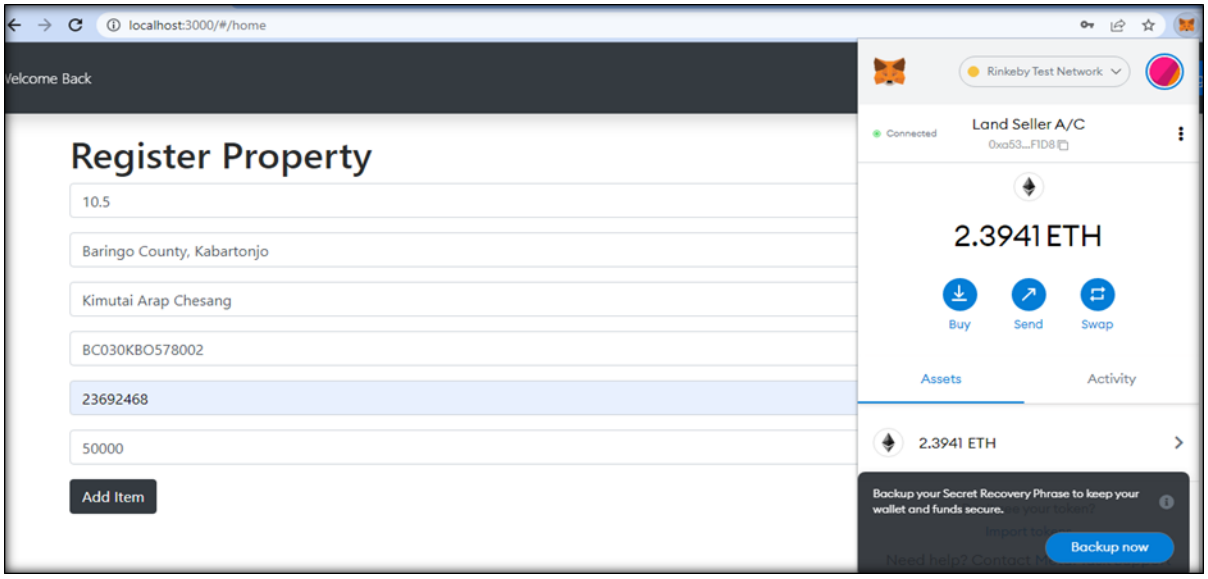


**Figure 3: Document Submission Form**

Once authenticated, users can easily upload title deeds and supporting documents through a user-friendly interface. The system validates these documents to ensure compliance with predefined criteria, streamlining the submission process. This automation minimises human error and enhances overall efficiency.

**Automated Verification**

User alert screen for entry of wrong records Figure 4 below:

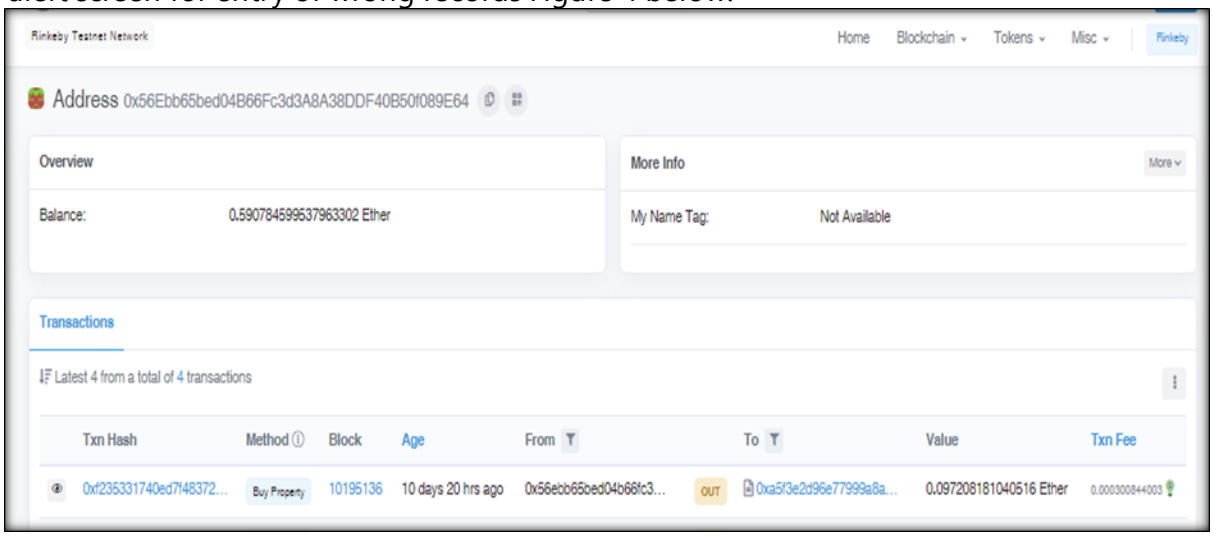


**Figure 4: Automated Verification Interface**

The system automatically verifies submitted documents by cross-referencing them with existing land registry records. This expedites the verification process while maintaining the integrity of the land registration system. Alerts are generated for discrepancies, enabling prompt resolution of issues.

**Smart Contracts Execution**

Execution of contract Figure 5 below:

| # | Size | Location | Land Owner Address | Land Registry Number | Price | Transaction Date | Transaction Time |
|---|---|---|---|---|---|---|---|
| 1 | 0.1 ha | Kiambu | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | A12232GH3424895 | 871546 kshs | Thu Jan 27 2022 | 12:11:34 GMT+0300 (East Africa Time) |
| 2 | 0.25 ha | London | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | LR0252022 | 1500000 kshs | Thu Jan 27 2022 | 17:20:58 GMT+0300 (East Africa Time) |
| 3 | 0.1 ha | Kabarnet | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | LR0012022 | 150000 kshs | Thu Jan 27 2022 | 17:28:29 GMT+0300 (East Africa Time) |
| 4 | 0.1 ha | Kabarnet | 0x56Ebb65bed04B66Fc3d3A8A38DDF40B50f089E64 | LR0012022 | 150000 kshs | Thu Jan 27 2022 | 17:31:16 GMT+0300 (East Africa Time) |
| 4 | 02 ha | Kabarak | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | lr2024 | 10000 kshs | Wed Feb 16 2022 | 13:52:09 GMT+0300 (East Africa Time) |
| 6 | 02 ha | Kabarak | 0x56Ebb65bed04B66Fc3d3A8A38DDF40B50f089E64 | lr2024 | 10000 kshs | Wed Feb 16 2022 | 13:56:09 GMT+0300 (East Africa Time) |
| 5 | 10.5 ha | Baringo County, Kabartonjo | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | BC030KBO578002 | 50000 kshs | Sat Feb 19 2022 | 11:21:36 GMT+0300 (East Africa Time) |
| 8 | 10.5 ha | Baringo County, Kabartonjo | 0x56Ebb65bed04B66Fc3d3A8A38DDF40B50f089E64 | BC030KBO578002 | 50000 kshs | Sat Feb 19 2022 | 15:11:56 GMT+0300 (East Africa Time) |

**Figure 5: Smart Contract Transactions**

Upon verification, smart contracts are generated to facilitate land transactions, encapsulating terms like payment conditions. These contracts execute automatically when conditions are met, updating the blockchain with new ownership details without intermediaries. This automation accelerates transactions and reduces costs. – do the screenshot of the code.

**User Notifications**

Notification of existence of registration of property Figure 6 below:

Buy Property

| # | Size | Location | Land Owner Address | Land Registry Number | Price | Transaction Date | Transaction Time | State |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.1 ha | Kiambu | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | A12232GH3424895 | 871546 kshs | Thu Jan 27 2022 | 12:11:34 GMT+0300 (East Africa Time) | Buy |
| 2 | 0.25 ha | London | 0xa53e4A65B37bBAb219945e244627be0c3E27F1D8 | LR0252022 | 1500000 kshs | Thu Jan 27 2022 | 17:20:58 GMT+0300 (East Africa Time) | Buy |
| 3 | 0.1 ha | Kabarnet | 0x56Ebb65bed04B66Fc3d3A8A38DDF40B50f089E64 | LR0012022 | 150000 kshs | Thu Jan 27 2022 | 17:28:29 GMT+0300 (East Africa Time) | Sell |
| 4 | 02 ha | Kabarak | 0x56Ebb65bed04B66Fc3d3A8A38DDF40B50f089E64 | lr2024 | 10000 kshs | Wed Feb 16 2022 | 13:52:09 GMT+0300 (East Africa Time) | Sell |
| 5 | 10.5 ha | Baringo County, Kabartonjo | 0x56Ebb65bed04B66Fc3d3A8A38DDF40B50f089E64 | BC030KBO578002 | 50000 kshs | Sat Feb 19 2022 | 11:21:36 GMT+0300 (East Africa Time) | Sell |

Download Transaction History

**Figure 6: Property Registry**

Users receive real-time notifications throughout the authentication and transaction processes, keeping them informed of submission statuses and smart contract executions. These updates enhance transparency and user engagement, reducing anxiety related to transaction progress. Timely notifications foster trust and participation.

**Logout**

After the termination of the confirmation session, the users can exit through a controlled interface without allowing any form of inference. Figure 7 below:

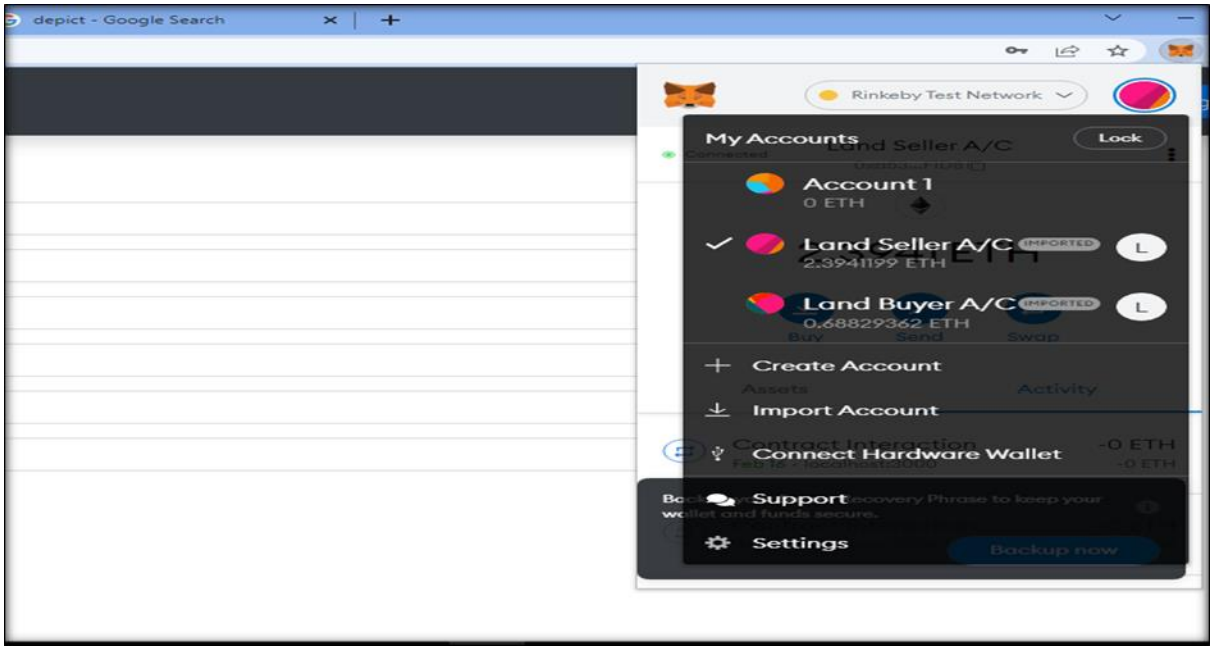


**Figure 7: Logout Interface**

After completing transactions, users securely log out, ensuring that their sessions are terminated to prevent unauthorised access. The system may also incorporate automatic session timeouts for additional security against inactivity. This logout function is essential for protecting sensitive information.

**Challenges**

Implementing a blockchain-based title deed registration system faces challenges such as varying technological literacy among users, inadequate infrastructure, and potential legal hurdles. Data security and privacy concerns also pose risks, while resistance to change from traditional processes may impede adoption. Addressing these challenges is essential for the successful implementation and acceptance of the new system.

## 5.0 CONCLUSION AND RECOMMENDATIONS

**Conclusion**: The Implementation of the designed secure title deed registration model for Land transactions in Kenya based on blockchain by this study ascertained that it is possible to execute Land transactions that guarantee non-repudiation of land records as the much-needed solution to the problem of land ownership conflicts in Kenya. The blockchain-based title deed registration model offers a significant improvement to traditional land registration in Kenya by enhancing trust and efficiency through features like decentralisation, transparency, and security. It effectively addresses critical issues such as data integrity and fraud prevention, ensuring reliable and accessible ownership of records. The model demonstrates the potential for successful implementation despite challenges like user adoption and infrastructure limitations, ultimately contributing to more robust land registration.

**Recommendations:** The study recommends that future research in blockchain may focus on the prospect of integrating the technology with Land taxation systems and the adoption of cryptocurrency as a legal tender to facilitate Land transactions in Kenya. Future research should explore implementation strategies and regulatory frameworks for integrating blockchain technology into land registration. Additionally, studies on the social and economic impacts of this model on various stakeholders, including marginalised communities, are essential. Investigating technological challenges and promoting public awareness of blockchain will also facilitate broader acceptance and engagement, guiding practical implementation in land registration systems.

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