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Blockchain and ML in land registries a transformative alliance

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ABSTRACT

This study presents a novel method for merging blockchain security and machine learning (ML) valuation to update land register systems. The system offers a safe, open, and effective framework for documenting and managing land ownership, addressing issues with conventional land registry procedures. Blockchain technology creates a tamper-proof record by cryptographically combining transactions and time-stamped entries to provide an immutable and decentralized ledger. In addition to building a solid foundation for the land registry system, this strengthens trust. Simultaneously, ML algorithms examine variables such as amenities and location to remove inflated pricing, providing accurate assessments and encouraging openness in the real estate sector. The system has been put into practice and verified in small-scale applications. Its features include enhanced data security, expedited ownership transfers, and accurate asset appraisals. Collaboration between governments, regulatory agencies, and technology suppliers is necessary for widespread deployment. Land registration procedures will change as a result of the revolutionary partnership between blockchain and ML technology, which offers a more effective, safe, and future-ready environment. Accepting this ground-breaking technique establishes a new benchmark for the updating of land ownership data and is a major step toward a more sophisticated and dependable method in the industry.

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1. INTRODUCTION

Land, a cornerstone of human existence, holds profound significance in people's lives as an invaluable asset with enduring value across generations. Beyond its tangible and intrinsic worth, land serves as a basis for investment, offering a stable and often appreciating value over time. However, the traditional methods of land registry, predominantly paper-based, have come under scrutiny in the wake of technological evolution.

The vulnerability of paper-based registries to manipulation and attacks has raised concerns about the security of property ownership records. Moreover, the perception of land value often revolves around financial considerations rather than its functional utility. People frequently gauge the worth of land based on market prices, overlooking the crucial role it plays in providing essential services and amenities.

In navigating the intersection of traditional values and technological advancements, it becomes imperative to reassess and enhance the systems that govern land ownership. The future of real estate registries hinges significantly on addressing the critical issues of pricing and security. Pricing poses a substantial challenge in the real estate sector due to its vast and highly competitive nature. The broad spectrum of properties and intense competition make accurate pricing a complex endeavour for real estate agents, buyers, and sellers. The need for precise property valuations is essential in ensuring fair transactions and informed decision-making.

The potential for unauthorized tampering raises the spectra of diminished worth for the actual owner, adding complexity and uncertainty to the real estate landscape. This study endeavors to propose an alternative approach to land registry procedures by integrating ML and blockchain. The primary goal is to address the dual challenges of security concerns and accurate price predictions for land assets based on their intrinsic value. Through the utilization of machine learning (ML) algorithms, the system not only enhances security but also facilitates the prediction of land asset prices in alignment with their true value. Furthermore, ML algorithms play a pivotal role in profile validation within this innovative framework whereas blockchain addresses the challenges associated with land security and data storage by dispersing each piece of information across decentralized nodes [1].

2. LITREATURE REVIEW

A subsequent research paper by Ameyaw and Vries [2] provided a comparative analysis of blockchain-based land registration in Nigeria and Ghana. This study assessed the feasibility of implementing blockchain-based land registries in these nations, examining both the advantages and challenges associated with the adoption of blockchain for land registration [2]. In 2018, Bennett delved into the integration of blockchain technology for land administration, specifically focusing on land registration. Their work featured a case study on a blockchain-based land administration, exploring both the merits and drawbacks of employing blockchain in land registration [3].

Shuaib *et al.* [4] with his coauthor provided the model for indent faction of blockchain registry system storing the value in hashes. Vayadande *et al.* [5] approach introduced the Blockchain system, emphasizing the connection between the registration Blockchain and the Khasra Blockchain through chain code to establish a legally binding tie, ensuring the validity of land records. In an medium article it is explanations is provided for mechanisms to create a marketplace for buyers and sellers, incorporating the proof of work consensus mechanism and POSTMAN API for secure communication and data transfer in a blockchain-based system using python and flasks [6].

Ozcelik [7] in Land and Property Management, focusing on deep classification for applications in land and property management, particularly in land registry systems. The authors explored how blockchain could improve land title registration, enhance transparency, and reduce administrative inefficiencies, also discussing its potential impact on land-related transactions. Yadav and Kushwaha [8] discussed the advantages of blockchain in land registration, addressing transparency, cost reduction, and simplification of the process, while highlighting challenges related to legal recognition, data privacy, and standardization.

In 2021, Aborujilah *et al.* [9] investigated the adoption of blockchain in land registry and transactions. This comprehensive survey showcased case studies from various countries, demonstrating real-world applications of blockchain in land management. The paper discussed how blockchain could enhance transparency, reduce fraud, and streamline land registration while addressing challenges like interoperability, data privacy, and regulatory frameworks.

Researchers [8], [9] proposed a blockchain-based method for securely storing property documents, utilizing the interplanetary file system (IPFS) and Ethereum blockchain. The approach aimed to enhance data security, reduce reliance on centralized databases, and improve accessibility to verified documents through the integration of blockchain and smart contracts. Both papers showcased the growing interest in and exploration of blockchain technology in real estate and land records management, offering innovative solutions to enhance transparency, security, and efficiency in property transactions and land record storage.

Lastly, Polat and Alkan [10] conducted a systematic review in which they examined the global implementation of blockchain technology in land registry systems. The review identified key challenges and benefits, including increased transparency, reduced fraud, improved efficiency, and enhanced trust among stakeholders. The authors analyzed technical aspects, implementation strategies, and regulatory frameworks of existing blockchain-based land registry systems, providing valuable insights for future implementations, with an emphasis on stakeholder collaboration and addressing legal and governance issues.

Choy and Ho [11] highlighted the importance of artificial intelligence for real estate price prediction which covers all the objectives of this study for making an adapting price prediction model which provides and regulates the actual value of real estate with the value of asset. This literature survey offers valuable insights into the intersection of blockchain technology and land registry, serving as a foundational resource for further research and development. Through systematic reviews and case studies, the survey identifies emerging trends, challenges, and opportunities in implementing blockchain in land registries.

3. APPROACH

Our primary objective is to develop a platform that serves as an interface for land asset transactions, facilitating purchases at nominal prices predicted based on the true value held by the assets. To streamline land purchasing and ownership transfer, we leverage the Ethereum blockchain. For accurate price predictions, we implement artificial neural networks (ANN) and regression models. These models consider various factors, such as proximity to schools and hospitals, the number of rooms, the presence of gardens, and the surrounding environment, to predict the land's value. This ensures a comprehensive assessment that goes beyond traditional metrics.

To enhance security and transparency, we eliminate third-party involvement by integrating an in-built chatroom. This feature enables direct communication between clients, fostering a more direct and trustworthy environment for land transactions. Figure 1 provides the brief flow model for our proposed system.

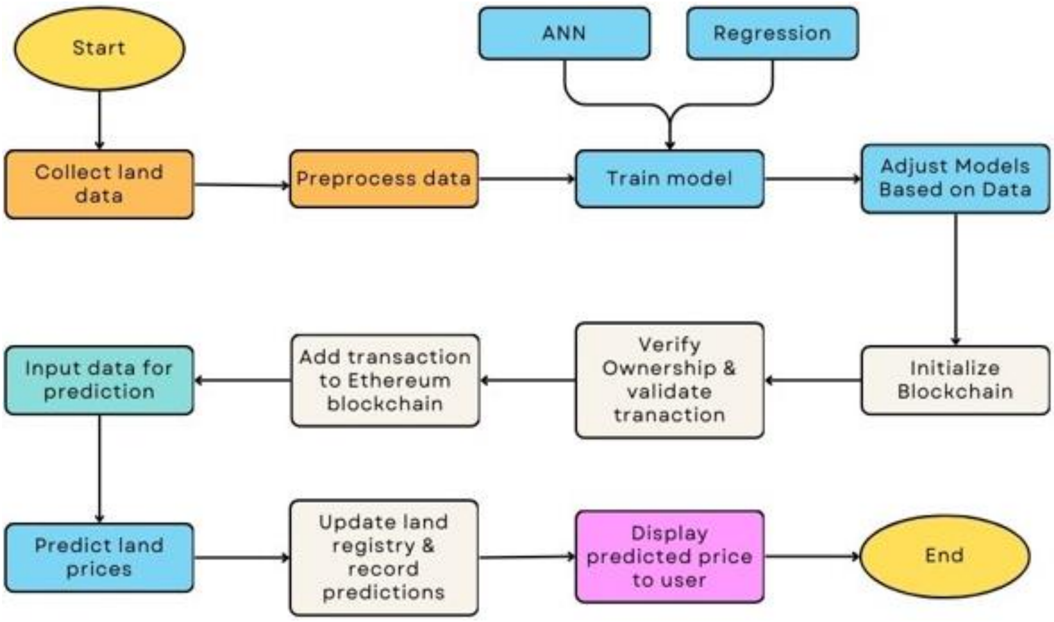

Figure 1. Working module

3.1. Module training

Equations should be placed at the center of the line and provided consecutively with equation numbers in module training. We refine our land price prediction models using both ANN and linear regression. The combination of ANN captures complex patterns, while linear regression interprets linear relationships.

3.1.1. Dataset description

Our dataset encompasses essential parameters crucial for determining the fair value of a piece of land, considering the distance to the nearest station contributes to the property's accessibility and convenience, a pivotal aspect in real estate valuation. The count of stores in the nearby vicinity serves as an indicator of local amenities and infrastructure, influencing the overall desirability and value of the land. Figure 2 scatter plot illustrates the relationship between unit house prices and the number of convenience stores. Figure 3 scatter plot analyzes the correlation between the unit price per house and the distance to the nearest metro station.

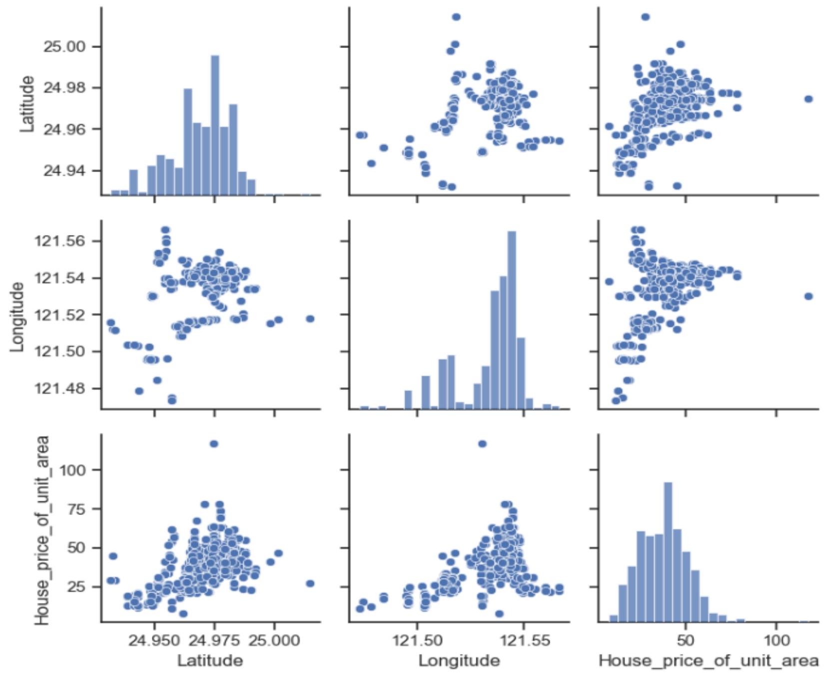

Figure 2. Scatter plot for convenience store and metro through unit house price

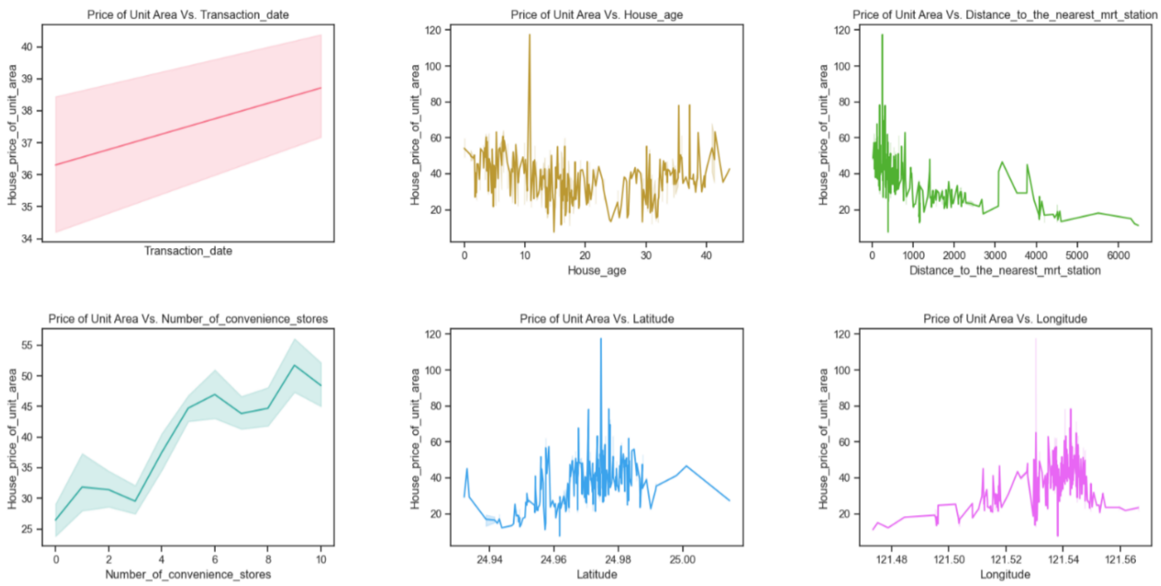

Figure 3. Scatter plot against unit house price unit house price

3.1.2. Artificial neural network

ANNs are a class of ML models inspired by the structure and functioning of the human brain. ANNs consist of interconnected nodes organized into layers: an input layer, one or more hidden layers, and an output layer [12]. Each connection between nodes (synapse) has an associated weight, and each node applies an activation function to the weighted sum of its inputs [13].

Weights and activation functions also have a pivotal role in which weights represent the strength of connections between nodes, and activation functions introduce non-linearity to the model, allowing it to learn complex relationships [14]. We incorporated backpropagation which adjusts weights iteratively to minimize the error between predicted and actual outputs, ultimately enhancing the model's ability to generalize and make accurate predictions on unseen data [15]. As an output layer, we used a sigmoid activation function. The formula for the algorithmic calculations (1).

$$Sigmoid(z) = \frac{1}{(1 + e^{-z})} \quad (1)$$

where z is the linear combination of input features and their associated weights, plus a bias term (2):

$$z = w^0 + w^1x^1 + w^2x^2 + \ldots + w_p * x_p \quad (2)$$

Here, w_0 is the bias term, w^1, w^2, …, w_p are the weights associated with input features x_1, x_2, …, x_p. In (3) provide the sum of products (SOP) between each input and its corresponding weight:

$$s = X1 * W1 + X2 * W2 + b \quad (3)$$

Activation in hidden layer is described by (4) where σ is the activation constat.

$$zj(1) = \sigma(aj) \quad (4)$$

3.1.3. Logistic regression

Logistic regression predicts the probability of an event by fitting data to a logistic function. Its output values lie between 0 and 1 expectedly because the model predicts the probability. The output of the logistic regression model is transformed using the sigmoid (logistic) function to ensure that the output falls between 0 and 1, representing a probability [16]. Our main using logistic regression was to enhance the likelihood of the observed data under the model parameters, which encompass both weights and bias.

3.2. Blockchain mechanism

The proposed system utilizes blockchain technology for facilitating land migration and ownership transfer as well storing the land registry data removing all the paper trails in regards to traditional system. data is securely stored on a decentralized public ledger. This ledger comprises blocks, each containing a unique cryptographic hash identifier and a reference to the previous block, forming a secure chain through cryptography [17].

3.2.1. Escrow ownership transfer

Employing a technical escrow ownership transfer mechanism act as a protective layer in transactions, temporarily securing funds or property until mutually agreed-upon conditions are satisfied. The implementation of this technical escrow process enhances the system's integrity, ensuring a secure and transparent transfer of land ownership [18]. The mechanism and architectural features of Escrow are elucidated in the following subsections.

This mechanism works as a validation proof just as a contract transfer of assets between the two parties. Escrow not only governs the transactions but also provides a log-based method to check-based rules applications for further consideration after the migration of assets. Escrow services often ensure legal compliance, offering a structured framework for transactions and minimizing legal risks [18]. Integration with smart contracts further enhances automation, ensuring a seamless and error-free transaction experience [19], [20].

3.2.2. Data storage

The foundation of blockchain technology lies in the utilization of distributed ledger technology (DLT). This DLT serves as a decentralized database capturing transactional information among diverse parties. The operations are systematically recorded in chronological order and organized into blocks. These blocks form an interconnected chain, with each block referencing the one preceding it, creating the characteristic structure known as a blockchain [21]. In the context of blockchain storage, files undergo a process called sharding, breaking them into smaller parts or shards. Each shard is duplicated to safeguard against data loss during transmission.

In this particular implementation, we used the decentralized storage network that's BitTorrent's technology, integrating its file-sharing protocol (BTFS) [22], along with Tron's decentralized blockchain platform. This network facilitates a system where storage renters compensate hosts for their surplus capacity. This decentralized and secure approach enhances data integrity and availability, ensuring a resilient and transparent storage solution.

BitTorrent ensures that land registry records are distributed across a multitude of nodes, promoting heightened resilience against potential failures or targeted attacks. Employing a redundancy mechanism, the system strategically breaks down files into smaller components and duplicates them across various hosts, thereby fortifying data integrity and availability. BitTorrent's peer-to-peer network architecture facilitates direct sharing and distribution of land registry records among users, eliminating the need for a central authority and fostering a more efficient and scalable data distribution model [14], [23].

4. RESULTS

For model performance evaluation, we used key metrics such as R-squared (R2), Mean Squared Error (MSE), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE) [24], [25]. Following was the result obtained by applying ANN and logistic regression for asset value prediction according to its real value in correspondence with the locality and facilities available. From Figure 4 and Figure 5 it clearly shows the comparison data frame, the predictions generated by the model closely align with the actual values, indicating a high degree of accuracy in the model's performance. The calculated Mean Absolute Error (MAE): 5.31 and Accuracy: 94.69%. This proximity between predicted and actual values highlights the effectiveness of the model in capturing the underlying patterns within the data.

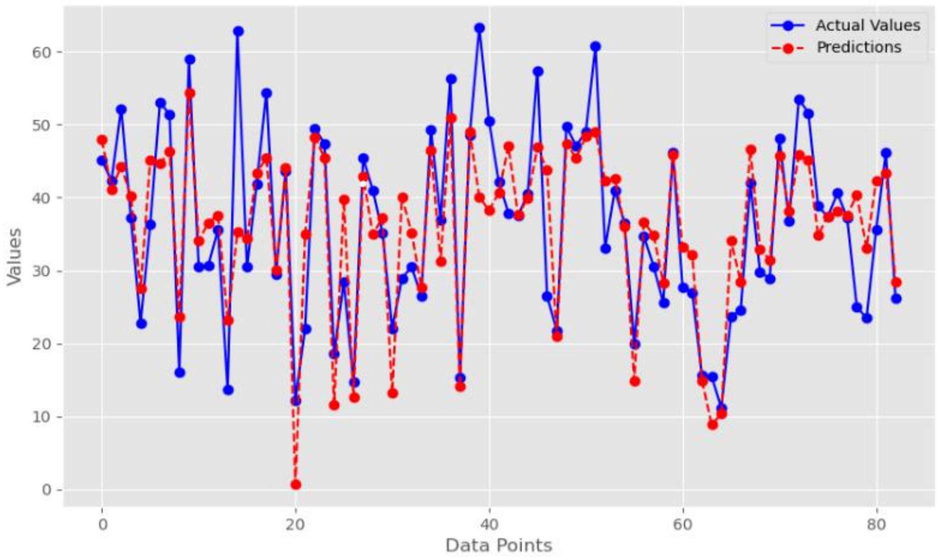

Figure 4. Actual vs prediction values deviation

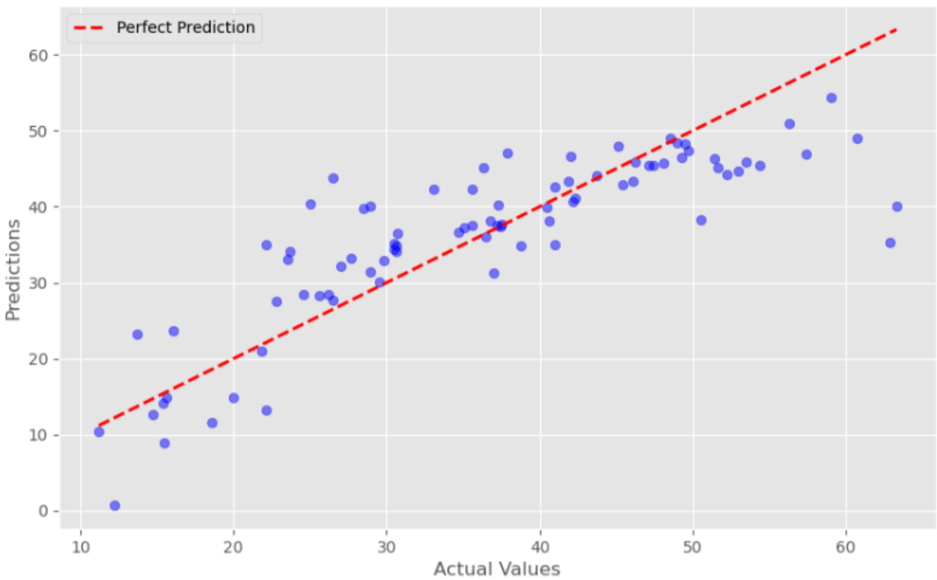

Figure 5. Actual vs prediction values scatter

The logistic regression model exhibits a moderate performance in comparison with ANN, as indicated by a mean squared error (MSE) of 53.51. Figure 6 provides the idea about the prediction value of logistic regression model with its actual values. The R-squared value of 0.68 suggests that approximately 68% of the variability in the target variable is accounted for by the model. Results highlighted that a blockchain-based approach in addition to ML adds features that improve security and dependability while addressing major issues with current systems. We have noticed that the main problems with conventional methods are successfully fixed by our suggested solution. We can strengthen the security of land assets and do away with paper-based procedures by incorporating blockchain technology.

This observation Table 1 emphasizes the advantages of the proposed blockchain and ML-based land registry system, showcasing its potential to bring about improvements in security, efficiency, accuracy, environmental impact, and transparency compared to the traditional system.

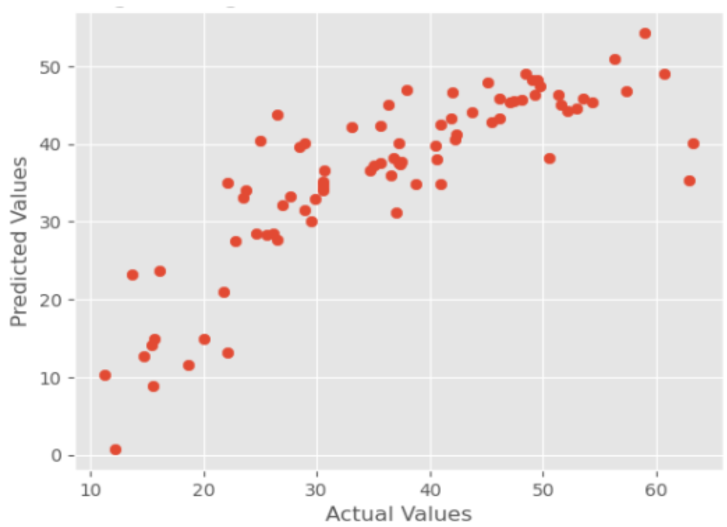

Figure 6. Actual vs prediction values for logistic regression

Table 1. Observation table

Observation point	Blockchain and ML based system	Traditional system
Data security	Enhanced by blockchain's immutability.	Vulnerable to unauthorized modifications.
Paperless processes	Eliminates paper-based documentation.	Relies on manual paperwork, leading to inefficiencies.
Immutability and transparency	Ensures an unalterable chain of custody.	Lacks cryptographic security features.
Prediction accuracy	Uses ML for precise land price predictions.	Relies on manual assessment, prone to inaccuracies.
Efficient ownership transfer	Streamlines automated and secure processes.	Involves manual procedures, leading to delays and errors

5. CONCLUSION

The integration of blockchain technology and ML algorithms in land registry systems represents a transformative approach that addresses critical challenges and unlocks substantial benefits. The combination of blockchain's security features and ML's predictive capabilities offers a comprehensive solution for modernizing and enhancing land-based registry processes. Blockchain ensures the security and integrity of land registry data. Through its immutable and decentralized ledger, blockchain safeguards against unauthorized modifications, providing a tamper-proof and transparent record of land transactions. This enhances trust among stakeholders and mitigates risks associated with fraudulent activities, ensuring the reliability of the land registry.

The implemented methods have demonstrated efficacy in small-scale applications, showcasing improved data security, streamlined ownership transfers, and precise asset valuations. The success of these methodologies suggests the need for widespread implementation on a larger scale. The marriage of blockchain and ML technologies presents an opportunity to revolutionize land registry systems globally, enhancing their efficiency, transparency, and reliability. As we move forward, it is imperative to consider the scalability and interoperability of these technologies to accommodate large-scale adoption. Collaborative efforts between governments, regulatory bodies, and technology providers are essential to establish standardized frameworks and ensure the seamless integration of blockchain and ML into existing land registry infrastructures. The potential benefits for stakeholders, including property owners, investors, and governmental bodies, underscore the importance of further exploration and widespread implementation of these innovative technologies in the realm of land-based registry systems.

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