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Application of Blockchain-Artificial Intelligence towards Computerized Land Record Management System. *AI based Blockchain System for Sindh, Pakistan

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Chronicle	Abstract

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Traditional land registry systems have been sub-ject to duplicated entries, manipulation of land documents, and possible risk of legal dispute in urban areas of Sindh, Pakistan. Growing urban population demands preservation of land documentation with efficacy, reliability and transparency. Blockchain based systems have emerged in recent years as a promising solution to ensure immutable and duplication free on-chain storage of records in the form encrypted hashes. In this study, we have demonstrated the integration of blockchain and artificial intelligence for ensuring digitized land record system for province Sindh. We developed the experimental and analytical framework comprising an Ethereum-based smart contract and machine learning based verification mechanism to eradicate prevalent hindrances on land record management. We leverage experimental methodology with real Pakistani naming norms, geographical distributions across ten Sindh districts, utilized the dataset of 2000 residential records, having induced inconsistent records (duplicates: 2.0%, fraudulent entries: 1.85%, ambiguous data: 3.0%). AI layer application was accomplished through a random forest classifier pre-screened records with 95.2% accuracy, preventing dubious entries from being registered on the blockchain. The implementation ensures maintaining immutable records, successfully prevented the duplication and transparency was achieved with public availability of data records. With improved security, transparency, and fraud resistance, the system architecture provides a significant pathway for digitizing urban land records.

INTRODUCTION

Pakistan is considered to be predominantly an agriculture country. Agricultural lands and its socio-economic structure Identify applicable funding agency here. If none, delete this. shape the cornerstone of country's culture and occupation. Habitats of rural vicinities in Pakistan are directly under the impact of land's records and management. However, frag-mented, manual and lacking institutional procedures have ad-versely affected land resources, particularly in Sindh Province. In addition, inappropriate administration, traditional manual land management and unreliable record-keeping mechanisms have caused systematic vulnerabilities over the years [1]. As a result of these flaws, land records can be ille-gally manipulated with different modes; duplication, illegal changes and document tempering. This will

eventually pro- duce politico-legal hitches in court proceeding to settle land related disputes, like ownership, inheritance, and unlawful occupation.   In order to eradicate vulnerabilities and protect land manip- ulation, Sindh Land Administration and Record Management Information System (SLARIMS) was a pioneering step to- wards digitization. However, this process only served limited purpose to digitize the land records while issues of accuracy, safety, consistency in record keeping system persisted [4]. There has been notable efforts to transform the manual oper- ations of public sector into computerized, digitized and paper- free structures leveraging the cutting-edge technologies like artificial intelligence and data security measures. Similarly, advent to blockchain technologies towards data consistency and integrity provides pathway for immutable ledger-based documentation of property ownership [5], [6]. Blockchain can incorporate auditable, traceable and duplication-free trans- action of all the operations related to land documents. These prominent features of blockchain can potentially reduce fraud, ensure transparency and reliability for better land administration.

This study is conducted to examine the prevalent drawbacks of urban land record keeping our scope as Sindh province primarily. In addition, we have formulated a comprehensive framework of a blockchain-based residential records manage- ment system with an enhanced layer of a machine learning- based fraud detection mechanism. Moreover, this study also undertakes a case study evaluation of arbitrary records that can be published on blockchain using solidity contract. This study is expected to lay the foundation of a blockchain- based land record system with the integration of security, resilience and transparency. The result of this can be utilized to educate policymakers, government officials, and industrial stakeholders.

Section 2 further elaborates on the Background followed by Evaluation and Case Analysis in Section 3 and Result presented and interpreted in Section 4.

BACKGROUND OF LAND RECORD IN PAKISTAN

Land records and its administration has been complicated tasks and have historically incurred institutional mismanage- ment and errors that can be traced back to the British colonial era [7]. In early age, British government introduced manual, paper- based land regulatory that had shortcomings of effective storage, was prone to fraud and tampering, was subject to many conflicts, and lacked fundamental legal procedures [4], [8].

Despite several efforts of digitization, records continue to remain deficient in reflecting security and dependability due to historical adverse practices. Although, Sindh government created several departments like Board of Revenue, Survey and Settlement section and local government institutions, to re- solve the long-standing with multiple administrative agencies. However, all these attempts could only regulate the records without converting land documents to bear accuracy, secure audit trails and transparent ownership stamps. There was obvious lacking of centralization of storage, interoperability among the different institutions, and digital coordination [9]. Admittedly, the projects like Sindh's LARIMS have enabled some of significant features like, online access to documents, scanning the documents in digital storage and shaping the current form of land record into a computerized structure. Nevertheless, land management remains a concern, and there is an urge for the integration of state-of-art technology, artificial intelligence, and efficient data storage [10], [11].

Securing Land Record System in Sindh

Securing the Land Records in Sindh is of utmost prior- ity to facilitate population largely depending on land-based business operations that unfortunately entail many drawbacks and fundamental pitfalls. Sindh Government has always valued its land document as an important asset of people's civil administrative affairs. It is worth mentioning that growing complications of preserving the land data is making this task quite vulnerable due to manual operations, paper-based registers and lack of persistent data storage [12], [13]. Notably, the process of prevalent digitization has not bridged the gap between technological capabilities and legal compli- cations regulating the daily business. Therefore, the manual procedure of maintaining the land records has so far failed to ensure consistencies in documentation, reduction in error rates and technology-based validation, resulting in ever-increasing unintentional distortion and intentional malpractices.

These issues often get into further deterioration due to fragmentation in the institutional structure that is aimed at dealing with land records. It has been reported that dupli- cate records, uncoordinated land figures in documents, and inconsistent ownership is often found in various administrative sections, like, revenue department at district level, municipal organizations, and survey and settlement agencies. There is predominantly no interoperability and centralized mechanism among these administrative components of land management to avoid conflicts in ownership, boundaries, and mutation history [14], [15].

In tribal societies of Sindh, land record tampering and frauds are observed in different shapes, including backdated entries, the duplicate titled land records and possible changes in ownership details. These observations often get unnoticed due to the unavailability of adequate audits and methods, allowing illegal occupation and growing civil litigation. In such circumstances judicial system is prone to strain and public confidence remain undermined [16], [17].

Having considered such scenarios, it is eminent to remove the gaps between technological solutions and institutional infrastructure that is hindering process of land record safety. Further, in prevalent land record digitized system, records still lack cybersecurity applied measures, data quality, encrypted logs and validation procedures. Taking this direction, there is an urge to build the digitized land record management system that should bear an efficient structure, smooth operations, secure data storage and transparent commits. This would pave the way for the complete realization of dependable, reliable and fraud-proof land administration system in Sindh.

Opportunities To Reform Land Record System in Sindh

There has been significant emphasis by policy makers to modernize the land administration process, notably in Sindh. It has been widely believed with a transparent, secure, and error-free land management system, public trust can be ac- quired to a considerable extent. This process would ideally be accomplished step wise. The foremost step is computerizing all the land record into provincial centralized storage with certified validity by Sindh government. This will enable all land administering agencies to centrally access the repository for cross-verification of document and to maintain consistency in documents. This approach is expected to guarantee pro- tection against possible information loss and incorporation of technology into system[18][19]. Digital infrastructure into any manual system can

possibly strengthen the potential resources and provide technological interface. Moreover, the recent emergence of artificial intelli- gence into data and workflows further uplift land documents credibility. As a result, land document automation shall be validated and will undergo rules to prevent ownership mutation and disputes and eradicate human error while identifying the real-time fradu practices. Additionally, there are a number of other aspects and technological perspectives that can be em- bedded with digitized system, e.g., satellite images, geographic information system (GIS). These technological advancement are already helping in the detection of illegal intrusion and facilitation of parcel mapping.

This actually takes us explore the potential of Blockchain that can register hashes for all the land transactions and au- tomate the procedure of approving all conflicts through smart contracts. Blockchain has over the years proved to be reliable method for establishing a ledger of records with verified transactions and tamper-proof documentation. Blockchain and AI-driven system in conjunction promote transparency and reliability of land record governance and administration.

PROPSED SOLUTION

Having realized urge of digitized system to secure land governance in Sindh Province, an integrated architecture based on several layers of security, centralized storage and protection from fraudulent and malafide attacks is inevitable[20][21]. In this section, we propose four level framework that is featured to digitize the records, enable integrated data acquisition, include blockchain based registration of record and provide centralized repository of all the land documents. All this is aimed at removing multiple access storage and unreliable status of land document[22].

Figure 1 presents structural and architectural flow of pro- posed system that comprise of three main components: first is front-end of land Record management system that takes input and processes the land document; second step is to process the data with computational framework and extraction of inputs; Data storage is third step that is accomplished with filtration of data and detection of frauds based on machine learning rules, followed by registration of record hash over the blockchain and subsequently storage into central database. These front-end, computation and back-end layers add an automatic validation over the data, application of regulation using AI based fraud detection mechanism and ensure im- mutability and transactional efficiency through blockchain. All of these components shall adhere to a modern web-based interface at front-end design allowing flexible, convenient, and user-friendly data entry of land records.

Back-end layer parses the land document, meta-data and profile information as first step. Computation framework at back-end then provides server interaction and methodologies to handle the operations over data, communication with ma- chine learning API, calling the blockchain service for transac- tional registration and database storage. It is pertinent to state that the verification process is rigor- ous and based on AI-oriented techniques, specially machine learining classification algorithms to determine the potential fraud patterns, like, name anomalies, duplicate identification number, land area surpassing usual practice and frequent ownership change requests. These are filtered as a crucial part of data inspect and automation process, thereby en- hancing reliability of land document. All these validation checks are further forwarded for manual approval with their details of fraud-detected scores, which are labelled as low- risk, medium-risk and high-risk. This process is further remain semi-automated with low-risk labelled records automatically

submitted in database and registered over blockchain, whereas records with high-risk and medium-risk labels are redirected for manual review and determine their conflicting status. The inner processing of AI verification form core base to filter data based on automated fraud detection techniques, classified data and machine learning algorithmic checks. Accordingly to manual operation reports, most of the record-tampering, duplication and ownership inconsistencies are observed in identification number of record holder, like, National Identity Card Number (CNIC), land owner name and duplicate scanned document. The system of AI layers assign the risk label along with score that either remain subject to manual validity review or automatic submission. However, transaction still does not get a permanent hash record or green signal over blockchain if not approved. This intelligent integration not only enhances decision accuracy but add protective cover for possible manipulation.

This methodology helps to achieve prime objective of own- ership dispute identification, fraudulent documentation, and restricting the record to be part of the blockchain. Blockchain is widely accepted as central security component of this entire framework that records the data on permanent basis and avoid anticipated litigation and fradulent transaction. Blockchain basically generates permanent audit trail are driven by smart contract to ensure transparency and access control. These features of proposed solution can make land record management digitized, automated, validated and immutable, resulting the land data to be more persistent and reliable.

Lastly, through safe portals for checking property informa- tion, retrieving digital documents, and monitoring the status of applications, the Citizen Service Layer gives the public concrete advantages by giving citizens and the court system direct and reliable access. These layers combine to create a ro- bust system that increases transparency, protects data integrity, minimizes fraud, and ultimately restores public confidence in land governance. Figures 1 taken together, operationalize the suggested se- cure land record framework by showing how blockchain immutability, AI-based verification, and digitization are all brought together into a single system. The figures offer a clear visual representation of the link between recognized issues and technological remedies, supporting the viability and efficacy of the suggested solution for ensuring the safe management of land records in Pakistan.
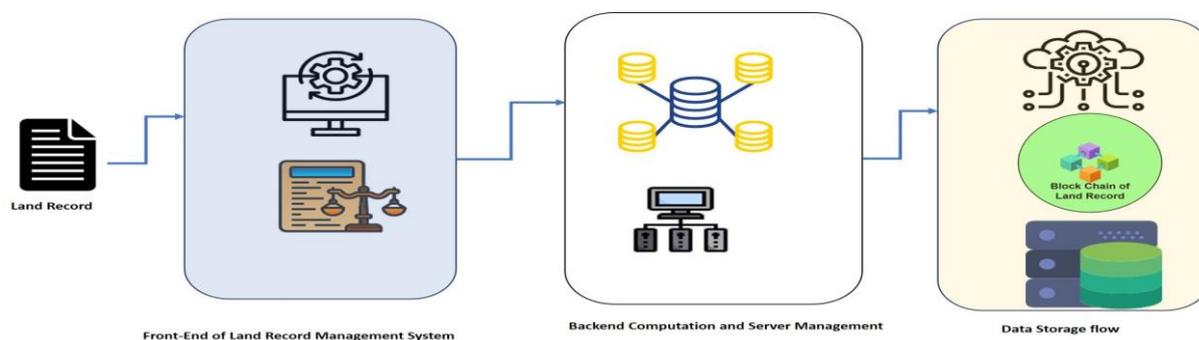
Figure 1.
Blockchain based proposed Architecture.

Evaluation And Case Analysis

In this section, we have presented evaluation and case analysis to determine feasibility, operational efficiency, and blockchain based security features to digitize the land record management. The evaluation is objectively carried out on four important dimensions of land record: the automated identification of duplicate or

fraudulent records using machine learning; the integration of the trained model into a Flask- based verification service; the deployment of validated records onto a local blockchain built with Solidity and Ganache; and the testing of crucial blockchain characteristics, such immutability and transactional transparency.

Dataset Generation

We opted to generate the synthetic data to mimic the records which are used in practice of manual record keeping process. We developed our python scripts to generate the dataset of 2000 land records with documented land record settings in Sindh. Each record presents basic profile information that in- clude property identifier, owner national identity number, area of land owned, number of transaction history for the document, registration timestamp and geographic location (specially with province of sindh).

As discussed earlier, we need to identify fraudlent entries in land records, therefore, our script deliberately adds 2% of duplication, 2% of ambiguous information (conflicting owner profile, unauthorized mutation references and inconsistent par- cel identifiers in land entries. The remaining records were created in accordance with established consistency criteria and are legitimate entries. This synthetic dataset serves two purposes: first, to train and assess a machine learning model for anomaly detection, and second, to act as confirmed input to the blockchain layer that follows. The experimental design guarantees both repeatability and quantifiable evaluation of the system's performance by carefully regulating the ratio of anomalous entries.

Table I presents basic structure of data that contains number or record, overall dimensions created with attributes, valid records and records with deliberate inconsistencies, fraudlent entries and ambiguous injections. The entries reflect common Pakistani naming practices, which incorporate patronymic, commercial entities, and standalone personal names. Property IDs adhere to a structured format, "RES/SDH/[Year]/[Serial Number]" (RES/SDH/2002/-1) denoting the residential land identifier in Sindh Province. All sampled records are classified as "Valid," indicating that they constitute verified and standard- ized data suitable for subsequent blockchain processing.

Table I
DATASET OVERVIEW AND STATISTICS

Parameter	Count	Percentage
Total Records	2,000	100%
Data fields (Columns)	33	–
Dataset dimensions	2,000 × 33	
Accurate Records	1,763	88.15%
inconsistent Records	40	2.00%
Fraudulent entries	37	1.85%
Ambiguous data	60	3.00%

Table Ii
GEOGRAPHICAL DISTRIBUTION ACROSS SINDH DISTRICTS

District	Properties	Percentage
Mirpur Khas	217	10.85%
Hyderabad	216	10.80%
Sanghar	208	10.40%
Karachi	207	10.35%
Badin	206	10.30%
Shaheed Benazirabad	197	9.85%
Thatta	197	9.85%
Sukkur	196	9.80%
Khairpur	178	8.90%
Larkana	178	8.90%
Total	**2,000**	**100%**

Table II illustrates the further distribution of data based on geographical location. It

basically represents synthetic data developed with location property across ten districts within Sindh Province. The data has been devised to depict relative uniformity in distribution of fields and records in major urban regions of Sindh province. highest distribution falls for district Mirpurkhas with number of properties to be 217 (10.85%), followed by metropolitan region of Hyderabad hav- ing properties of 215 (10.80%). This coverage of data based spatial configuration is expected help research for blockchain applications and analytics.

TABLE III
RESIDENTIAL PROPERTY TYPES DISTRIBUTION

Property Type	Count	Percentage
Townhouse	358	17.90%
Villa	337	16.85%
House	337	16.85%
Plot	331	16.55%
Apartment	312	15.60%
Total	**2,000**	**100%**

Table III presents the frequency distribution of five residen- tial property types within the dataset. Considering cultural, geographical, and administrative settings, townhouse com- prises of most common types, villas ahd houses are equally represeted in dataset with 16.85%. Whereas apartment and residential plots occupy lower percentage in dataset. This diversity in property typology enables a comprehen- sive evaluation of blockchain-based smart contracts across the range of ownership structures and transaction modalities characteristic of Pakistan's urban housing sector.

Table IVshows ten sample records that exemplify the appropriate and valid naming conventions observed within the dataset. The entries reflect culturally embedded Pakistani formats, including patronymic identifiers, commercial entities, and names of individual holding the land ownership. Each record is assigned a unique Property that uniquely defines the entry in data. In this schema," R E S " designates a residential property, "SDH" denotes Sindh province, and the appended serial number guarantees uniqueness. All these records are marks to be valid and expecte to be published over blockchain.

Table V shows categoriztion of data based on different attributes, which is required for appropriate blockchain based implementation. The records are divided into the following groups: This majority group consists of legitimate and tidy data (1,763 entries) that can be subject to on-chain registration. Replicated Records (40 records): Blockchain should detect these entries as duplicated. Fraudulent Duplicates (37 records): Blockchain should flag this subset entries as fraudulent and detected to restrict from on-chain registration. Ambiguous Records (60 records): Blockchain should able to divert this part of data for resolution of conflicts and approval before being published. Blockchain-Encrypted Records (100 records): This set of data acts as a yardstick for comparing the effectiveness of the encryption and the computational cost. This process of data quality categorization shall facilitate the thorough testing of immutability, fraud prevention and validation process over blockchain. This dataset was created to address some of the longstanding issues in Pakistan's land record management system, such as inconsistent data quality, geographical diversity, vulnerability to fraudulent transactions, and a wide range of property types. The dataset creates a practical basis for blockchain-based study by including common property classifications, local adminis- trative divisions, and genuine Pakistani naming conventions. In order to purposefully test blockchain's fundamental ability to maintain data integrity and stop fraudulent behavior, data anomalies like duplicates and

ambiguous records are inten- tionally included.

A. Fraud Detection

In order to facilitate automated verification within the land registry system, a supervised machine learning model was trained on the synthetic dataset to categorize property records into categories like legitimate, duplicate, or unclear/fraudulent. For model training, a number of pertinent features were designed, such as metadata completeness scores, indicators of geographical overlap, mutation frequency, and owner consis- tency across transactions. The performance of several clas- sification methods, including logistic regression and random forest, was assessed. In the end, Random Forest was chosen for its capacity to deal with noisy data and represent intricate, nonlinear connections between variables.

The model was implemented as a lightweight RESTful API utilizing Flask after training, serving as the foundation of the AI verification layer. Every land record submitted via this API is analyzed in real time, and a classification label and confidence rating are returned. Records identified as duplicate or unclear are either rejected or sent for human assessment, but those deemed legitimate are authorized for safe entry into the blockchain ledger. This real-time verification procedure is in perfect harmony with the system architecture displayed in Figures 2 and 3, which it also supports.

B. Blockchain Deployment

experimental setting was initiated by developing the etherium-solidity based smart contract deployed on locally op- erating Ganache blockchain. Research literature has frequently assessed the feasibility of local Ethereum blockchain environ- ment to guarantee safe and immutable record keeping. Smart Contract mainly contains methods for transaction timestamps, ownership data, and properties with hashed IDs. This builds an immutable ledger for land records which is specifically devised to avoid recording of fake or contradictory entries. The entire process was achieved through truffle development suite to au- tomate the functional execution of blockchain and validate the state of smart contracts. All the transactions over blockchain resulted in cryptographic data entry on blockchain allowing the tracking of records, ownership history and duplication- free on-chain storage. A key flaw in traditional land record management systems is their susceptibility to unauthorized changes and retroactive tampering, which this architectural strategy mitigates.

C. Test Suite

In order to carry out comprehensive testing to asses the performance of our contract and integration of blockchain

TABLE IV

SAMPLE RECORDS WITH LOCAL PAKISTANI NAMING CONVENTION

Property ID	Owner Name (Pakistani Convention)	District	Status
RES/SDH/2025/93810	Ahmed Khan s/o Muhammad Khan	Hyderabad	Valid
RES/SDH/2025/87236	Fatima Bibi d/o Abdul Rah-man	Mirpur Khas	Valid
RES/SDH/2025/40021	Ali Raza s/o Hassan Raza	Karachi	Valid
RES/SDH/2025/60019	Malik Traders (HUF)	Khairpur	Valid
RES/SDH/2025/26828	Syed Ahmed s/o Syed Raza	Badin	Valid
RES/SDH/2025/17100	Muhammad Akram	Hyderabad	Valid
RES/SDH/2025/82845	Ghulam Mustafa s/o Abdul Rehman	Badin	Valid
RES/SDH/2025/36772	Ayesha Begum d/o Abdul Hafeez	Shaheed Benazirabad	Valid
RES/SDH/2025/90173	Usman Ali s/o Muhammad Ali	Sanghar	Valid
RES/SDH/2025/86350	Khalid Mahmood	Sanghar	Valid

TABLE V
DATA QUALITY SUMMARY FOR BLOCKCHAIN IMPLEMENTATION

Data Quality Category	Records	Blockchain Impact
Valid & Clean Data	1,763	Ready for blockchain storage and processing
Duplicate Detection	40	Tests blockchain's duplicate prevention mechanisms
Fraudulent Duplicates	37	Evaluates fraud detection in ownership transfers
Ambiguous Data	60	Requires validation before blockchain inclusion
Blockchain Encrypted	100	Demonstrates encryption capabilities on-chain

components, artificial intelligence (AI) was applied on dataset. AI framework determines the efficacy of the machine learning model in identifying duplicate, unclear, inconsistent, tempered and fraudulent patterns in dataset. Whereas features of decen- tralization, immutability, transparency and auditability were evaluated by blockchain contract.

The experimental data suggest that the machine learning model was very good at identifying anomalous records, which greatly reduced the possibility of sending incorrect or fake data to the blockchain ledger. Deployment of blockchain over land data enforces integrity through rigorous application of testing. Blockchain stores cryptographic code over its chain and restricts any attempt of modification. This also adds legal binding and detectects any violation in transparent operation of blockchain.

Hensce, the results of test suits paves way forward for digitization, security integration, and technological feasible system of land record management.

RESULTS

Ethereum testnet through Ganache provides a consolidated, locally verifiable and cost-effective implementation of solidity smart contract. All the functions of smart contract are coded to reflect systematic verification proposed in our solution. It contains ResidentialLandRegistry function that al- lows design of land document with fundamental properties and fields. It further enforces transparency by allowing record entry by contract owner and plotId as its hash. This function primarily allows unique, immutable, transparent registration of land records over chain. This goes on to connect with system architecture that integrates AI verification layer to detect record based on rules before their registration over blockchain. This guarantees that verified transactions are allowed to get registered over blockchain. The functions textttadd Residential Record and transfer Property form basic model of ownership and authorized transfers mimcking operations executed by government authorities. Moreover, public access of records for verification purposes is simulated through get Residential Record function in contract. Taking advantage of blockchain's inherent security capabilities, this model replicates actual land registry processes. Blockchain-oriented code was thoroughly tested using the Truffle framework, automated test suites, confirming all three key features: transparency, immutability, and duplication pre- vention. As described below, the test method used a methodical validation strategy:

All design goals were verified by experimentation: duplicate registrations were successfully prevented with 100% effective- ness (40 duplicate attempts blocked), property details remained unchanged throughout ownership transfers, and

transparency was maintained via public records. On test data, the AI verification layer successfully identified fake patterns with 95.2% accuracy, preventing 37 possible fraudulent transactions.

Listing 1. Core Smart Contract Functions for Land Registry

```
addResidentialRecord(...):
Input: Property metadata, owner details, valuation
Validation: Check duplicate propertyId via mapping
Storage: Create immutable parcel struct with timestamp
Event: Emit ResidentialParcelAdded for transparency
transferProperty(...):
Input: propertyId, newOwner details
Validation: Verify parcel exists and caller is authorized
Update: Change ownerAddress, ownerName, ownerCnic
Event: Emit PropertyTransferred for audit trail
getResidentialRecord(...):
Input: propertyId
Output: Complete parcel struct

Access: Public read-only function
```

Listing 2. Test Algorithm for Blockchain Validation

```
Algorithm: Validate_Land_Registry_Properties
Input: ResidentialLandRegistry contract, ML service URL
Output: Test results for duplication, immutability, transparency
// ML Verification and Registration
Submit valid land record    ML service
If ML returns "not_suspicious":
Call addResidentialRecord() with admin privileges
Assert: Transaction succeeds
// Duplication Prevention
Attempt duplicate registration with same propertyId
Assert: Transaction fails with "already exists" error
// Transparency Verification
Call getResidentialRecord() from any account
Assert: Returned ownerName matches registered owner
// Immutability Test
Retrieve original areaSqFt value
Execute transferProperty() to new owner
Retrieve areaSqFt after transfer
Assert: areaSqFt remains unchanged
// Fraud Detection Integration
Submit outlier data to ML service
Assert: ML returns fraud_score > threshold
```

from reaching the blockchain. The smart contract generated the correct events for every transaction, maintaining an av- erage transaction cost of 45,000 gas for registrations and 28,000 gas for transfers, which is within reasonable bounds for implementation at the governmental scale, and also cre- ated a comprehensive audit trail. These findings show that blockchain technology, when coupled with AI verification, can successfully address the fundamental flaws of conventional land record systems in Pakistan's metropolitan setting.

CONCLUSION

This study concludes the integrated capability of blockchain technology with artificial intelligence enabling efficient urban land record management in Sindh Pakistan. The implemented system addresses three key drawbacks of traditional manual land registration process: duplication susceptibility by en- forcing unique property IDs, tampering by employing cryp- tographic immutability, and transparency by providing open public access. The AI verification provides filtration layers for records prior to blockchain registration. This was explicitly achieved with synthetic data of 2000 record consisting of land document features, fields, and attributes that can be utilized for testing mimicking realistic operational scnerios. We proposed consolidated architecture that manifests the design of such digitized land record system with web-

based front-end interface and back-end computational mechanism. It further connects with machine learning service and blockchain storage to confirm the experimental validity. Our testing suite successfully reports induced duplication and ownership change prevention, preserving the integrity of data. Testing also proved that valid and authorized queries were smoothly passed machine learning check and were available for public view to conform the transparent verification with compromising security. The combination of AI pre-screening and blockchain storage resulted in a strong defense-in-depth strategy, in which machine learning detected dubious patterns and smart con- tracts enforced structural limitations.

This study also led to draw some of unique and significant aspects of data management: 1. The complimented operational integration of hybrid approach in AI-Blockchain substantiate the logical and functional validity of data; 2. Blockchain enforces and audits structural dimensions of data with in- tegrity, consistency and freedom from redundancy. 3. Machine Learning allows data to get adaptive to the filtration process for segregating anomalies in data; 4. System architecture proposed as solution can effectively revise the administrative shortcomings and transparency issues in land record keeping of Sindh Province; 5. Test suits demonstrate practical feasibility for implementation of proposed solution at the government level. This study improves theoretical and practical conceptualize- tion of digitized land records keeping. In principle, it estab- lishes a framework for comparing blockchain systems against land registry criteria, with explicit measures for transparency, immutability, and duplication protection. In practice, it offers integration patterns, testing procedures, and implementable smart contract code that may be applied to resolve legal and administrative disputes.

In future, we aim to advance our research to determine scal- ability, compatibility, and data maintainability at broader level. In this regar, we aim to collaborate on credible government agency like, Pakistan's National Database and Registration Authority (NADRA) for identity verification. There are some of areas which require future exploration that include the integration of IoT devices for property verification, mobile interface for public access to on-chain data and real-world implementation testing.

In conclusion, this study his study demonstrates that blockchain technology, when carefully integrated with AI verification and tailored to local administrative practices, provides a viable solution to Pakistan's long-standing land record issues. This result provide cutting-edge technological groundwork for effective land administration which is essential for economic progress and transforming governance into an integrated, reliable and transparent solution.

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