Decentralized Ledger for Land and Property Transactions in Sri Lanka Acresense

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Acresense

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Abstract— **Land & property can be identified as one of the core assets in any county in the world. Governments spend significant amount of money to identify, define, manage and maintain the transactional information around land and property in a country. Creating a proper mechanism to make this information available to the public users can be considered as one of the key indications that shows the development of a country. The system currently in use to record land and property transactions in Sri Lanka is a book-based system where all the information is stored in handwritten folios. This method is inefficient, time consuming, unsecured and complex when compared to the advanced systems which are used by developed countries in the world. This study is carried out to find a secured, efficient, cost effective solution with regards to the concerns and other problems related to land and property transactions in Sri Lanka. Proposed solution includes a decentralized ledger to record land and property transactions which runs on top of blockchain technology. All new transaction entries will be validated by smart contracts to verify the validity of the transactions. After performing a proper consensus mechanism, the transaction records will be stored in cryptographically secured blocks. So, the data integrity could not be violated. Additionally, investors and the land buyers can get information about the current market trends & predictions before buying or investing into a land. Also, the proposed system supports the users to view the land information graphically and allows the system users to view the desired land parcels without physically going to the actual location via the geographical information system.**

Keywords— Decentralized ledger, GIS, Blockchain, Smart Contracts

I. INTRODUCTION

Sri Lanka is a country with a total land extent of 65,510 Sq. Km, rich of natural, cultural and historical values. According to the statistics of land ownership & distribution shows 82% of these lands are managed by government and religious institutes like temples and churches. The rest 18% is privately owned and managed by citizens. 73% of the total Sri Lankan population owns a land parcel where the other 27% is landless [1]. Most of the lands has legal issues in plans, deeds, or in ownership and this uncleared lands cause issues to both to buyers and the sellers. Most of the times people who has excess land is used to sell, rent or lease their excess land parcels or to use to generate income by cultivating economical and other crops. “Land” can be identified as one of the most valuable assets in Sri Lanka due high demand and its limitations as a resource. Most of the privately-owned land parcels are handed over from families from generations to generations as family property.

Current land and property transaction system in Sri Lanka is complex due to the multiple number of intermediaries and government authorities involved in this process. Transactions are governed over more than 30+ rules and regulations to avoid the fraudulent transactions. But still the current process has so many loopholes where people used to perform illegal transactions and fake the ownership of the land parcels. Existing process is time consuming and costly for all the parties involved. All the land transactions are currently recorded in manually documents (folios). These documents can be altered hence the data integrity could be violated. False ownership can be considered as a major issue in the current system and this has created a chaotic situation by causing millions of loses to both landowners and the government.

Millions worth land and property transactions happens daily and approximately the involved parties have to pay 8%-9% of the total estimated value of the transaction for taxes and government fees and also 4%-8% of the value as legal fees [2]. When compared to the full amount of the transaction this will be a big percentage for the parties involved in these transactions. When looking to these problems in all aspects it is important to minimize these high costs, reduce the complexity, paperwork and also to improve the security in the current land and property transaction domain. Since the blockchain based transaction ledgers are already a proven model to store transactions, it can be considered as a valid solution to overcome the prevailing issues.

II. Background study

The historical details of land registration systems in Sri Lanka shows that Sri Lankans were used to maintain the land records in “Lekam Mitti” before the Dutch and British [3]. During the Dutch era land ownerships were kept in “Land Thombu Records” which had the ownership of a particular land parcel to a family. Most significant changes to the land registrations in Sri Lanka have been done under the British rule where land registration ordinance no. 8 of 1863 was introduced to register lands with independent to the title [4]. This ordinance considered land title registration and deed registration as two separate provisions. In 1907 another attempt was made to register the land titles in Wellawatte and Kirulapone areas. After several years of gradual development, the “Registration of Documents” was introduced in 1927 as the ordinance no. 23. With this ordinance, only the deeds that were related to land transactions were registered. This system also has introduced some problems such as uncertainty of the ownership, fraudulent transactions and lengthy procedures of proving the ownership while doing the registrations. As a solution for the aforementioned problems and various other concerns, the “Registration of Title” has introduced under the act no. 21 of 1998.

The aforesaid ordinances have built a solid legal framework within Sri Lanka in order to secure someone’s ownership to a particular land parcel. Even though the current land registration system has raised with a good judicial structure, it can still be time consuming and prone to fraudulent transactions due to the lack of technology involvement in the field. The folios that are being used in current land registration system are handwritten documents that take a considerable amount of time to read and they can also be altered by creating loopholes for land thefts. As a solution for these kinds of problems a digital ledger can be used to hold the initial land transactions where authorized people can read and write the records and other parties can read the non-sensitive details as per the permissions that they have obtained.

With the development of the distributed ledger technology most of the countries are experimenting on migrating to blockchain based land registries in order to overcome the difficulties involved in the land transactions. Sweden is one of the countries that uses a blockchain based land registry since 2017 and it is said that they can save over 100 million USD from the Swedish taxpayers just by eliminating the paperwork, reduce fraud and speeding up transactions [4]. There are basic set of requirements a country must satisfy before migrating to a digital land registry. Most challenging part of having a digital land registry is that it does not initially identify the right owners and create the actual title. Therefore, before moving to this kind of a system, a country must have a proper title registration system where it identifies the correct holders of a particular land parcel. “Bim Saviya” is the Sri Lanka’s title registration programme started under the supervision of Ministry of Land and Land Development in 2007 [5]. This programme is expected to be completed in 2020 and upon the completion it will create a proper surrounding for a distributed land registry with an underlying blockchain ledger where authorities can perform land transactions with more transparency.

Sri Lanka has been resorting to surveying, cartography and photogrammetry for geoinformatics, up until recently. This area of work kept on improving through development and evaluation of new ways in response to constructive criticism over the past decade. Now it has come to a point where the involvement of geospatial data, GIS and other related technologies is becoming the common practice.

Even though this transition from the traditional methods through to the modern geoinformatics keeps on improving, it carries certain constraints and limitations, which makes the transition a challenging one. Identifying these challenges correctly and implementing the correct solutions for those using the correct technological avenues open up new business opportunities. The solution suggested as an information system by this work attempts to provide the meaningful and deeper engagement sought after by individuals and organizations from GIS and IT, by providing a valuable business tool for real estate investors.

III. Proposed System

Main objective of the proposed system is to overcome the errors and loopholes in the current manual system and to provide an efficient trustworthy solution to replace the existing manual processes. As a solution the proposed system *AcreSense*, provides a unique set of features to both government and non-government stakeholders. The final web platform which is going to be served as an e- Land registry to the community will consist of following components.

1. A decentralized blockchain ledger for record-keeping the land and property transactions.
2. A smart contract registry which will govern the rules upon the transactions.
3. Land valuation prediction and trending monitoring module.
4. A geographic information system which will include a graphical representation of lands across the country.

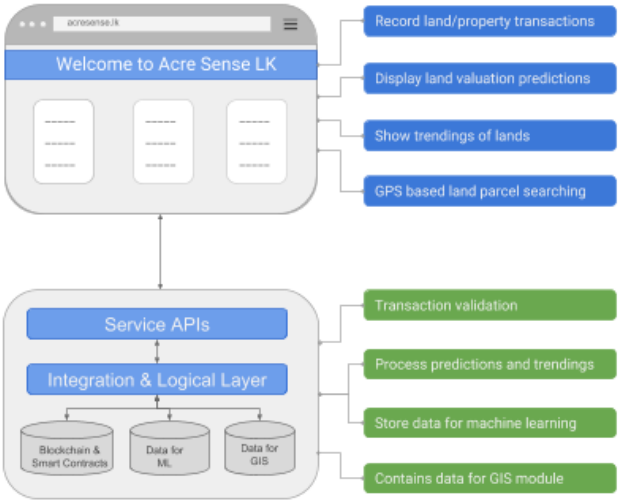

Fig. 1. High level feature breakdown diagram

The core component of this overall solution will be the decentralized ledger which is going to hold all the transaction details. This is going to be implemented by using the blockchain technology to eliminate fraudulent alterations to the transactions that are being recorded. The smart contracts will ensure that a particular transaction could be valid if and only if the defined set of rules are satisfied. The land valuation prediction module will analyze all the transaction details that are previously recorded and display the current valuations of land in a particular area. This output will predict the valuations for different geographical areas in and this could be used by several entities such as investors, bankers, land buyers and sellers to get an idea about current land price estimations. The trending monitoring module is will be displaying most popular lands among the community. Geographic information system will display all the registered land parcels along with selected set of non-sensitive data on top of a map layer. It will also facilitate GPS based searching of land parcels so that the stakeholders can view the land parcels without physically being to the location.

IV. Methodology

The main focus of this study was to implement a solution which has an underlying decentralized blockchain ledger and a smart contract layer which will be maintaining the land registration records without having the involvement of intermediaries. This also included two separate modules for land parcel viewing and land valuation prediction as value added functionalities for the whole solution.

To begin with the blockchain based ledger, the core technology was selected by doing a preliminary study. First, few candidate blockchain technologies were selected and analyzed the advantages and disadvantages of those technologies with respect to the land recordkeeping domain. As a result of this preliminary study, ChromaWay's Postchain was selected as the core technology for implementing the decentralized ledger. According to the Postchain documentation, one must design and develop a custom block in order to deploy it in the Postchain framework to begin with transactions. The custom block that has been implemented in this context is known as "Base Block" and it contains operations that needs to write transactions into the blockchain. It also has the Postgresql schema structure for the table creation. After the block has been defined it should be deployed to the Postchain framework to begin with the transaction recording. All the steps that are required for developing and deploying a block is documented in the Postchain document and those steps are carefully followed in this context for the implementation [6].

For every blockchain, there is a consensus mechanism which validates the blocks before they are added to the blockchain. In the implemented solution, the PBFT (Practical Byzantine Fault Tolerance) consensus is used as it has many benefits for the consortium databases [7].

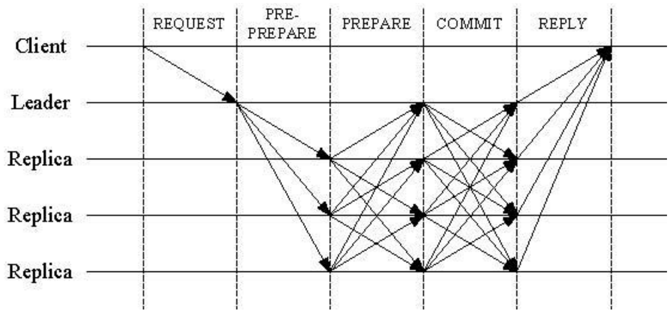

Fig. 2. Flow of the PBFT algorithm [8]

With the smart contract layer all the transactions are signed before it is committed to the blockchain. When an authorized person submits a new deed through the implemented platform, it will be sent for approval of three parties. Granter should be the first party who signs the deed with his/her public key (A public and private key pair is given upon the successful registration of a user) and after that the grantee signs the deed. Finally the notary who is assigned for the transaction will sign the deed. The signing process is a step by step process in which each step will be recorded in a separate blockchain with a unique blockchain id. A transactional block will only be added after getting approval of the parties associated with the transaction. This flow is solely managed by the smart contract layer which is implemented using ChromaWay's Esplix smart contracts [9].

Machine learning, and prediction module is implemented with the main objective of providing accurate predictions of the land parcels in different geographical locations in Sri Lanka. One of major problems to adopt a land value prediction system to Sri Lanka, is the unavailability of data with sufficient features for the prediction model to train on. Hence, average prices of the lands being sold in each quarter, provincial and district wise, for the last 6 years are consumed as the training data for this model. Respective time series data were extracted from publicly available sources like advertising websites.

The Box-Jenkins method [10] or more commonly known Auto Regressive Integrated Moving Average (ARIMA) models is the most general class of models used to forecast a short-run estimation of a time series which could be based on annual, quarterly, monthly or even weekly, daily or hourly data.

It is denoted as ARIMA(p,d,q) where 'p' represents the order of the autoregressive process, 'd': the order of the data stationary whereas the order of the moving average process is denoted by 'q'. The ARIMA models applied in this research follow the standard express stated below[11].

$$(1 - \Phi_1 B - \dots - \Phi_p B^p)(1 - B)^d Y_t = (1 - \theta_1 B - \dots - \theta_q B^q)e_t$$

A three-step approach was used in applying this model in the research.

1. Model Identification and Selection:

The first step of this phase was to determine if the time series is stationary or not and to look out for significant seasonality that should be modelled in it. The stationarity of the time series in subject was determined by studying three statistical properties: constant mean and constant variance over time and autocovariance which is independent of time. First when the time series was plotted it was clear that there is an overall increase in trend with some slight deviations towards the end.

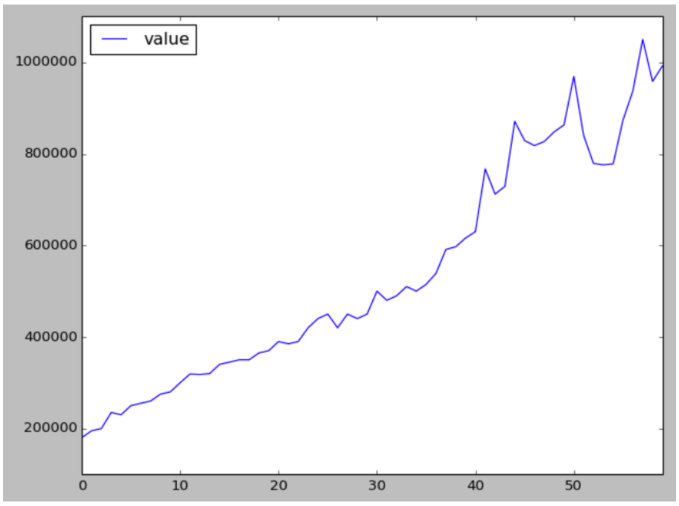

Fig. 3. Traning Data

To evaluate the stationarity of this time series, two statistical methods: **Plotting Rolling Statistics** and **Dickey-Fuller Test** were used. The increasing mean in the results from these tests suggested that this time series was not stationary.

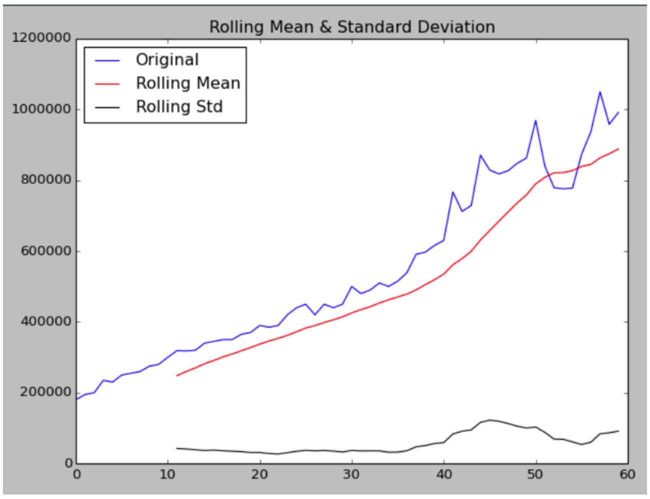

Fig. 4. Roaling MEAN and standerd devation graph

Results of Dickey-Fuller Test:

- *Test Statistic:* 1.378663
- *p-value:* 0. 997015
- *#Lags Used:* 10.000000
- *Number of Observations Used:* 49.000000
- *Critical Value (5%)* -2.922629
- *Critical Value (1%)* -3.571472
- *Critical Value (10%)* -2.599336

Trends and Seasonality are two major reasons for a time series to become non-stationary. Trend is the varying mean over time and Seasonality is the variations in the time series at specific time frames. The method followed in such scenarios is to estimate the trend and seasonality in the series and remove them to get a stationary series. Smoothing, or considering the rolling averages method was used to remove trends in the time series in subject. The rolling mean was subtracted from the original series to obtain a much better stationary time series.

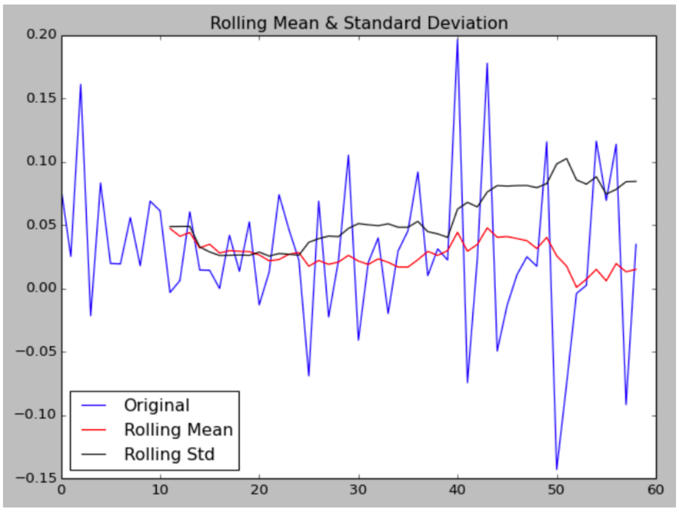

Fig. 5. Roaling MEAN and standerd devation graph after smoothing

For further processing of the time series, differencing and decomposing mechanisms were used.

2. Parameter Estimation:

Once the time series is stationary, the major challenge in the ARIMA models is to estimate or determine the values for parameters p, d and q. Methods that were followed in order to make this step easy were looking at the Auto Correlation Function (ACF) and the Partial Auto Correlation Function (PACF) for the given series. The parameter ‘p’ was determined as the lag value where PACF graph crosses the upper confidence interval for the first time and the value of parameter ‘q’ was determined as the lag value where the ACF graph crosses the upper confidence interval for the first time. The parameter ‘d’, the order of the data stationary could be determined on the basis where the ACF function approaches zero.

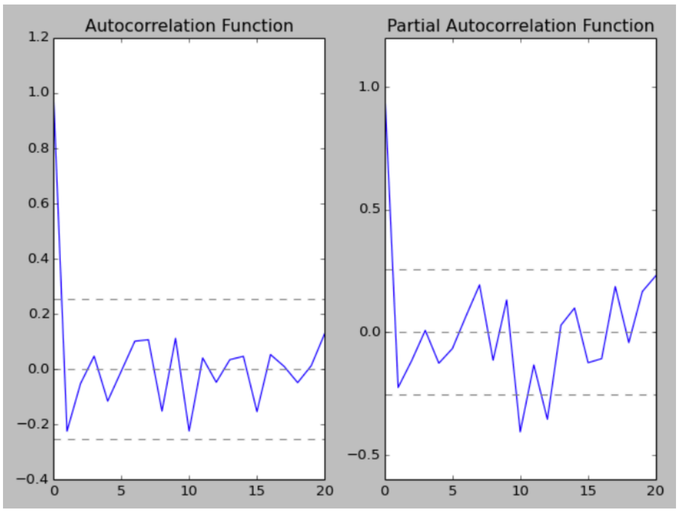

Fig. 6. ACF and PACF functions graph

3. Testing the model:

The trained model was tested to confirm that it conforms to the specifications of the univariate process. The forecasts of the model are the variations of the average cost of land in a given province, whereas the value of a land in a given location could vary depending on factors like the geolocation, the environment and could be subjected to random rises and drops of values due to reasons such as natural disasters and development projects undertaken in the given area.

The main focus of GIS implementation was to provide a solution which land buyer, land investors or any other party to find or publish lands with single click and providing business and social, location-based tools. To begin with the GI based solution, the core technology was selected by doing a preliminary study. First, few GI based technologies were selected and analyzed the advantages and disadvantages of those technologies compared with Sri Lanka. Some technologies and services which provide by those technologies-based companies are not available for Sri Lanka. Unavailability of digitize maps, digitize aerial photographs and digital spatial data were kind of barriers. As a result of this preliminary study, Google Map and ArcGIS were selected as the core technologies for implementing the GIS based solution for the whole solution.

Final target was identified existing systems and user requirements. Currently similar system is on progress under “Survey department of Sri Lanka” [12] which can provide only lands details in limited areas.

There are two main modules in the GI system. Those are powered by Google and Esri. First is responsible for fulfill the gap between the user and the system. Users can go through system available all lands on the map. Another two custom search engines generate additional details for the lands. These search engines generate details based on land, property and social, business separately.

The map which powered by Esri, provides facilities to analyze spatial data based on different criteria. Most of features which a notary or land inverter are available in this section. All operations come through our regular backend to guarantee the privacy and security of the users. GI system does not track or expose user’s location to a third party.

Whole GI system is able to serve to estimate compensation for lands Government agencies, local Government authorities, Survey & Mapping, Environment & Forestry, Land Use Planning, Census & Statistics, Transportation, Utility Boards such as Water, Electricity & Telecommunications. It can save time and cost by of land buyer by providing images and details.

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V. RESULTS

The digital ledger can be identified as the main outcome of this context. This was tested upon the implementation and the resulting blockchains were unalterable by any means. It allows only direct reads from the created relation and all the writes must be done through the client software. This client software is also built according to the Postchain's GTX architecture [6] and it acts as a middleware between the web interface and the blockchain ledger.

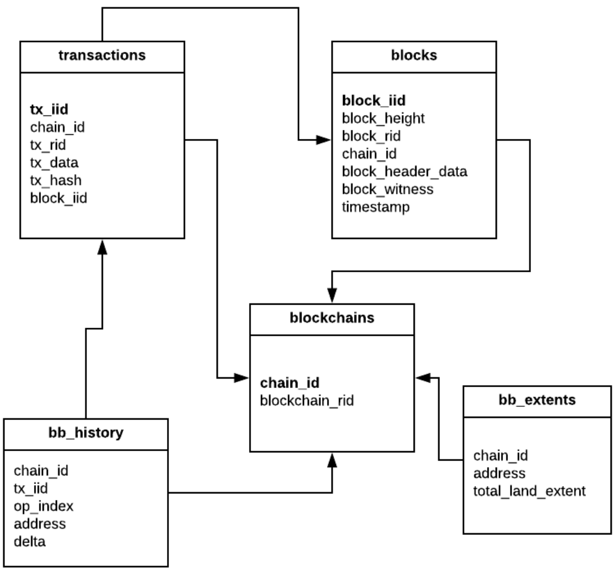

Fig. 7. Resulting schema for the blockchain ledger

VI. CONCLUSION AND FUTURE WORK

Blockchain based decentralized ledger, followed by the smart contract's engine has provided a secure way of recording the transactional information to overcome the existing issues. Providing custom tailed solutions to government and non-government authorities to fulfill their custom requirements will be one of the main targets for AcreSense in the future.

User can know more details about the lands and environments with-outreach to lands physically. It saves lot of time and cost from land buyer or investor side. Users can get an idea about lands by system generated impartial data. When government or non-government party need an estimation, this is the best option. This system provides high level details which needs for a lands valuation or estimation in a disaster, road mapping.

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