Smart Plant Disorder Identification System

Project ID: 2020-025

Project Proposal Report

B.I. Sariffodeen

B.Sc. (Hons) Degree in Information Technology spec. in Cyber Security

Department of Computer Systems Engineering

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Declaration of the Candidates & Supervisor

We declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
B. I. Sariffodeen	IT17354516	

The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Name of Supervisor	Date	Signature
Dr. Janaka Wijekoon		

Abstract

Agriculture is a knowledge intensive industry. As a developing country which traditionally has been dependent on agriculture, most Sri Lankan farmers rely on heuristic agricultural practices. According to the Food Agriculture Organization (FAO) of the United Nations, 'unnecessary use of fertilizer' by Sri Lankan farmers leads to soil pollution, degrading cultivatable land and has an inadvertent effect on crop health as well as consumer health via contamination of food crops. A common perspective among farmers is: 'applying more fertilizer leads to a better yield', which is a misconception encouraged by Fertilizer Vendors for profitability and accepted by most traditional farmers. The low penetrability of expert knowledge to the grassroot level has been a complication in increasing relevant awareness. Since farmers are often dependent on Vendors for Fertilizer purchasing, they are also reliant on them with regards to decision making; generating a vendor-centric purchasing ecosystem for fertilizer.

In such a critical context, this research component is aimed at providing a solution for the information asymmetry and knowledge gap existent with respect to adequate administering of fertilizer. The proposed solution is a decentralized, distributed system integrating experts and farmers to enhance informed decision-making capacity of farmers. The proposed community-driven platform would employ a blockchain-based approach. The recommendation of fertilizer is based on accurate identification of nutrient deficiencies in plants with its relevant stage.

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GDP – Gross Domestic Product

FAO – Food and Agriculture Organization

1 INTRODUCTION

1.1 Background

The Agriculture sector contributes up-to 6.9% of the national GDP and 26.1% of Sri Lankans are employed in the agriculture sector [1]. Although agriculture is not as prominent as it was, it is a major driving force of the country's economy.

According to extensive studies, the lack of literacy and awareness among farmers is a major drawback for the agricultural sector [2]. In the Indian Sub-Continent, most farmers remain illiterate and impoverished. They operate in isolation, with little or no bargaining capacity and lack high-quality agricultural practices that could improve their productivity.

DATE	VALUE	CHANGE, %
2016	131.9	-57.05 %
2015	307.1	17.54 %
2014	261.3	50.19 %
2013	174.0	-18.73 %
2012	214.1	-16.80 %
2011	257.3	12.34 %
2010	229.0	-18.60 %
2009	281.4	-9.73 %
2008	311.7	8.04 %
2007	288.5	-0.96 %
2006	291.3	14.11 %
2005	255.3	

Figure 1.1: Demographic of fertilizer consumption in Sri Lanka (2002-2016).
Source: knoema.com/atlas/Sri-Lanka/Fertilizer-consumption

According to Figure 1.0, as of 2016 Sri Lanka consumes 131.9 Kilograms per Hectare of Fertilizer. Although there is an evident decline in fertilizer consumption, the quantities consumed indicate that a substantial amount is invested within a calendar year for fertilizer.

Research indicates a direct link between the fertilization practices of farmers and the soil quality as well as quality of yield [3]. A gap exists between the recommended dose and actual use of fertilizer. This is attributed to farmers most often being manipulated by vendors to use low-quality or inadequate fertilizer products at uneven prices [4].

Indiscriminate fertilizing leads to soil toxicity and causes contamination of surface and ground-water sources; contributing to environmental pollution and adversely effecting human health [5].

1.1.1 Component Overview

With the context of fertilizer administration in the background study conducted, the lack of distributed expert knowledge among the farming community in Sri Lanka is made evident. The proposed system is aimed at addressing this issue by creating a decentralized platform bridging farmers, agro-experts and fertilizer vendors.

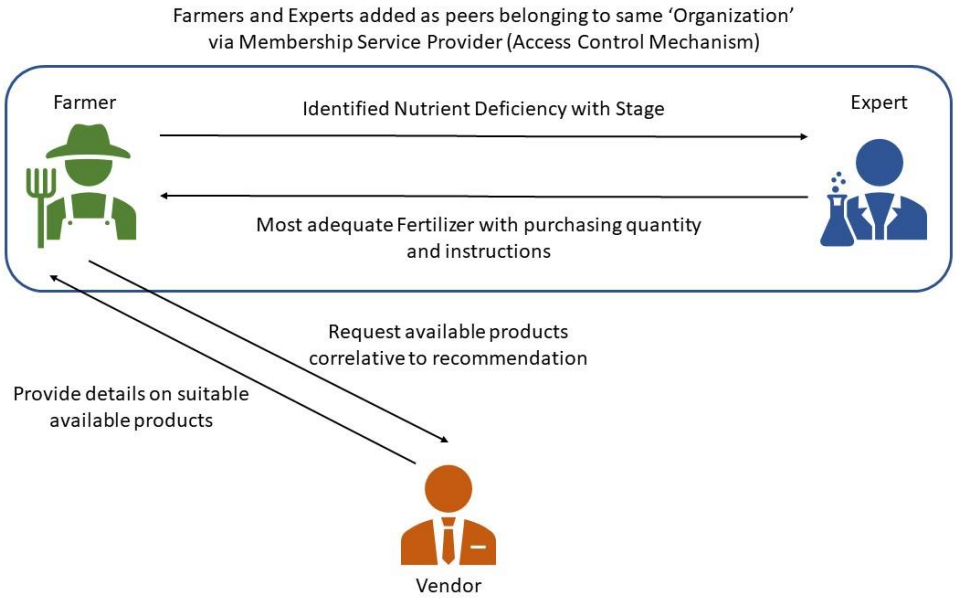

Figure 1.2: High-level System Diagram of Proposed Solution

The system is to be constructed employing the principles of Private blockchain networks [6].

1.2 Literature Survey

According to the FAO-ITU E-Agriculture Strategy Guide for Asia-Pacific region [7], improving the capability of farmers to access knowledge-banks, and institutions via Information and Communication Technologies (ICT) improves their productivity and profitability. Availability **of right information, at the right time, in the right format, and through the right medium**, influences and affects the livelihoods of

many stakeholders involved in agriculture through enhanced decision-making capabilities.

As stated by IBM [2], although government subsidies and other relevant institutions provide the farming communities with relief, most farmers remain impoverished. There is an increasing requirement for a reliable, convenient and sustainable solution to address various challenges. It is further stated that e-Agriculture solutions would ideally lower overhead costs while improving productivity. This theory has been established by Grameen initiatives carried out by entrepreneurs in rural India.

Inadequately planned long-term fertilization regimes and management practices often has a negative impact on soil chemical and microbial properties [3], resulting in soil pollution and toxicity. This is mostly impacted by the lack of awareness on accurate fertilization regimes. Agronomically-oriented research has been conducted on enhancing soil management practices and fertilization efficiency [8]. Yet, it is suggested that when moving from experimental, controlled environments to field conditions; issues with regards to acquired data reliability, determining correlations between variables, and practical applicability of technical recommendations add uncertainty to any approach.

According to Fujisaka [9], very few researches and implementations have been conducted to try and derive information relevant to strategies and practices followed by farmers. Most studies have not been focused on tackling an identified problem:

	Purpose
1	Comparing crop management in various environments and pedo-climatic conditions
2	supporting authorities and extension services with useful information to aid their decision-making when defining agro-environmental regulations and territorial development strategies,
3	to relate the most common fertilization management techniques with indicators of environmental quality

Table 1.1 Purpose of deriving agriculture related information

Sighting illiteracy as a contributing factor for lack of information access [10], it is also noted that the unstructured nature of rural farmland and agriculture also contributes to uneven distribution of information. According to William M. Rivera [11], knowledge-driven frameworks exist for agricultural purposes which are mostly institution based

and does not consist of readily available information systems for farmers to rely on. It is also recommended that such frameworks should be adapted into 'Agriculture innovation systems' and 'Agricultural Knowledge and Information Systems', adapting technological advancements for the benefit of the agriculture community.

1.3 Research Gap

During the background research and literature survey it was evident that there are several contributions made toward improving accessibility of actionable information to farmers. Yet, it has been proven difficult to reach out to impoverished farmers specifically of developing countries [2], and they mostly rely on heuristic agricultural and fertilizing practices relying on word-of-mouth and trial-and-error. Most such practices lack a scientific basis.

Although fertilizer is available in a free, open market most farmers are tempted by vendors to buy inadequate and low-quality fertilizer at uneven prices [4] with most farmers unaware on the best available product to use at relevant instances.

Research conducted on fertilizer management and application have not reached far beyond controlled development stages [8] and have not been deployed in field scenarios ensuring food security.

Hence, as evident; no research has been conducted in adapting a knowledge-driven system to streamline fertilizer procurement by assisting the farmer to make the most well-informed decision. Therefore, this research is being conducted to introduce a solution for the beneficiaries to be used in real-time field conditions. This component is intended on constructing a decentralized system for streamlined and informed fertilizer procurement for farmers.

1.4 Research Problem

Enabling farmers to access knowledge banks and institutions via ICT is proven to improve their productivity and profitability [7]. Yet, agriculture is an industry where ICT has not penetrated up-to grassroot levels in developing countries [2] with any innovations being made having a controlled scope and struggling to adapt to field conditions due to feasibility and impracticality issues. With the focus on the research,

it has been possible to breakdown the research problem identified for this component to several questions:

- How feasible and acceptable would a technological solution integrating farmers, field experts and vendors be?
- How is it possible for proposed system to lift the asymmetry of information between the farmer and vendor?
- How can information be transmitted securely between farmer and experts while also maintaining transparency of transactions involving vendor?

2 OBJECTIVES

2.1 Main Objective

Main objective of the proposed system is to streamline procurement of fertilizer using private ledger blockchain concept [6] to benefit the farming community and lift bias of the procurement eco-system away from the vendors.

2.2 Specific Objectives

- Initiate enhancement of information accessibility of farmers (Specifically those in rural and impoverished areas).
- Utilize expert knowledge to assist farmers in well-informed decision making.
- Lift information asymmetry and bias identified in fertilizer procurement, providing edge to farmer via actionable information.
- Generate better fertilizer management practices among farmers backed by expert knowledge, minimizing soil pollution and health risk to consumers.

3 METHODOLOGY

The primary requirement of the proposed component is constructing a decentralized informative system for farmers to make the best-informed decision with regards to fertilizer procurement. The proposed system would enable farmers and experts to communicate effectively and securely with no interference from vendors involved.

3.1 Logic on employing Blockchain via Hyperledger Fabric Framework

3.1.1 Blockchain Technology

- Multiple parties share data with regards to deficiencies
    - Farmer-Expert
    (1. On identification using Digital Image processing and verification via soil analysis, farmer can share relevant data (i.e. nutrient deficiency with relevant stage) with expert(s)
    (2. On retrieval of data from farmer, expert shares Recommended Commercial Solution with instructions on quantities to be purchased
    - Farmer-Vendor
    (1. Farmer requests relevant products from Vendor and makes preferred choice with recommended quantity
- Multiple parties update data

    (1. Updates made by Vendor for any parameter of products (i.e. Price, Commercial brand, Quantity) can be viewed by Farmer and is verified by Experts

    (2. Communications between Farmer and Expert occurs in private channels [2], hence is not visible to Vendor

    Above approach would mitigate Information Asymmetry in identified vendor-consumer ecosystem
- There exists a requirement for verification with regards to products offered by vendors
- An intermediary (sales agent, cooperate entity etc.) would add complexity and asymmetry to procedure
- 'Transactions interact' (Most adequate solution provided *by expert* **via** deficiency identified *by farmer* & adequate commercial product with quantity *chosen by farmer* **as offered by** *vendor*)

(5 out of 6 criteria fulfilled as per list developed by PwC [13] for understanding feasibility of adapting a blockchain based solution for an identified problem)

3.1.2 Hyperledger Fabric

This component is proposed to construct a decentralized informative system for farmers to make most adequate fertilizer procurement as verified by expert feedback and knowledge. Hence,

- Confidentiality of transmissions between farmer and expert is a primary requirement
- There is no requirement for mining hence cryptocurrency since system constructed is a distributed community driven system.

Further elaboration is provided in table below:

	Bitcoin	Ethereum	Hyperledger Fabric
Ledger	Public	Public	Permissioned/Private
Consensus	Proof of Work	Proof of Work	Solo
Smart Contract	None	Solidity	Chaincode
Mining (cryptocurrency)	Bitcoin	Ether	Optional. Not required for proposed system
Language	C++	Golang, Python	Golang, Java

Table 3.1 Comparison of Blockchain Frameworks

3.2 Introduction to approach made

- A permissioned/private ledger blockchain based on the Hyperledger Fabric framework is implemented for the proposed system to prevent anonymity and encourage a level of trust between the users.
- Native Cryptocurrency will not be employed by the proposed system since mining will not be required and this would also be ideal for a community-driven distributed system.
- Typically, blockchain employs an order-execute mechanism. Yet, the proposed system is composed of a execute-order-validate mechanism which resolves typical issues in Scalability, Flexibility, Performance and Confidentiality found in Blockchain.

- Since the proposed system is aimed at shifting the information asymmetry existing in the Fertilizer Procurement procedure, it is suggested to implement an endorsement policy specifying which nodes need to vouch for the execution of a smart contract (e.g. Farmers and Experts should both vouch for a smart contract triggered at any vendor peer)
- Confidentiality is made possible via a channel-based architecture where participants can establish a 'channel' between a subset of participants to whom transactions should be visible.

3.3 Workflow and critical components of proposed system

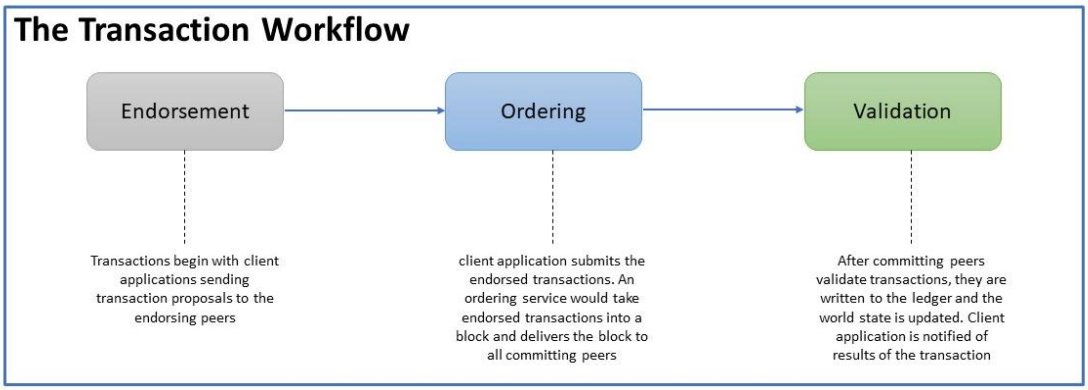

Figure 3.1 Transaction Workflow of Hyperledger Fabric

- **Endorsement**

Relevant Peers agree on the result of a transaction before it is passed to the ledger. An endorsing peer executes smart contract, which would pass a transaction to the ledger. That peer then signs the transaction and returns it to the proposer of the transaction.

This is based on an endorsement policy which defines the peers which needs to endorse a transaction. Simply, an endorsement policy can be as follows: *Peers A, B, C, and D must all endorse transactions of type T.*

- **Ordering**

Transactions are ordered so that updates to the world state are valid when committed to a network. It is proposed to not employ mining techniques for the proposed

distributed network. Instead, there are three identified techniques that can be utilized: SOLO, Kafka, and Simplified Byzantine Fault Tolerance (SBFT).

Kafka is utilized for industrial purposes while SBFT has very less implementations in use. It is highly recommended that SOLO ordering mechanism be used for experimental purposes in distributed networks [12].

- **Validation**

Once validation occurs via committing peers, they are written to ledger and world state is updated. Client application is concurrently notified of the results of the transaction.

3.3.1 Constructing a farmer-friendly Informative System

- The purpose of the system constructed is to maintain secure transactions (i.e. sharing of relevant information in the case of proposed system) between experts and farmer. As such, peers maintained by farmers and experts (identified as 2 organizations) can be deployed in a single consortium, making transactions occurring between these organizations visible to and verifiable by those only involved in said consortium.
- Furthermore, access control mechanism (Membership Service Provider-MSP) can be used to identify relevant peers and define which rules govern them. This access control technique can be employed to distinguish vendors and adjudicate rules enabling farmers and experts to view any transactions or changes in world state made by vendors, further enhancing the decision making capability of farmers and regulations made to mitigate vendor supremacy in Fertilizer procurement.

3.4 System Architecture and Overview diagram

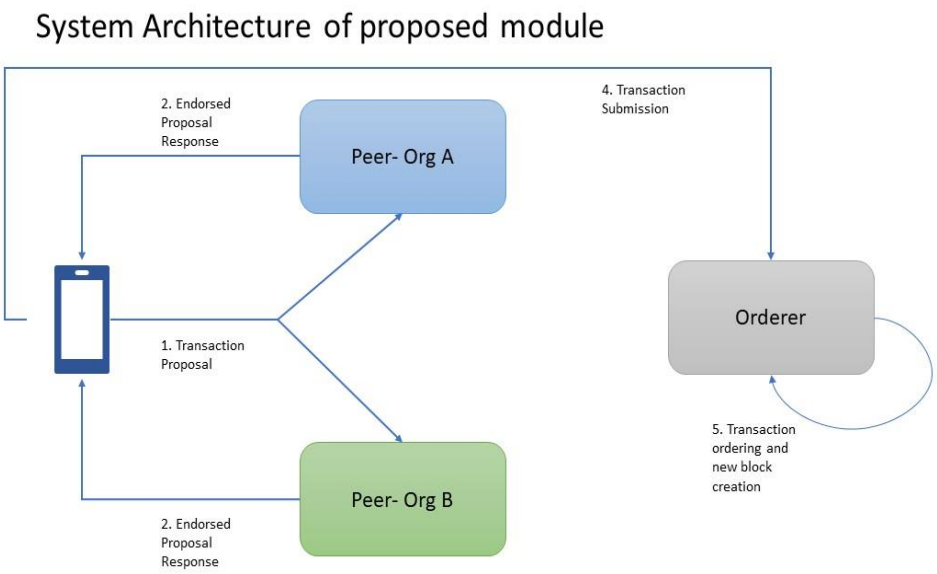

Figure 3.2 System Architecture Diagram (Further elaborates flow in Fig 3.1)

The system diagram in Figure 3.3 (below) elaborates how farmers and experts will always communicate via secure channels. It also represents how rules can be governed for farmer and expert peers (Peer 1 and 2 respectively in Organization A) to fall under an organization using Membership Service Provider (MSP). Via such an approach, they fall under a permissioned network in which any changes and transactions cannot be viewed by the vendor. Transactions or changes in world state of the Vendor (Peer 3) are visible to members of Organization A.

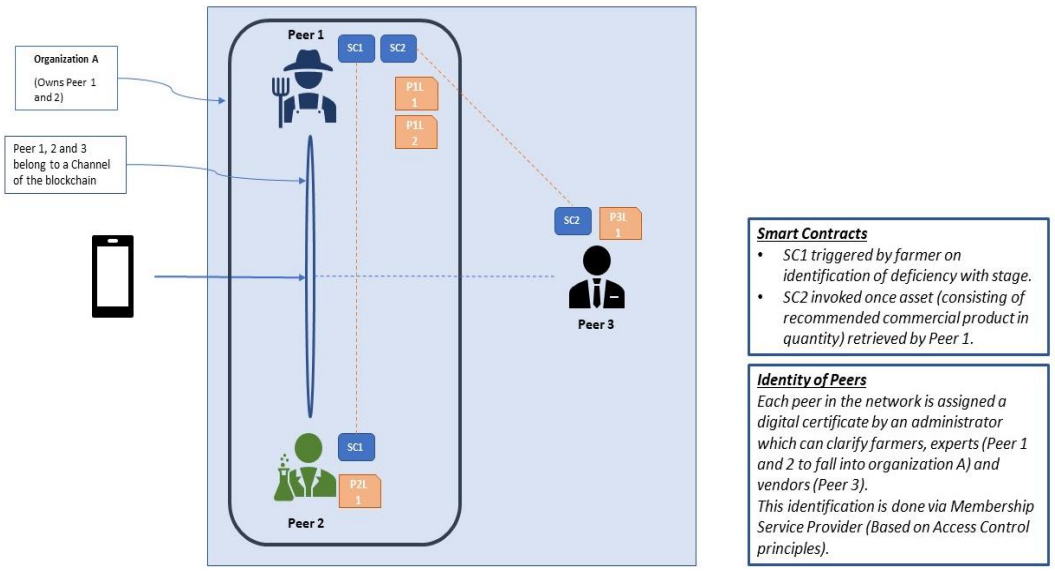

Figure 3.3 System Overview Diagram

4 PROJECT REQUIREMENTS

4.1 User Requirements

- Farmer should be able to view perceived information on nutrient deficiency in plant type with relevant stage.
- Farmer should be able to transmit data to expert for evaluation in a secure method.
- Expert should be able to transmit data to farmer (recommendations for identified deficiency)
- Farmer should be able to view recommendations and select most adequate product offered by vendors
- Vendor should be able to transmit data on available adequate products to farmer on request

4.2 System Requirements

- Hardware Requirements: Minimum i7 – 5^{th} gen with 8 GB RAM
- Software Requirements: Linux environment for constructing Blockchain using Hyperledger Fabric Framework, CouchDB recommended as a State DB
- Server Requirements: Amazon AWS Server

4.3 Functional Requirements

- Data transmissions between farmer and expert should occur confidentially without awareness of vendor
- Farmer and expert should be able to view any changes and transactions made by vendor

4.4 Non-Functional Requirements

- The blockchain should be scalable to sustain growth of community involved
- Confidentiality, Integrity and Availability of data transmitted should be preserved

5 BUDGET AND BUDGET JUSTIFICATION

Amazon AWS Server – Cost estimated LKR 2700-5000

(Further understanding on capacity and other pre-requisites to be obtained on progression of development)

6 CONCLUSION AND RECOMMENDATIONS

The proposed component is to construct a decentralized, community-driven informative system for farmers to make best-informed decision regarding fertilizer procurement. Studies have shown how farmers most often rely on heuristic practices for fertilizer administration. It is further discussed that information availability for rural farming communities in developing countries such as Sri Lanka is at a very primitive stage. The component is proposed sighting such shortcomings in a critical component of agriculture such as fertilizer, and modern technological advancements which ideally make farmers more exposed to ICT. The system is primarily constructed for shifting the information asymmetry which is disadvantageous for farmers and enhancing information availability. A community driven system consisting of farmers, experts and vendors would enhance interactive and informed decision-making capability of farmers. A permissioned blockchain has been recommended for preserving confidentiality of data transmitted between expert and farmer, as well as to maintain transparency in all transactions made by the vendor. Such a system would be feasible for a developing country such as Sri Lanka since internet and relevant technologies are steadily reaching out to grassroot levels of the island. Another primary contribution factor for the acceptance of proposed component as an ideal solution is the dependence of Sri Lankan economy on the Agriculture industry as well as the close association of the industry with the Sri Lankan society. Overall, the proposed component would be a steppingstone in enhancing information availability for farmers and cultivators.

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