SMART PLANT DISORDER IDENTIFICATION

Project ID: 2020-025

Project Proposal Report

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Sri Lanka Institute of Information Technology Sri Lanka

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

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Sri Lanka

February 2020

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.

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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.

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Abstract

Plants require nutrients for sustenance and growth. A decreased nutrient uptake of the plant causes nutrient disorders. Not only do these disorders compromise the yields produced by the crop it also means the transfer of nutrients from the plants to the consumers is inadequate. This negatively affects the global food chain. The soil composition available around the world is depleting in nutrients at a rapid rate due to its overexploitation by agricultural activities and the use of fertilizers in an unsustainable manner. Against this backdrop is the requirement for an increase in food production by 50%. It is abundantly clear of the urgency in the required solution. One of the main contributing factors affecting soil degradation is the addition of unnecessarily large amounts of fertilizer. This not only affects the soil but also contaminates the ground water which eventually leads to pollution of the environment. In the same way agriculture is connected to several other global issues. Fixing the underlying cause of soil degradation can ensure better geo-conditions for future generations, but also decrease poverty and hunger that affects majority of the area inhabited by the farming communities, aid positively in tackling climate change and ensure sustainable biodiversity. Thus, contributing to several sustainable development goals set out for the world by the United Nations. The most direct solution to the issue of soil degradation is to add only the necessary amounts of fertilizer required by plants to produce a significant yield without nutrition deficiencies. Facilitating this solution is a smart disorder identification system which recommends the best remedy. This solution uses trending techniques from the domain of Information and Communication Technology. internet of things, image processing, machine learning and block chain are vital elements used in designing this solution. This research investigates the devising of this solution.

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List of Abbreviations

CNN Convolutional Neural Networks

R-CNN Region-based Convolutional Neural Networks

1 INTRODUCTION

1.1 Backrgound

The mid twentieth century saw the birth of the green revolution [1]. Agriculture made mass scale advancements in producing new high yielding seeds creating the onset of chemical fertilizer and pesticides production as well. This resulted a boom in agriculture, especially in the developing countries of the time [2]. The strain it would have on the environment, however, wasn't predicted then.

According to Professor John Crawford, of the University of Sydney, on seismic implications soil erosion and degradation in the future, 70% of the topsoil in the world has seriously degraded [3]. In other words, the plant growing soil layer is almost gone. Meanwhile, 70% of freshwater use is for agriculture purposes [3]. The loss of soil in this way will hamper the growth of plants, affecting the food chain of all living things which would be catastrophic for survival in the most basic of ways in times to come. The continuation of such soil degradation will result in a loss of food production by 30% [3] in stark comparison of the projected food requirement for the next 20 – 30 years demanding a growth of 50% more food [3] to sustain the growing population and food consumption trends.

Professor Crawford highlighted one of the reasons for topsoil depletion being the use of chemical fertilizer and bad agricultural practices [3]. While the 'go green revolution' seemed to have a direct impact in sowing seeds of the current crisis the world finds itself in, the computer-tech led revolution is aiding in solving such problems in the agriculture industry amongst others.

Powering Growth: realizing the potential of Agtech for Australia, a report by KPMG in 2016 defines AgTech as the digital technologies that provide the agricultural industry with more tools, data and knowledge to make more informed decisions and improved productivity and sustainability. Currently all over the world trends of using block-chain, Internet of Things (IoT), artificial intelligence, robotics and automation is being integrated in the agricultural field [4].

The aim of this project is to use such technology and devise a means of effectively identifying nutrition deficiencies in plants to add only the necessary amounts of fertilizer/required chemicals, thus, maximizing on the yield in one aspect and minimizing on the degradation of soil in another. The rest of the proposal will highlight the status quo on this topic, the research gaps identified, and the technology and methods planned on being used to bridge such gaps.

1.2 Literature review

The nutrition available in soil moves through a cycle. Moving from plants, to the organisms that devour plants until it returns to the soil through the decomposition of the bodies of the organisms that used plants as a source of food. These food sources nourish and sustain the organisms through the nutrients trapped within the plants. A lack of nutrition in soil will fail to sustain life. This is the overall impact of nutrition within soil.

However, as highlighted in the introduction the soil nutrition levels are directly interlinked with farming practices around the world. A closer look at the current status on the usage of technology in this regard shows several key findings.

Firstly, an excess or deficiency in soil nutrients causes a severe loss in yield. Therefore, early and accurate diagnosis of plant nutrition disorders is a vital part of managing a farm [5]. Managing plant nutrition disorders can be divided into several activities. These are, identification of a nutrient disorder, identification of the degree of the said disorder, analyzing the soil composition to determine the reason behind such disorders and finally, to provide the most suitable remedies to the farming community. While the first three have issues directly involving field practices within farming the final activity arises out of work and interactive practices within the farming community.

The current methods used in identifying plant nutrition disorders is very expensive and highly cumbersome for field use. Currently satellite imagery and expensive Chlorophyll-meters are used for the identification of such nutrition disorders [5]. These methods require high funding which most of the farming communities cannot afford. For example, 49% of the population in Sub-Saharan Africa live on less than 1$ a day, 10 years back [6]. Sub-Saharan Africa accounted roughly of a third of the overall growth within the period of 1993 – 2005 [6] showing how heavily involved the country’s labour force is in the agricultural industry. Expecting farmers from such regions to use the existing systems for identification of plant nutritional disorders is far from being pragmatic.

Meanwhile, the current methods in use to identify the degree of nutrition deficiency in plants are mainly tissue analysis and soil analysis [7]. These require laboratory expertise and is also time consuming. Thus, both methods and soil composition evaluation methods used are not practical in managing a farm by most of the farming community.

Finally, upon researching on the interactions of the farming community in agriculture related activities a severe problem identified was that of information asymmetry which results in middle actors capturing a margin [4] while sustainable suggestions made by the agricultural researches being neglected. This statement was further confirmed by the discussions held with soil experts at the Kahagolla Agri-research Institute of Bandarawela, Sri Lanka.

While the current status regarding the above four main factors are as above this research project aims in finding solutions for them using Information and Communication Technology techniques such as image processing, machine learning, block-chain and IoT. The subsequent sections will identify the research gaps existing in using such technologies, the research problems to be addressed while doing so, objectives and the methodology required to achieve such objectives.

1.3 Research Gap

The main research gap identified in the project is the unavailability of an accurate early detection ‘smart’ system using Information and Communication Technologies (ICT) to identify nutrition disorders in plants and provide suitable recommendations that benefit farmers in carrying out sustainable agricultural practices. This has been divided to the main four components required for the research module, handled by the four different group members. The components are:

1. Accurate dentification of nutrition deficiency (amongst N, P and K)

2. Identification of the degree of nutrition deficiency and recommendation of suitable remedy
3. Soil analysis using IoT to provide accurate degree of nutrition deficiency in soil and recommendation
4. Implement a secure and distributed platform for identifying best commercial product for deficiency based on diagnosis

The four components will bridge this research gap using Image Processing, Machine Learning, Internet of Things (IoT) and Blockchain based technologies.

1.4 Research Problem

The main research problem identified is the divided into four main sections. These are:

- The inability to detect a plant with a particular nutrition deficiency specifically amongst a number of deficiencies based on symptoms appearing on the leaf. The inability to detect nutrition deficiencies in this manner amongst a variety of plants subsequently is the first main research problem identified.
- The inability to detect the degree of a plant identified to contain nutrition deficiency accurately and analyse the reason for such a deficiency using several variables. The inability to carry out the above function and recommend a suitable remedy for the deficiency are all part of this same research problem.
- The inability to measure and analyse the soil composition data by means of an IoT device that is practically usable in the field. The unavailability of a solution to provide these values to be used for further analysis on the amount of fertilizer required in a short time with a significant accuracy.
- The inability to provide farmers with verified information by researches on the best fertilizer to be used at a given time without being influenced by the vendors.

1.4.1 Research questions

Several research questions stem from the four main research problems identified above. These are;

- Investigating the best machine learning and image processing techniques to be used to select for identification of the nutrition disorder and its degree.
- Investigating the plant nutrition deficiency symptoms and the relevant magnitude of nutrient deficiency in soil.

- Investigating the best method to be used to set up a control experiment to analyse the above variations
- Investigating the use of Arduino in assessing soil composition.
- Investigating the most practical method to be used to vary soil composition and obtain a usable measure to analyse and use the data on soil composition
- Investigating the use of block-chain technologies in creating a system for the interaction of stakeholders.
- Investigating the attitudinal manners in promoting this system to be used by the stakeholders.

The investigation of the above criteria will ask the researches the relevant research questions needed to be answered to solve the relevant research problems listed previously.

2 OBJECTIVES

2.1 Main Objective

The main objective of this research project is to provide an intelligent solution capable of identifying the nutrition deficiencies in plants, the extent of the nutrition deficiency and recommend the suitable remedy through soil analysis in an agriculture researcher verified system. The main and specific objectives of the separate components are highlighted next.

2.2 Specific Objective

2.2.1 Accurate identification of nutrition deficiency (amongst N, P and K)

The specific objective of this component is to identify the nutrient deficiency in a plant with speed and accuracy using image processing technique and CNN.

2.2.2 Identification of the degree of nutrition deficiency and recommendation of suitable remedy

The primary objective of this component is to identify the degree of the disorder. Secondly, this component aims in using the results obtained from component 3, to recommend the suitable remedy in terms of the application of chemical fertilizer etc.

2.2.3 Soil analysis using IoT to provide accurate degree of nutrition deficiency in soil and recommendation

The main expectation of this component is to develop a fully functionally IOT device to measure Nutrient levels (NPK),Organic Matters, EC Conductivity, pH level of selected soil crop and creating inputs for Machine learning algorithm which is created by member 2.

2.2.4 Implement a secure and distributed platform for identifying best commercial product for deficiency based on diagnosis

The primary objective of this component is to identify the most suitable methodology to implement a distributed platform to provide farmer – vendor – agricultural researcher engagement while over coming information asymmetry. Blockchain has been identified as the most suitable technology for a distributed system as proposed and Hyperledger Fabric module will be employed for implementation.

3 METHODOLOGY

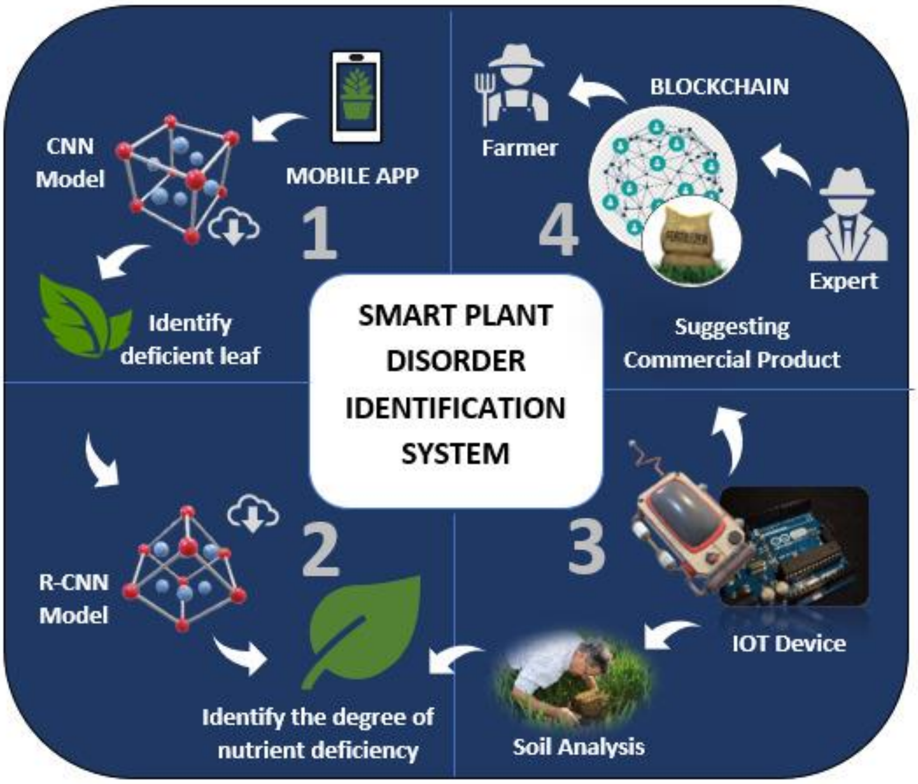


Figure 3.1.1 System Overview of the Smart Plant Disorder Identification System

3.1 System Over-view

The system overview diagram shown below provides information on the overall functionality of the system proposed in this proposal. In the first component and image is captured via a mobile device and identified as a healthy of nutrition deficient leaf. This process uses Image Processing techniques and CNN model for Machine Learning and is elaborated in more detail in this chapter.

This image is then passed onto the next the component which using Image processing and mask R-CNN model to identify the degree of the nutrition deficiency. It then uses the values passed on by component three to analyse the probable reason for such a deficiency and correlates the accurate remedy that ought to be taken.

This remedy moves through to component four which is responsible in creating a platform for all stakeholders to interact using only verified data for the aquisition of fertilizers.

3.2 Accurate dentification of nutrition deficiency (amongst N, P and K)

Figure 3.2.1: System flow diagram

As shown in the figure 3.1, Once the farmer upload or capture the leaf image through the application, the system will intelligently identify the plant type and detect the nutrient deficiency through the image processing techniques and machine learning. First, the image is classified into two. Such as healthy leaf or nutrient deficient leaf by referring the trained dataset. Nutrient deficient will further be categorized into nitrogen, phosphorous and potassium deficiency.

3.2.1 Procedure

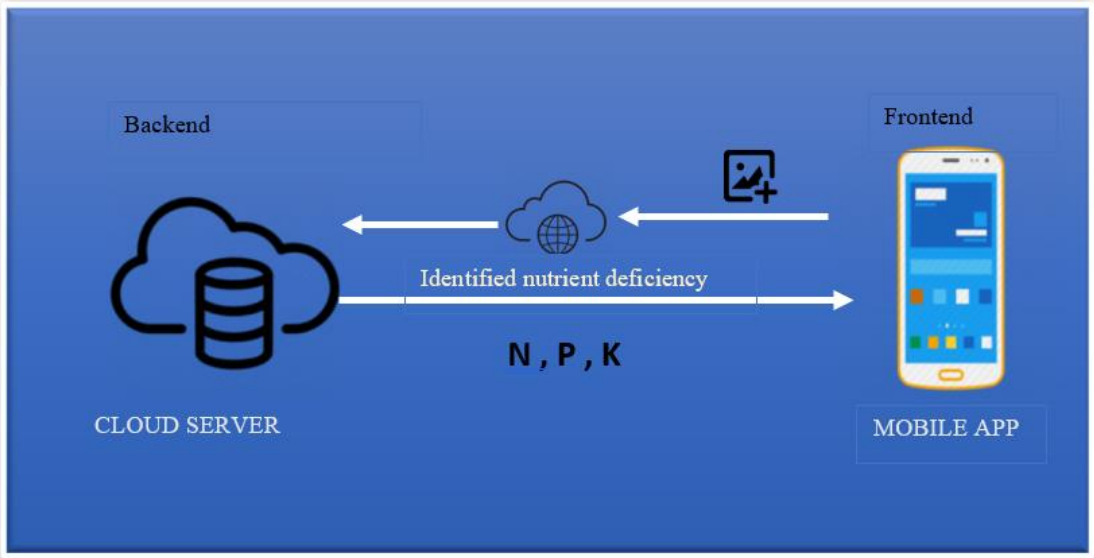
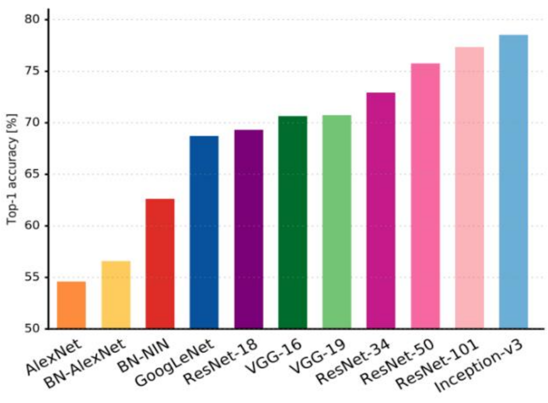


Figure 3.2.1.1 : System diagram of this component

As shown in the figure 3.2, To identify the nutrient deficiency, CNN model is trained through the transfer learning[12] using Tensorflow which is written using the python language. Android, java and firebase database is used for the mobile application development which will be helping to interact with the user. The dataset is to be collected by online resources as well as images taken in the field visits and laboratories. Once the leaf image is uploaded by the mobile app, it will be received by the cloud server which has the trained model. It will classify the healthy leaf and deficient leaf by comparing the images in the trained model. Further the system will identify type of nutrient deficiency affected by the leaf.



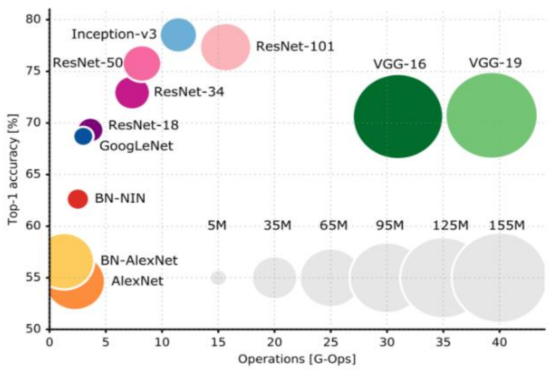


Figure 3.2.1.2 : Graph represents about the accuracy level of common neural network[12].

There are many CNN architectures that are being used by different communities of researchers [8]. After the comprehensive study of neural network architecture [10], it is decided to apply the Google Inception V3 architecture to the nutrient deficiency identification in plants Figure 3.3, illustrates the accuracy level of selected neural network architecture.

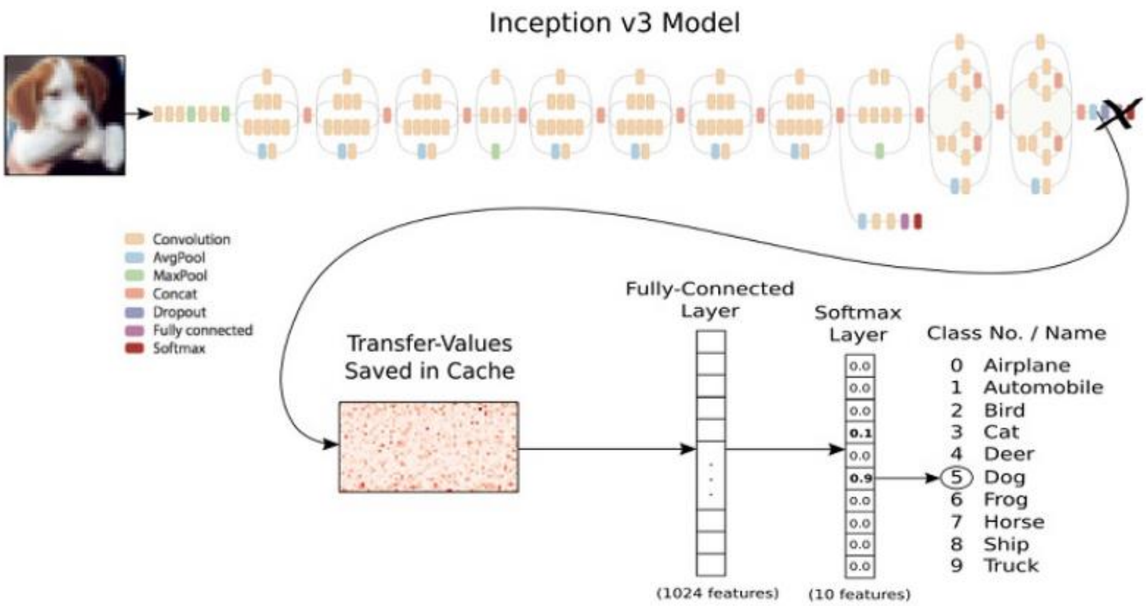


Figure 3.2.1.3: CNN model architecture [10]

Figure 3.4 illustrates the image classification is done using the CNN model of Google Inception V3 architecture. Recognition of image can be done with feature extraction and classification through fully connected layers and softmax layers [9]. This model extracts the features of leaf such as colour and texture from input images through the convolutional layer. Image classification is done through the softmax function which assigning the probabilistic value between 0 and 1 [10]. Through the transfer learning, existing model can be retrained for different set of data for similar problem. The main advantages of transfer learning are saving the training time and gives better performance for neural network with less dataset [11]. Until the actual dataset was prepared, Sample flower dataset is planned to evaluate the selected neural model architecture

3.3 Identification of stage of nutrient deficiency and recommending the appropriate remedy

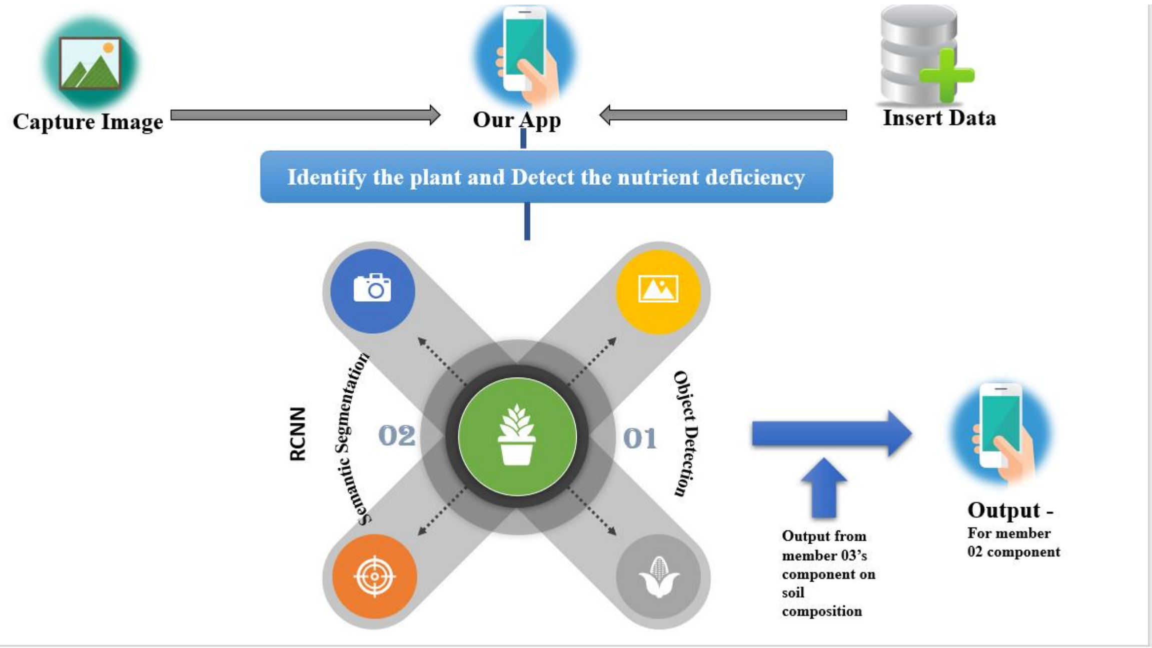


Figure 3.3.1: System overview diagram to identifying the severity of disorder and recommending a solution

Firstly, the controlled experiment needs to be set up at the kahagolla research institute in Bandarawela, Sri Lanka (discussions are currently underway to formally facilitate such experiments). Secondly, a thorough study of image processing and machine learning is required to implement the product. Next data set collections will be carried out and finally, testing of the trained data set will ensue.

For image processing, RGB images will be required in large quantities including the various factors that affect image quality considering sunlight, time of day etc. A certain amount of image processing is carried out on the classified leaf indicating the nutrition disorder. This is done to identify the severity of the disorder. Here, object detection and image segmentation of image processing will be carried out with the use of the RCNN model where through image segmentation the symptoms will be observed on a pixel level classifying the severity of the disorders.

Next, these images will need to be trained using multiple models to identify the various degrees of nutritional disorders. A model each will be required to identify each stage for a given plant. Then these multiple models will need to be integrated or layered in the proposed CNN. Initial training of the neural network will use several test images like balloons or flowers. By including transfer learning feature extraction is to be automated. Next with the use of data sets that are obtained by public depositories like Kaggle etc the model is further trained. Finally, the data set collected will be used to observe the conclusion of the neural model. Some technological requirements would be to use machine learning (ML) frameworks such as Tensorflow python, keras libraries and google co labs.

Finally, the data set collected will be used to observe the conclusion of the neural model. Some technological requirements would be to use machine learning (ML) frameworks such as Tensorflow python, keras libraries and google co labs.

The integration of the input obtained from component 3 will be done next. A rule based system will be used where when certain criteria are met through results from the neural networks and the component three it should be able to identify the reason which would have a specific recommendation.

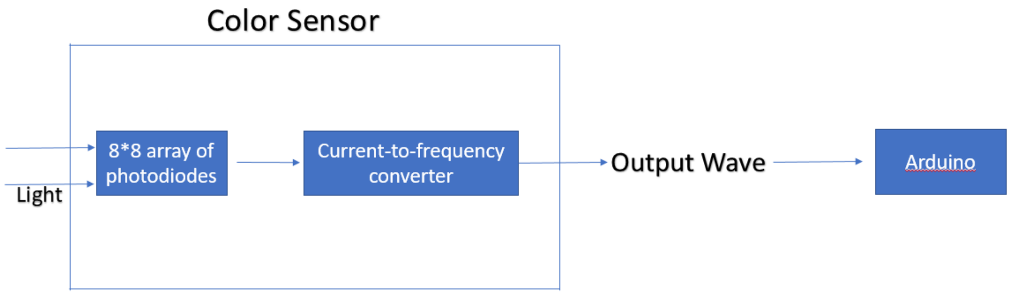
Next a testing phase will be carried out to check the effectiveness of the model.

3.4 Soil analysis using IoT to provide accurate degree of nutrition deficiency in soil and recommendation

The challenge of IOT device is to make inputs to main algorithm. Except measuring the NPK level of soil the proposed device has to pass input to main algorithm. In the proposed system, color intensity of soil will be calculated,

1) The level of nutrients need to be measured by taking sample of soil. Color sensor will help to find the level of nutrients in the soil.

2) The light sensor will help to show the correct color of the soil content so it is easy to find the level nutrients in the soil. Light sensor will project the light on the soil content so that the correct color.



3.5 Implement a secure and distributed platform for identifying best commercial product for deficiency based on diagnosis

Blockchain has been identified as the most ideal technological solution to implement a distributed platform for informed decision-making in fertilizer procurement for farmers due to several reasons. They are:

- Multiple parties share data with regards to deficiencies
- Multiple parties update data
- 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 for understanding feasibility of adapting a blockchain based solution for an identified problem)

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 3.5.1 Comparison of Blockchain Frameworks

3.5.1 Elaboration of Approach made

- A permissioned/private ledger blockchain based on the Hyperledger Fabric framework is implemented to prevent anonymity and encourage a level of trust between the users.
- Native Cryptocurrency will not be employed by the proposed system which would 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.

3.5.2 Workflow of proposed system

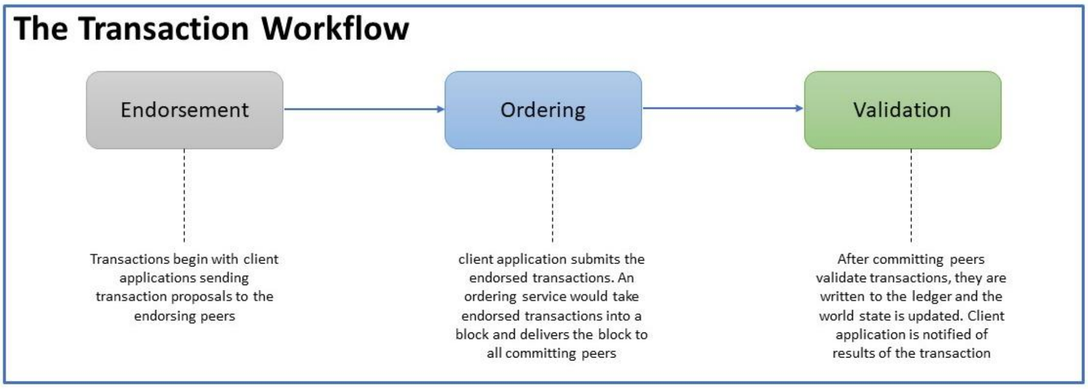


Figure 3.5.2.1 Transaction Workflow of Hyperledger Fabric

- 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.

3.5.3 System Architecture and Overview

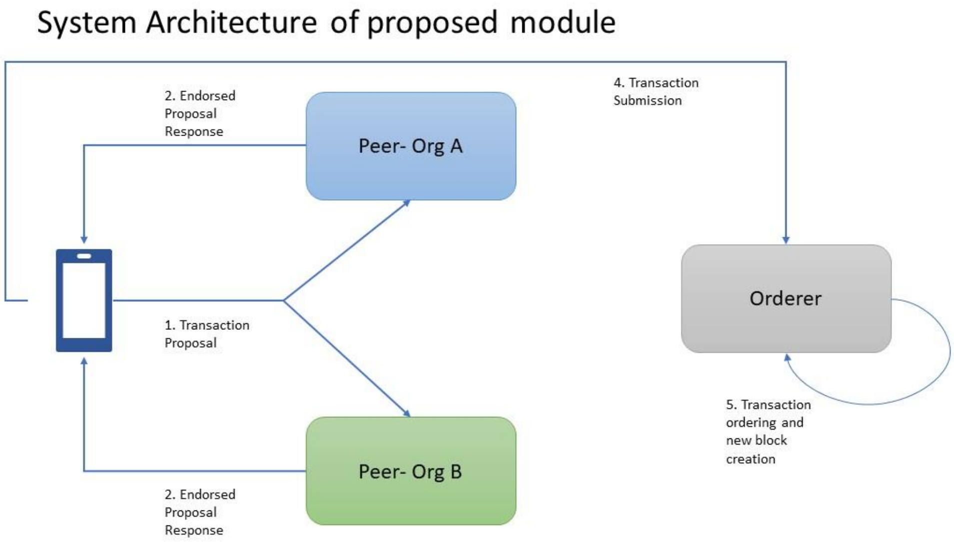


Figure 3.5.3.1 System Architecture Diagram

- 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.

- 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).

- 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.

The procedure and overview of transactions occurring in proposed system is as follows:

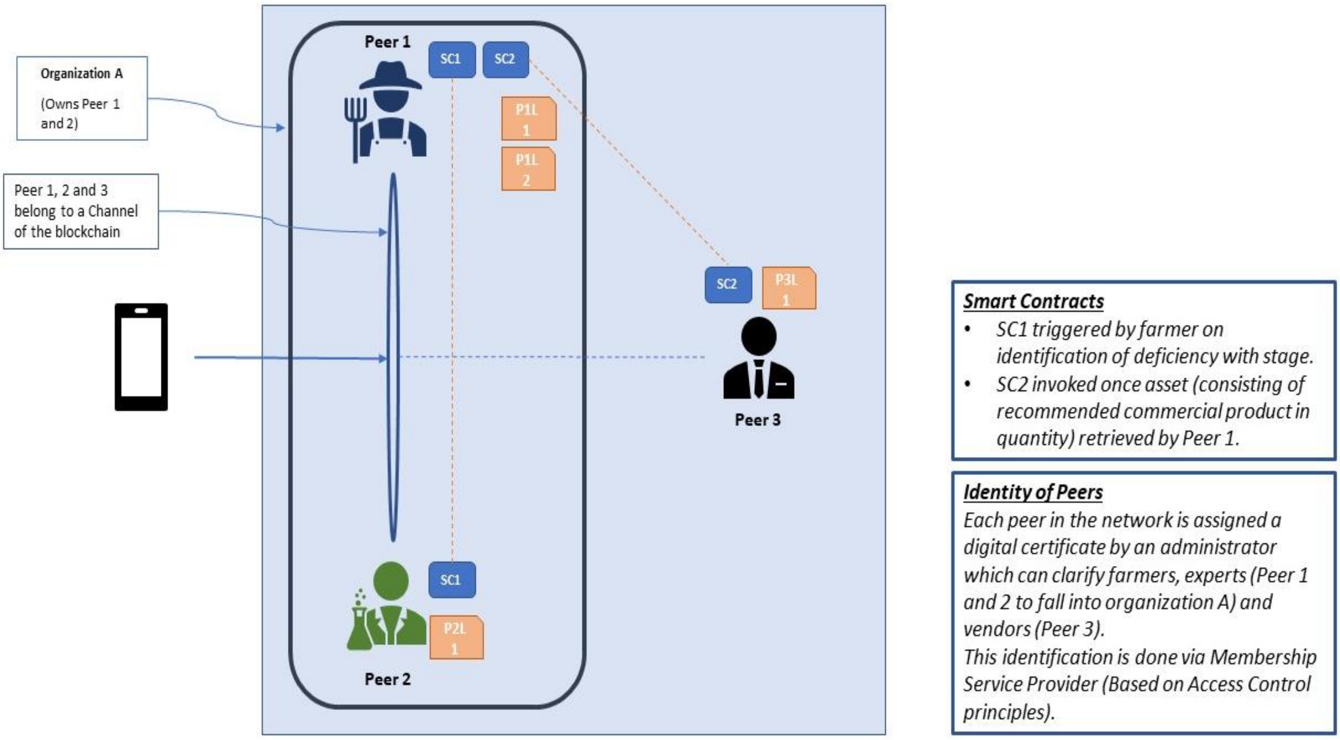


Figure 3.5.3.2 System Overview Diagram

3.6 Work Break Down Structure and Gannt Chart

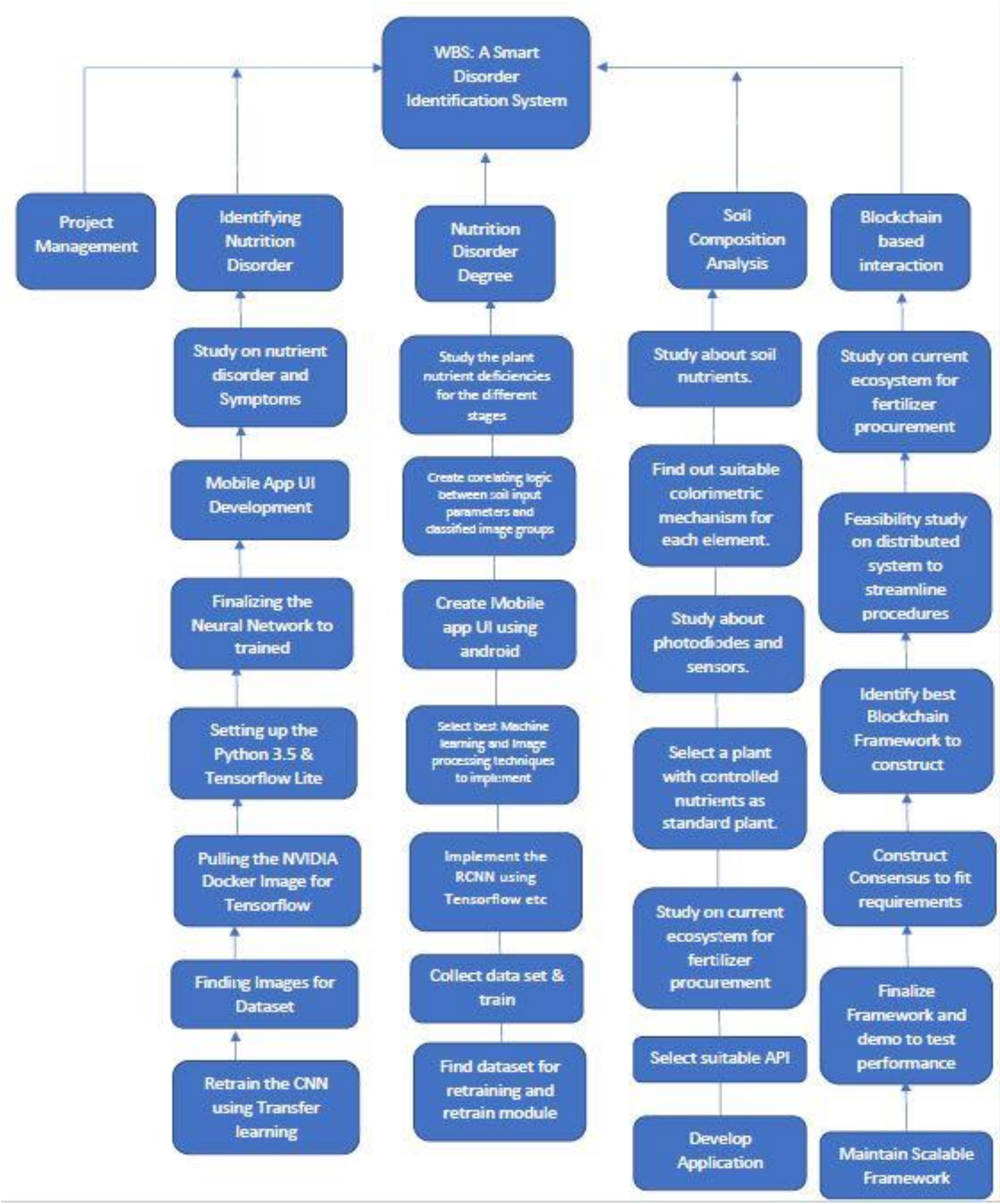


Figure 3.6.1: Work Break down Structure

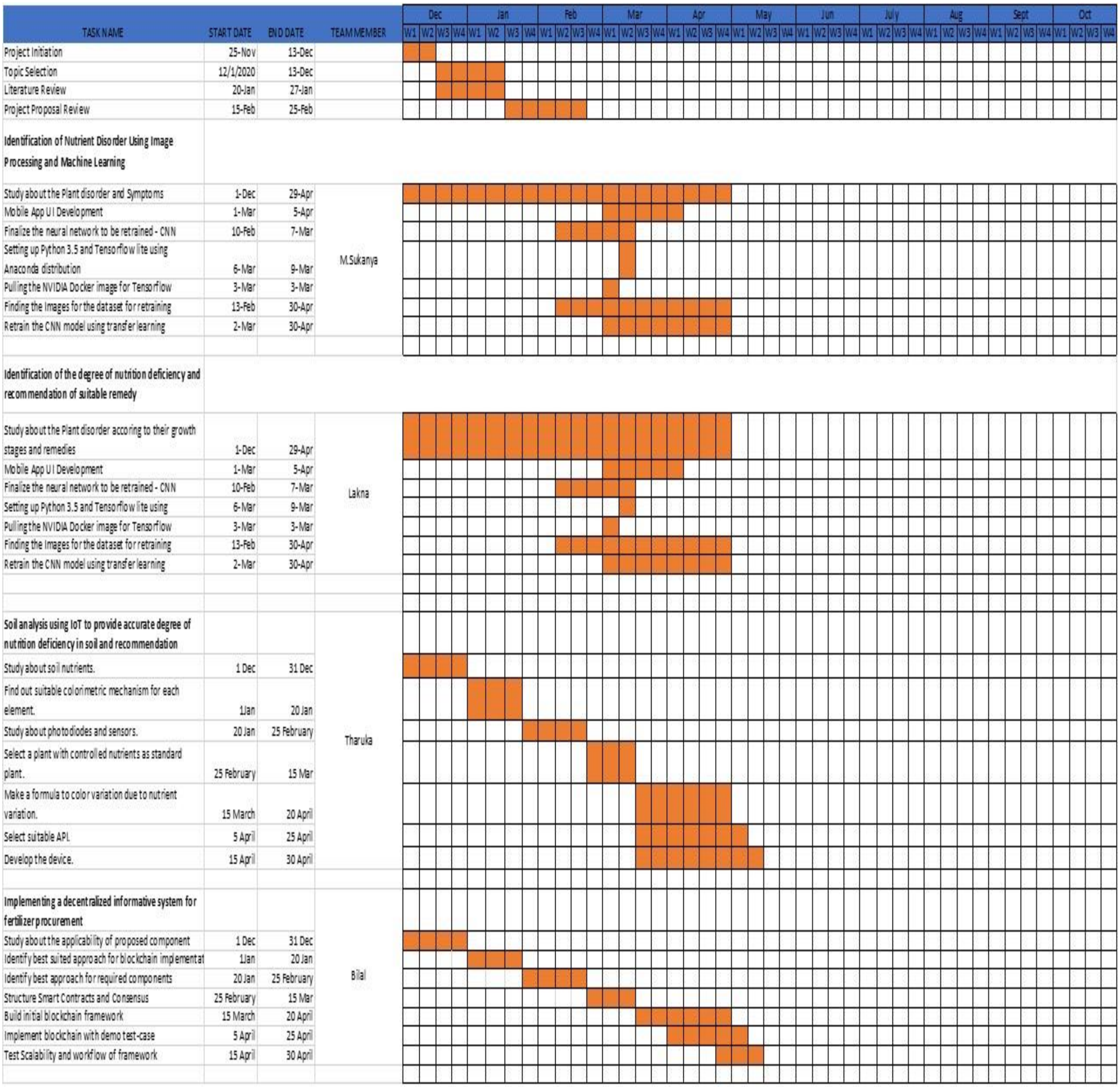


Figure 3.6.2: Gannt Chart

4 PROJECT REQUIREMENTS

4.1 Functional Requirements

- Be able to capture an image of crop leaves through the app.
- Be able to select images from the smartphone's memory.
- Be able to identify the crop and nutrient deficiency from the leaf image
- Be able to identify the degree of nutrient deficiency for the plant at given growth phase
- System should be able to prompt accurate remedy; chemical needed
- Be able to retake the test by user
- Farmer (user cat.) should be able to view best suited commercial products (Remedy) based on deficiency and related stage
- Expert (user cat.) should be able to recommend best remedies based on stage of identified deficiency visible only to farmer
- Any changes made by vendor should be visible to all users with constantly maintained logs
- Vendor should have minimum awareness of transactions between Farmer and Expert

4.2 Non-Functional Requirements

- Be able to detect the nutrient deficiency within the short time
- Be able do the Image extraction and classification within the less processing time.
- 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

The table below shows a rough calculation of the expenses that have been predicted so far. It is subject to change in the course of the research given the requirements

Table 5.1: Budget of the system.

Resources	**Cost**
Sensors	
1. Arduino Uno Board	2000.00
2. Tcs230Tcs200 Color Recognition Sensor	700.00
3. Light Sensor	650.00
4. AWS Cloud services	2700.00
Other (Transport)	4500.00
Total	10050.00

6 DESCRIPTION OF PERSONAL AND FACILITIES

Table 6.1: Description of Tasks

Name	Task
M.Sukanya	● Literature review ● Requirement gathering and analysis ● ER mapping and Database designing ● Function implementation (Identifying nutrition deficiency – Nitrogen, Potassium, Phosphorus) - Inserting the image - Image processing and Data Extraction - Classification - Get the output of plant name and identified disorder ● Testing - Unit testing - Integration testing - System testing ● Documentation

L.H.Rajarante	● Literature Review ● Requirement gathering for designing experiment to identify growth stage of plant and nutrient requirements ● ER mapping and Database designing ● Function implementation (Identifying nutrition degree deficiency – Nitrogen, Potassium, Phosphorus) - Create GUI for mobile - Image processing using object detection and semantic segmentation - Classification using the RCNN model - Input soil composition values and correlate the relevant reason for the nutrition deficiency stage - Output the recommended remedy ● Making the dataset - Collecting images for training model - Image collection for retraining of model ● Assimilate final findings

K. T. Ramasinghe	● Literature Review ● Feasibility study for best approach to addressing requirement ● Identifying procedure and necessary components for IoT device ● Construction of device ● Demo testing of device using given sample ● Finalizing of product
B. I. Sariffodeen	● Literature review ● Requirement gathering and analysis ● Smart contract and Consensus construction ● Function implementation - Adding entities (peers) to respective organizations and rules of governance - Ensuring scalability proposed system - Maintain confidentiality of transactions between expert and farmer - Ensure transparency of transactions and changes made by vendor ● Demo testing ● Functional component Testing ● Documentation

7. CONCLUSION

This research project has several techniques used frequently in different other domains. However, the application of the techniques mentioned above are very novel in the field of agriculture as shown through referencing various statements. Owing to this reason the research could face challenges that require a change in methodology to obtain the best results and to include the dynamic nature of the agriculture industry.

Meanwhile, the agriculture industry currently possesses a large demand for the usage of ICT [4]. As outlined above, the importance in this project is as a result of this demand but mostly due to the diverse and extent of impact on the stakeholders involved within this industry.

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