SMART SURVEILLANCE SYSTEM FOR COCONUT DISEASES AND INFESTATIONS

2021-042

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology Specialized in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology
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DECLARATION

I declare that this is my 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 my 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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Signature of the Supervisor (Dr. Janaka Wijekoon) …………………………….

Date ..………………………

ABSTRACT

Coconut products are gaining popularity in the world market majorly among health-conscious consumers. A range of new value added products that were trade globally in the recent years show an increasing export volume. Therefore, coconut growing countries are developing strategies to increase the production and productivity to meet the increasing demand. One of the major challenges for coconut production is the yield loss due to pest and disease outbreaks. During last few decades many control methods were identified for management of various pest and diseases of coconut. Application of these control methods at the farm level was hindered due to poor communication between research personals and growers. Smart ICT intervention could play a major role in bridging this gap to develop efficient pest and disease management strategies in coconut.

The coconut caterpillar is one of the major pests of coconut for which control methods have been developed. Due to the difficulty of identification of symptoms, out breaks occur leading to economic yield loss. The aim of the research is to develop a mobile application identification process to classify coconut caterpillar infestation by deep convolutional neural network techniques. Furthermore, the progression level is also calculated to measure the infestation severity. Fast R-CNN is used for the identification while Mask R-CNN is used to calculate the progression area along with OpenCV and TensorFlow libraries to extract the number of caterpillars to finally calculate the progression level.

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LIST OF ABBREVIATIONS

Abbreviation	Description
CCI	Coconut Caterpillar Infestation
CNN	Convolutional Neural Network
CRISL	Coconut Research Institute of Sri Lanka
GDP	Gross Domestic Product
CDO	Coconut Development Officers
RPN	Region proposal network
SoC	System on Chip
CSA	Channel-spatial attention
AI	Artificial Intelligence
RPN	Region Proposal Network
FCN	Fully Convoluted Neural Network
SVM	Support Vector Machine

1. INTRODUCTION

1.1 Background & Literature survey

A smart agricultural solution with automated plant disease detection and classification tools has been identified as an important resource of data which supports taking decisions in farm management [1]. AI integration, training deep learning models and Convolutional Neural Network (CNN) are such digital tools which provide the optimum solution for the identification of plant diseases [2]. The traditional manual observation method is time-consuming and also can make errors because farmers fail to detect plant diseases in their initial stages and in large areas.

In any crop cultivation, damage due to pests and diseases accounts for a substantial reduction in the quantity and quality of yield resulting in low profitability. In addition to the heavy crop losses due to pest and disease incidents, the farming community is further burdened due to poor communication between farmer and extension personnel which make them less aware on recommended pest and disease management practices. These challenges have laid the foundation for the development of integrative mobile-based applications, which includes automated pest and disease diagnosis, disease progression level identification and dispersion pattern analysis facilitating crop management [3, 4].

Smart mobile-based applications using different artificial intelligence and neural network models were designed to control diseases and pest infestations for different crops. Prediction of wet appearance on the wheat flag leaves by environmental variables [5], identification of tea leaf diseases such as black spot, blister blight, and leaf rust using leaf color intensity [6], detection of *Rhizopus* rot in red tomatoes using near-infrared spectroscopy [7], identifying diseases in *Phalaenopsis* seedlings using texture and color [8] are some studies carried out using the above technologies and tools for disease management in agriculture. Similarly, for pest management, insect identification and control systems [9, 10], an expert system of tea pest management for appropriate control measures [11], identification of pest infected leaves using image processing techniques [12] are some of the examples.

Coconut is one of the major plantation crops with a 1% contribution to the GDP. The kernel of the nut is used as a component in the daily diet of Sri Lankan people providing 70% fat, 15% of calories, and 5% protein. In addition, the kernel and other parts of the nut (nut water, shell, husk) and almost all parts of the tree (trunk, leaves, ekel, flower) provides the raw material for a large number of industries. Therefore, coconut is considered a food crop, industrial crop, and livelihood crop. A survey was conducted to understand the perception of the essentiality of coconut in people's daily lives. As shown in Figure 1.1, more than 98% of participants agree on the fact that coconut is essential for daily life of Sri Lankan people.

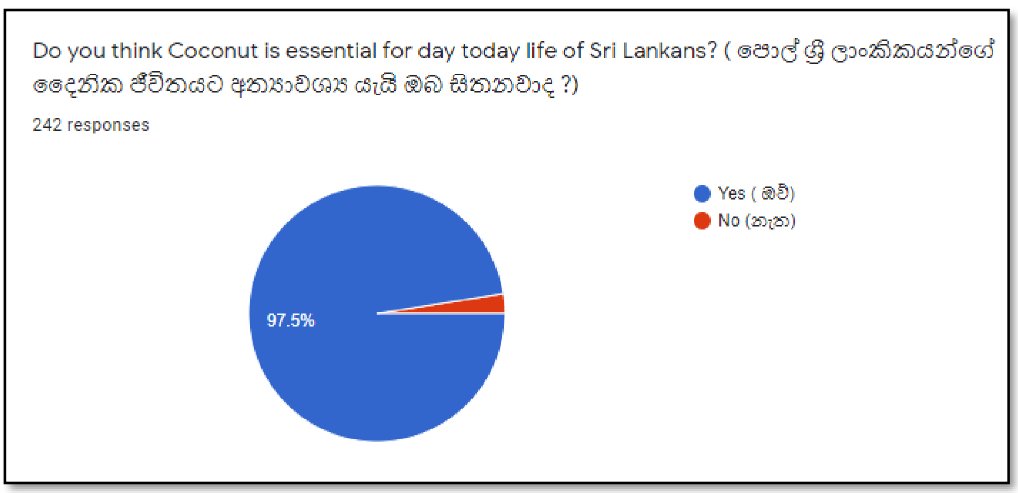

Figure 1. 1 : Survey report on the importance of Coconut for the daily life of people

The high incidence of pests and diseases is considered one of the major constraints related to coconut production and farm productivity [14]. As a perennial crop of which productive lifespan extends up to about 50-60 coconut palm is threatened by many pests and diseases. The stature of the palm creates difficulties to adopt traditional manual observation methods as well as pest management practices [13]. In view of the high risks involved, an expert system was developed that would facilitate farmers to learn about diseases and pest infestations that cause damage to the palm. It also provides the cause of disease, preventive strategies and expertise ideas for the convenience of farmers. [15]

Coconut caterpillar *Opisina arenosella* Walker is one of the main pests of coconut in Sri Lanka since the damage, defoliation was first reported in 1898. Thereafter frequent outbreaks were reported from coastal districts of the North-Western, Eastern, Southern and Western Provinces [16]. Research studies have confirmed that moderate to high densities of coconut caterpillar is capable of causing economic yield loss and outbreaks mostly reported between February and October. Female coconut caterpillars lay eggs on the dorsal surface of coconut leaflets. The five instars of the larval stage feed on the dorsal surface for about 30-40 days resulting in the characteristic scorched appearance of coconut leaves. Infestations mostly occur in leaves at the lower whorls of the crown. In an outbreak, not only the lower leaves but a large number of leaves are affected. Figure 1.2 shows an infested coconut land and a leaf damaged by the coconut caterpillar. Naturally the population of coconut caterpillar is kept under control by natural enemies of the pest but the low temperature during the night time of February to October period is unfavorable for the natural enemies. Therefore, an outbreak of the pest could occur during this period. In order to prevent a coconut caterpillar outbreak which will bring an economic loss, identification of the pest at the initial stage is very important. The coconut growers have been advised to notify relevant authorities, the Coconut Research Institute and the Coconut Development Officers of the area if caterpillar infestation is identified. As the recommendation of control measures are based on the pest populations, assessment of the pest population is conducted before recommending the control measures [17].

Figure 1. 2 : Damage caused by Coconut Caterpillar [25]

In order to assess pest population by the manual method, 20 leaflets are randomly collected from one infected leaf of the middle whorl of an infected palm. Based on the diseased palm population, samples are collected from an adequate number of palms. The larval and pupa stages inside the galleries of leaflets are collected and counted separately. A sample data sheet is shown below in Figure 1.3. This whole process is arduous as well as time-consuming when considering the time taken for farmer observation, notification to CDO, visit of the field to collect samples, asses the samples and giving the feedback to the farmer with control measure.

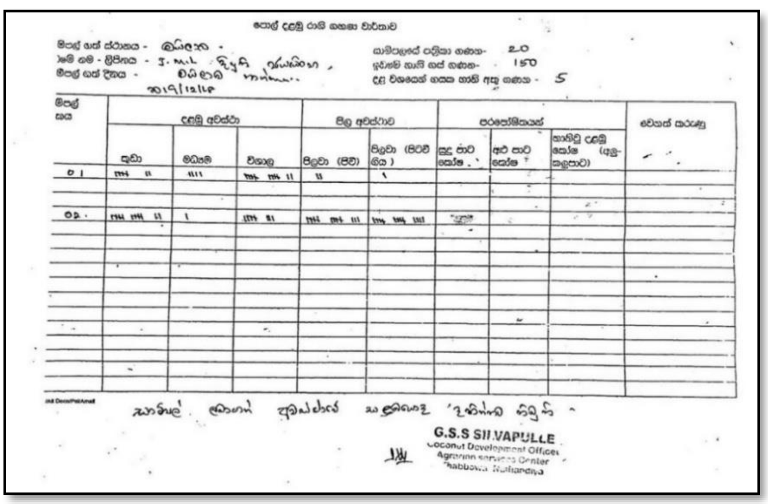

Figure 1. 3 : Sample sheet of how data is collected for coconut caterpillar infestation

According to Chandy [18] pest identification and assessment techniques that based on learning features automatically to collect more valuable information will be more sustainable in the future. The author has proposed a system for the identification of coconut pest infestations using deep learning techniques. In this system, the pest infestations are identified by using a drone that will fly through the coconut lands in order to capture the images. It will identify the pest infestation by processing the images using deep learning and image processing. Finally, the result is sent to the user's mobile phone using WIFI [18]. Recently another study reports the detection of diseases like stem bleeding disease and leaf blight disease and red palm weevil infestation in coconut through deep learning techniques. A collection of manually collected images of both normal and abnormal coconut trees were separated using popular segmentation algorithms. First, the abnormal boundaries were marked. After marking the boundaries, pest infections and diseases were predicted using 2D-Convolutional Neural Network (CNN) [19]. Automation of counting and classifying aphids is reported by Lins *et. al.* [20] In this report the authors suggest that the counting insects manually is time-consuming and prone to errors. To overcome this problem, the authors present a method and software to which enable automation of counting and classification of aphids using computer vision, image processing and machine-learning methods.

In addition to the coconut caterpillar damage, scorching or brown patches of leaves occur due to a condition known as leaf scorch disorder. The symptom of this disorder is also tip browning of the coconut leaflets at the lower whorls. Later the scorching spreads throughout the leaflets [21]. Therefore, there is a possibility of miss identification of coconut caterpillar damage as the leaf scorch which is not a spreading infestation. This may lead to an outbreak of coconut caterpillar due to neglecting the initial symptoms. As shown in Figure 1.4 people are not aware of the association of browning symptom with coconut caterpillar infestation (CCI) but are aware of it as scorching and nutrient deficiency symptom.

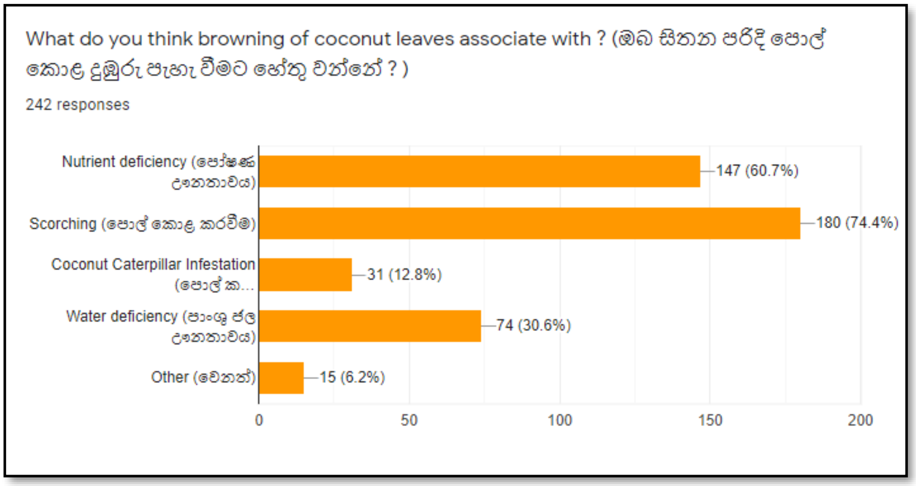

Figure 1. 4 : Survey report on reasons for browning in coconut leaves

According to the research background and survey discussed above, smart surveillance of one of the major coconut pests, the coconut caterpillar to identify the infestation accurately and to calculate the progression level would benefit the coconut farming community. This will also provide necessary information for researchers to decide on the correct control measures to save the palms from getting and spreading the infestation. There are very few research reports on precision agriculture techniques to identify some pests of coconut palms in India. However, this is the first such attempt in Sri Lanka with a farmer participatory approach and the first research to provide the progression level of CCI by calculating the region of infection with the caterpillar count.

1.2 Research Gap

In coconut caterpillar infestation the damage is caused by the larvae by feeding on the lower leaf surface. According to the Coconut Research Institute of Sri Lanka (CRISL) to identify the severity of infestations, it is necessary to extract the extent of the affected leaf area as well as the number of caterpillar larvae in that particular leaf. The research reports [15], [18] and [19] describe some studies by Indian researchers on smart agricultural solution with automated plant disease detection and classification tools such as AI integration, training deep learning models for coconut disease and pest management.

The research “A” reports on the use of image capturing drone, identification of pest infestations using deep learning techniques [18], The pest infestation is identified using a drone that flying through the coconut lands capturing the images through a GoPro camera. The drone is embedded with NVIDIA Tegra System on Chip (SoC) with ARM Cortex-based CPU and GPU for the purpose of image processing. To differentiate the pest affected and healthy areas, Region proposal network (RPN) and Channel-spatial attention (CSA) are used. The authors propose to identify the infestations but the extraction of progression level to minimize the risk of an outbreak is not considered. On the other hand, since the coconut caterpillars live on the dorsal leaf surface, the identification cannot be correctly done by examining the upper surface of the leaf. Through a drone capturing the lower surface is difficult. The result may be misleading when coconut leaf scorching disorder is prevalent in the field. Since the drones are not affordable at farmer level, the field level operations need the expert’s involvement. Therefore, pest management will be less efficient than using a mobile application approach because without the experts the farmers cannot identify the infestations.

An expert system was developed in research “B” [15], where few diseases of coconut are taken into consideration. The system only provides an overview of coconut diseases for the users. Object Expert System language called CLIPS was used in this research. The system suggests the users to select the correct answer based on the symptoms in each screen that they provide. After the discussion session is over, the proposed expert system provides the identification and recommendation of the diseases to the user. In this system, the identification process is not done using AI technologies. The identification is done only for several diseases and not for pest infestations, it depicts the diseases through the inputs of the user making the system less reliable since users lack in-depth knowledge about diseases. If the user selects the incorrect symptoms, the recommendations provided by this system will be inappropriate.

A recently published research “C” [19] have developed a system using image processing and deep learning techniques to detect leaf blight disease, stem bleeding disease, and pest infestation caused by red palm weevil. In this research a range of hand-collected images from normal and abnormal coconut tree were separated using popular segmentation algorithms. First, the abnormal boundaries were marked. After marking the boundaries with the use of a custom-designed deep 2D-Convolutional Neural Network (CNN) pest infections and diseases are predicted. The researchers have analyzed few CNN models to correctly classify and distinguish both healthy and infected trees using inductive transfer learning method. Finally, the research confirms that the most effective segmentation method was the k-means clustering segmentation. Furthermore, the custom-designed deep 2D-CNN model has achieved an accuracy rate of 96.94%. However, the detection of CCI and the progression levels are not considered in this research.

The below table 1.1 shows a tabularized format of the above explanation with regard to classification of coconut caterpillar infestation (CCI).

Table 1. 1- Comparison of former researches

Application reference	Identification of CCI	Progression level detection of CCI		Mobile-based identification approach
		Damaged leaf area	Number of caterpillars	
Research A	✓	X	X	X
Research B	X	X	X	X
Research C	X	X	X	X
Proposed System	✓	✓	✓	✓

Since there are no reports on mobile based identification system for coconut caterpillar, in this study we propose to develop a mobile application which farmers can use to identify the infestation as well as the progression level with ease without the help of an expert. After the infestation is identified, the details of the infested palm location will be sent to CRISL. Based on the information, researchers can assist the farmer with the most suitable management practice or the necessary guidance to prevent further spread preventing economic loss.

1.3 Research Problem

The productivity of any crop is reduced by pests since the beginning of agriculture. Therefore, protection of the crops from pests is essential to achieve high productivity levels that required to fulfill the demand for human consumption and to make agriculture profitable. The yield of cultivated crops is threatened due to destruction and competition from pests, especially when they are grown as large-scale in monocultures. Coconut is mainly grown as monoculture plantations and also it is a perennial crop of 40 to 60 years, therefore, pests can thrive well the year-round.

The leaf-eating caterpillar, a prolific feeder of coconut leaves is a serious pest of coconut palm causing significant yield loss. It infests coconut of all age groups and due to the feeding damage palm shows a scorched appearance due to the drying of leaves. Similar necrosis on the leaves also appear due to the disorder called Leaf Scorch Decline. As shown in Figure 1.5 our community is not familiar with coconut caterpillar damage and the symptoms associated with it. This can result the pest not reported to authorities at the initial stages. Therefore, educating people to identify the pest at initial stage of an infestation will pave the way to the effective management of the pest.

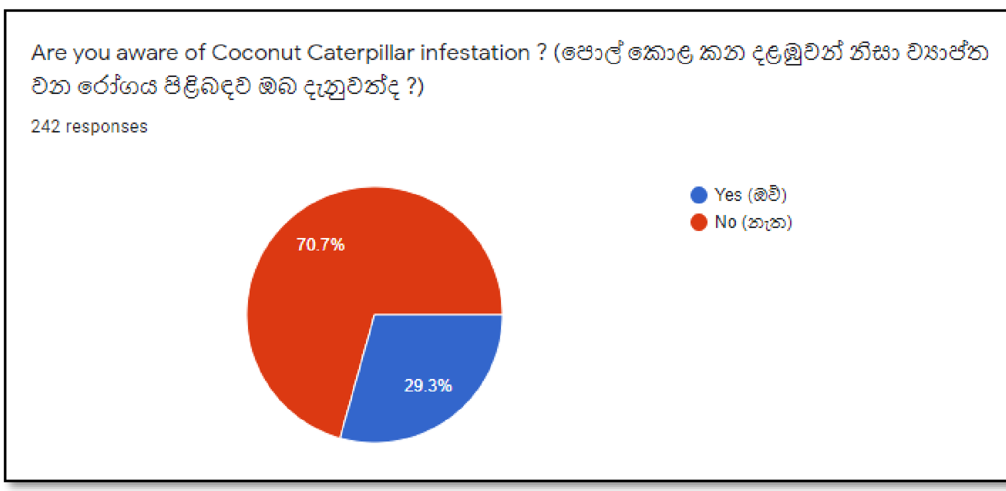

Figure 1. 5 : Survey of awareness on coconut caterpillar infestation

The CRISL has developed an efficient biological control method for coconut caterpillars by identifying, breeding and releasing a natural enemy of the pest. With the increase of severity, the biological control method needs to be supported with chemical control of the pest [17]. Therefore, identifying the severity of the disease by the community itself will speed up the selection of specific management practices. According to the survey, many are willing to get the knowledge on deciding the severity percentage as shown in Figure 1.6.

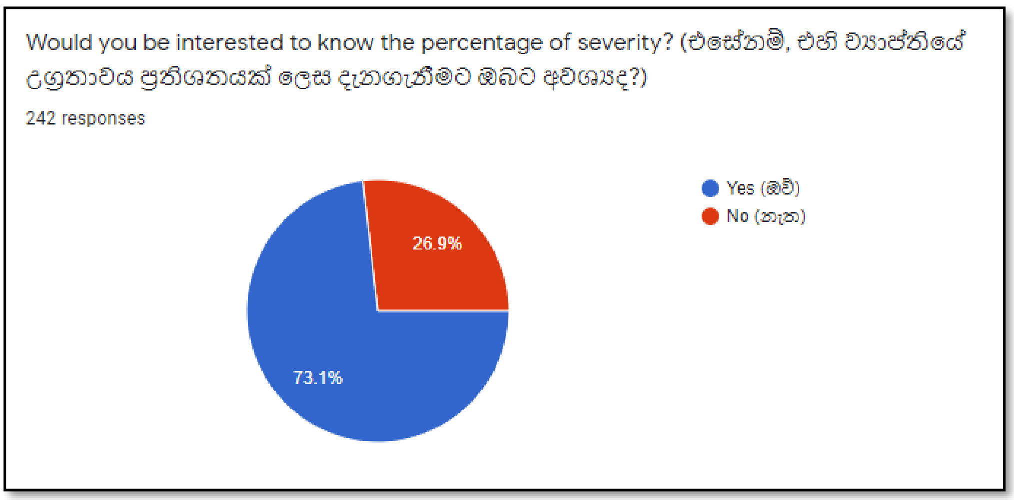

Figure 1. 6 : Summary of willingness to learn about the severity

There are no reports on smart agriculture tools developed for the identification and determination of the severity of coconut caterpillars by the coconut growers or the community. Therefore, the present study proposes a mobile application system where the stakeholders can easily identify the pest differentiating the symptoms from leaf scorch disorder and report the severity of the infestation to relevant authorities to speed up the control of the pest avoiding possible outbreaks which can result in an economical yield loss.

2. OBJECTIVES

2.1 Main Objectives

The main objective of this study is to develop a mobile application though which coconut growers can easily identify the coconut caterpillar infestation while differentiating its symptoms from symptoms of leaf scorch disorder. A photograph image of the lower leaf surface of infested leaf will be the input by coconut grower. The severity of the infestation will also be detected same time and will be informed to relevant authorities to speed up the application of control measures to prevent possible outbreak of the pest.

2.2 Specific Objectives

There are three specific objectives that must be reached in order to achieve the overall objective described above.

Identify Coconut Caterpillar Infestation (CCI)

- Photograph of the abaxial surface (lower surface) of coconut leaf will be analyzed using Deep Learning techniques such as Faster R-CNN to classify browning of leaves, availability of galleries (Larvae construct galleries of silk and frass, in which they hide when disturbed) and caterpillars to identify whether the coconut leaf is infested with coconut caterpillars.

Identifying the progression level of infestation

- To measure the extent of browning throughout the coconut leaf and to mask the progression level of damage, Mask R-CNN is used to accurately segment the area of the infestation which will help the researchers to decide on control measures.

Extracting the number of coconut caterpillars

- To identify the severity of damage using an indexing technique, total number of caterpillars will be counted using computer vision (OpenCV) for the researchers to decide on a control method.

3. METHODOLOGY

The proposed smart system is capable of identifying coconut caterpillar-infested leaves compared to healthy coconut leaves. Furthermore, the percentage of the progression level is calculated to make awareness to farmers and stakeholders regarding the severity of this infestation and the damages that can occur to their lands. The progression level is calculated with two parameters. First, the area of the infestation is considered. Next, the number of coconut caterpillars available on the sample leaf is extracted. With these two parameters in hand, using an indexing method the final percentage of the progression level is calculated.

3.1 System Architecture

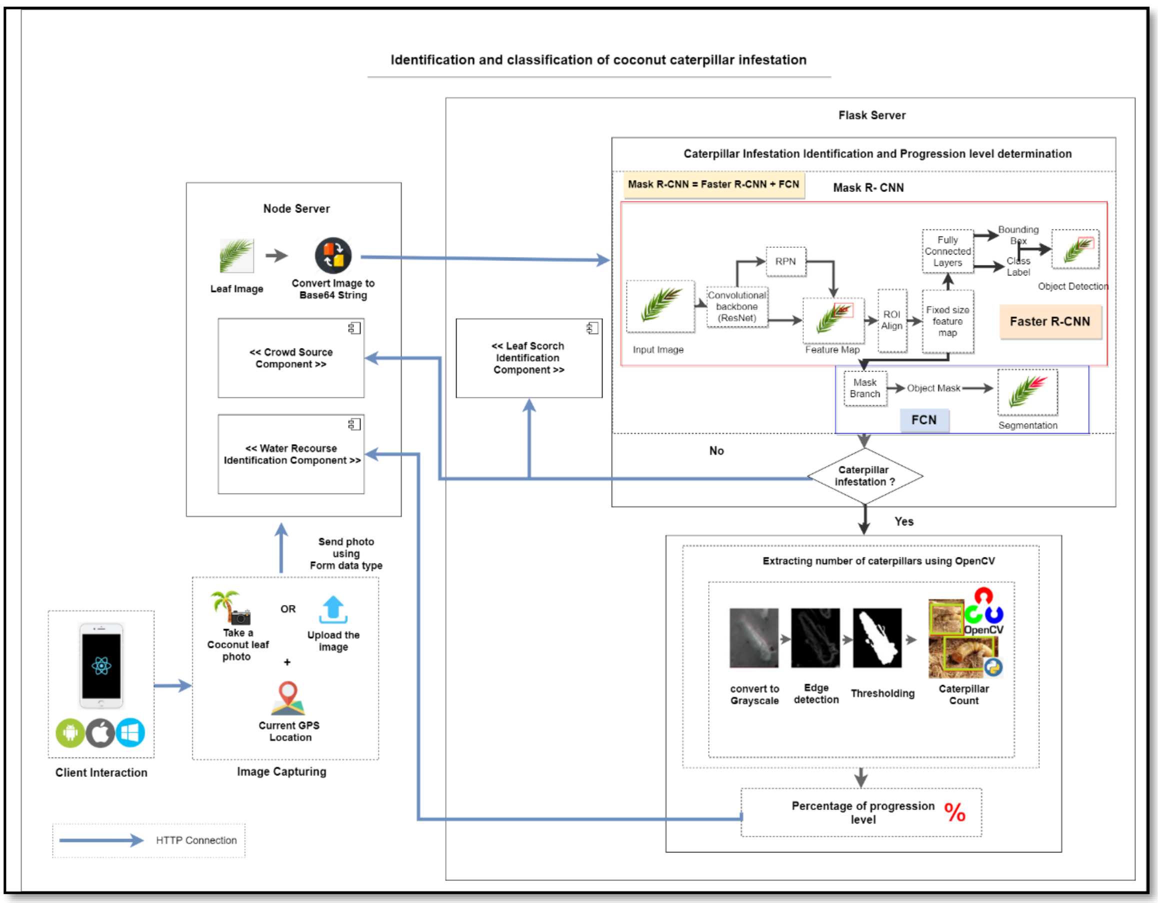

Figure 3. 1 : Coconut Caterpillar Infestation System Architecture

Figure 3.1 illustrates the overall high-level architectural diagram of the proposed component on identifying and classifying coconut caterpillar infestation. Initially, the stakeholder is provided with the opportunity of capturing an image or uploading a previously taken image to the system using a cross platform mobile application implemented using React Native. The captured image is processed and uploaded to the node server where it is converted to Base64 string. The converted image is then sent to the flask server to determine the coconut caterpillar infestation using deep learning and AI technologies.

There are three main components where first the system identifies whether the leaf is infested by coconut caterpillar, if not it will generate a message and displays that the inserted image is not of infested leaf. Faster R-CNN is used to identify the infestation using object detection. There are two main stages of Faster R-CNN. First, a Region Proposal Network (RPN) which uses a CNN architecture to propose the regions which recommends candidate object bounding boxes. The next step, which is more likely similar to the Fast R-CNN architecture, extracts the features of each candidate box utilizing RoIPool, conducts classification to identify the pest infestation, and uses bounding-box regression to mark the region of the infested leaf with a label [22].

If the system identifies that the leaf is infested it will mark the area of spreading by segmentation algorithms. Mask R-CNN is used to perform pixel level instant segmentation. Mask R-CNN is essentially Faster R-CNN with an additional branch of Fully Convoluted Neural Network (FCN) layer for applying an object mask in addition to the current branch for bounding box recognition. Figure 3.2 visualizes a detailed diagram of how the infestation is identified and segmented using Mask R-CNN. Among the several architectures of Mask R-CNN, the architecture ResNet will be used for this proposed system. For feature extraction ResNet-101 is commonly used in both Faster R-CNN and Mask R-CNN [22].

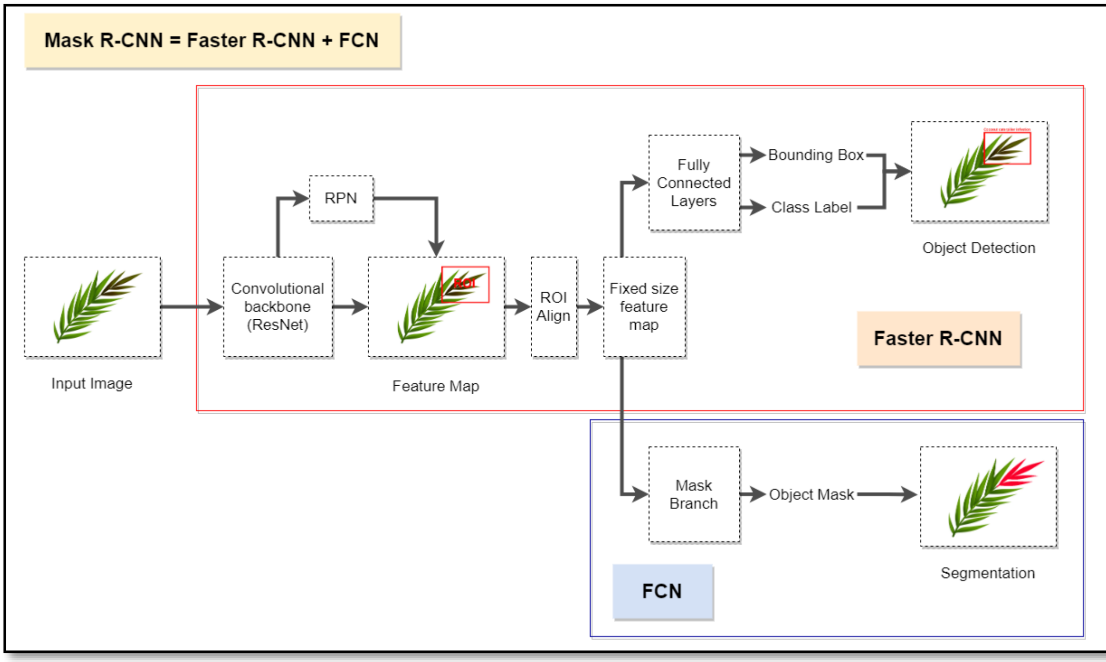

Figure 3. 2 : Identification process using Mask R-CNN

Finally, to calculate the progression level the number of coconut caterpillars available in that the particular leaf will be extracted using computer vision with TensorFlow and OpenCV libraries to provide an accurate result for the stakeholders to prevent their lands from getting harmed by the infestation.

Summary of technologies, techniques, architectures and algorithms used for the classification of Coconut Caterpillar Infestation is shown in the table (Table 3.1) below.

Table 3. 1 : Technologies, techniques, architectures and algorithms used.

Technologies	React Native, Expo, Python, TensorFlow, Flask Server Node Server, OpenCV, Intellij Idea, Keras
Techniques	Feature Selection, Data Augmentation
Algorithms	Faster R-CNN, Mask R-CNN
Architectures	ResNet

3.1.1 Software solution

The Software Development Life Cycle (SDLC) is a methodical approach to software development that ensures code accuracy and consistency [23]. When requirements shift, in the conventional approach software developers are unable to go back to earlier steps therefore, they are compelled to carry out all of the steps in the correct order. However, if agile methodology is used in SDLC developers are not required to do so. Being agile is all about adapting to changes. With compared to several agile frameworks scrum is the most effective agile framework as compared to the others mentioned. Scrum is an agile project management framework that is lightweight and can be used to manage and solve complex adaptive problems [23]. Figure 3.3 illustrates the six core processes of agile methodology.

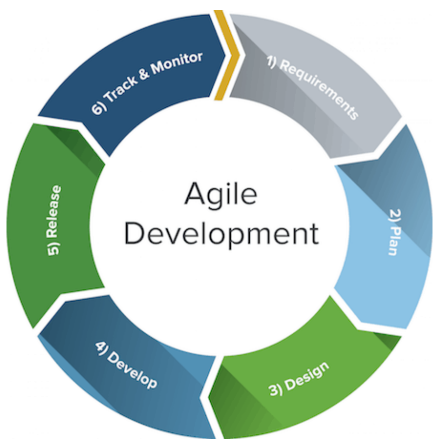

Figure 3. 3 : Agile Methodology [23]

- **Requirement gathering**
    - **Collecting information from CRISL**

      To collect information on diseases and pest infestations of coconut a series of online meetings were conducted with Dr. Nayani Aratchige, the Principal Entomologist of CRISL with participation of Dr. Janaka Wijekoon as our supervisor. In this meetings it was highlighted that coconut caterpillar infestation is prevailing mostly in areas of North-Western, Eastern, Southern and Western provinces of Sri Lanka. She further explained that pest outbreaks occur due to lack of knowledge of farmers in recognizing symptoms of the infestation and inability to differentiate symptoms from leaf scorch disorder. Due to these reasons development of a smart mobile-based identification system would be helpful to farmers, researchers and CDOs to manage the disease at early stages.

- **Data gathering**

  For initial understanding samples of coconut caterpillar infested leaves were provided by Crop Protection Division of CRISL. In future the images of infested palms will be collected from infested areas in Puttalam, Kalpitiya, Madurankuliya etc.

- **Conducting a survey**

  In order to get an idea about the knowledge of people about pest and diseases of coconut and their symptoms, a survey was conducted with 14 close and open-ended questions by distributing a questionnaire. Overall 242 responses were provided.

- **Feasibility study (Planning)**
  - **Economic feasibility**

    The economic feasibility report addresses the project's development cost and benefit. Unless a suitable economic feasibility plan is in place, the process would fail. Therefore, the proposed system should be less expensive and efficient.

  - **Scheduled feasibility**

    A schedule feasibility assessment evaluates the timelines for planned projects and has a direct effect on the project since the project's intent will fail if it is not completed on time. Therefore, the proposed system should complete each task in the relative time period as mentioned in figure 4.1.

- **Technical feasibility**

  Technical feasibility planning necessitates an evaluation of the required skills and expertise for mobile and web application development, as well as the ability to understand software architectures and the communication skills to effectively gather the necessary information from stakeholders in order to successfully continue with the system's development.

- **Design (system and software design documents)**

  After the planning phase, system and software design documents are created which contributes to the overall system diagram.

  - **Sequence Diagram**

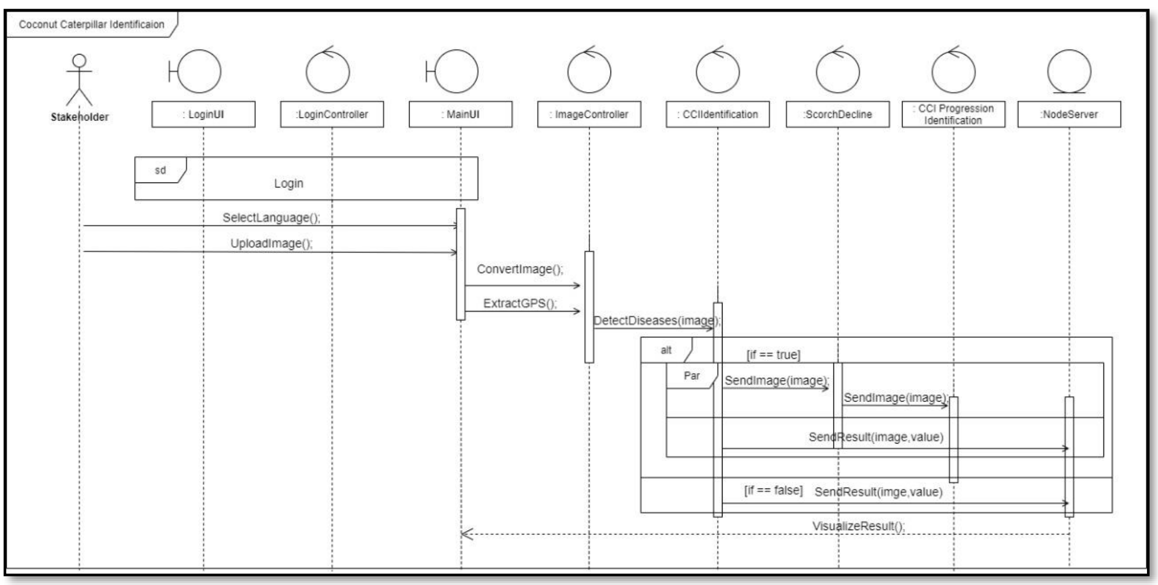

Figure 3. 4 : Sequence Diagram of CCI Component

- **Use Case Diagram**

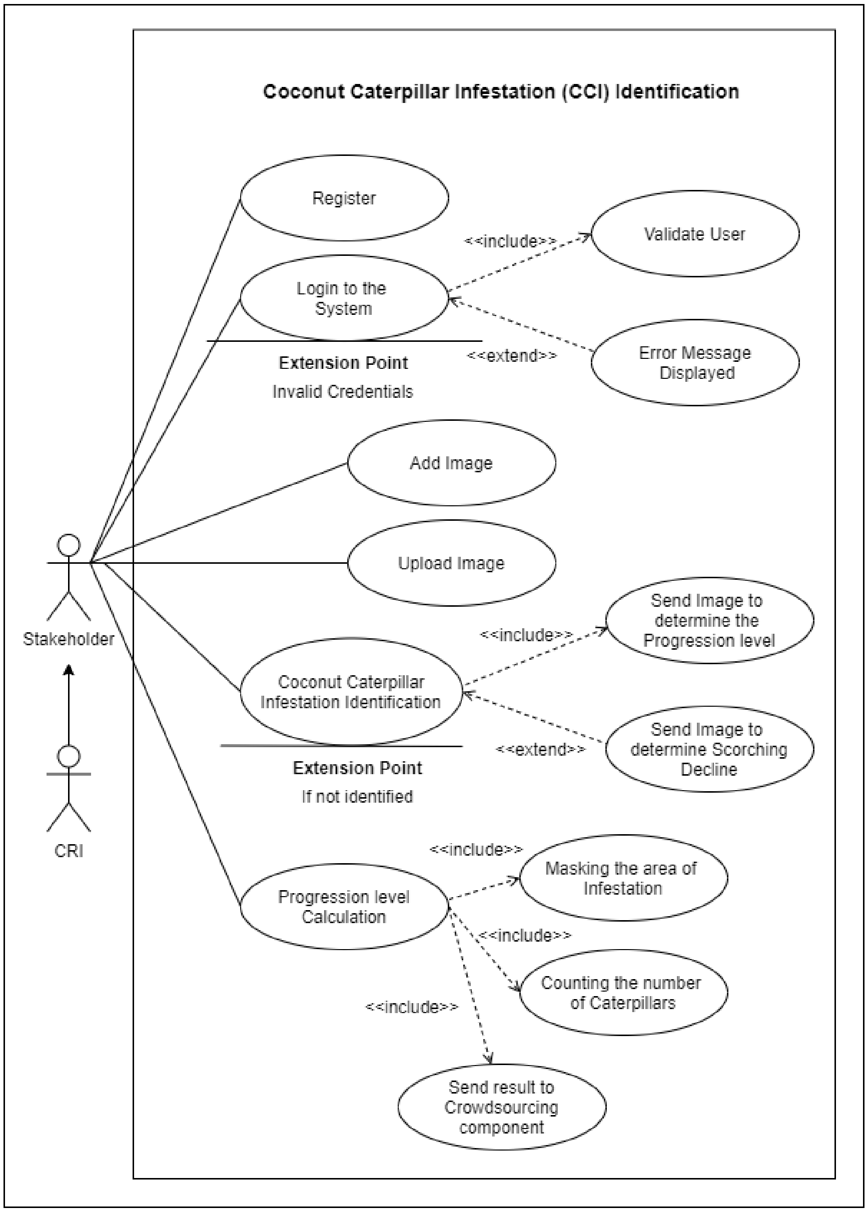

Figure 3. 5 : Use Case Diagram of CCI Component

- **Implementation (Development)**

  The implementation process, as discussed in the methodology, includes the development of below functionalities to satisfy user requirements providing the ultimate solution with high accuracy and reliability.

- Implementation of a cross platform mobile-based identification system using React Native and expo.
- Coconut Caterpillar Infestation identification system using object detection and image processing using Faster R-CNN.
- Masking the area of infestation on the leaf using Mask R-CNN.
- Extracting the number of caterpillars with computer vision methods using TensorFlow and OpenCV libraries.

- **Testing (Track and Monitor)**

  In this phase of software testing, system gaps and missing requirements are checked along with errors and bugs to fix them and assure the quality of software. Series of testing processes such as unit, component, integration, system and user acceptance testing are carried out to achieve the purpose.

3.1.2 Commercialization

This research is proposed as a smart solution for one of the research gaps identified in the research programme of CRISL. When developed, the application will be introduced to the coconut growers, Coconut Development Officers and the researches at CRISL to use it in their pest control programme.

The system comprises of two versions; first one provides the identification of coconut caterpillar infestation. Farmers will be notified if the leaf is infested with coconut caterpillar infestation with high accuracy. The second one which is the premium version provides the severity levels of the infestation. This premium version should be purchased by the stake holders to identify the severity to take accurate precaution measures.

3.1.2.1 Future scope

For the future scope the application will be extended to identify other pests of coconut.

4. PROJECT REQUIREMENTS

4.1 Functional requirements

1. The system should be able to identify coconut caterpillar infestation and appropriately display the results to the user.
2. The system should be able to mask the infested area and calculate the amount of coverage.
3. The system should be able to extract the number of caterpillars
4. The progression level should be determined correctly using the calculated infested area and caterpillar count.

4.2 Non-functional requirements

1. User-friendliness - The system should provide a cross-platform application for both android and iOS users while maintaining an attractive, responsive and well comprehensive interphase.

2. Reliability - The system should not fail or get stuck at any time throughout the process. The users should feel secure and confident while using the application. All sensitive information must be protected.

3. Performance - The system should perform efficiently by providing fast and accurate results to the users.

4. Availability - The application should be accessible to all users, regardless of language. It should be able to be used whenever it is needed.

4.3 System requirements

The purpose of software requirements is to define the software resources that must be enforced on a system in order for the proposed system to function properly. The software specifications requirements for this proposed component are as follows.

- React Native and Expo to create a cross platform mobile application.
- Keras to analyze deep learning models
- Intellij IDEA to implement the code using Python.
- OpenCV and TensorFlow libraries to extract the number of coconut caterpillars
- Flask Server to run the models
- Node Server to connect web and mobile applications with Flask Server while CrowdSourcing the results obtained by the system to users.

4.4 User requirements

This mobile application will be developed for three types of users.

1. The coconut growers

   Coconut growers will use the application to identify and differentiate symptoms of coconut caterpillar damage by capturing an image with their smartphone. The severity of the damage also will be assessed by the application

2. The research officers of the CRISL

   They will use the application to evaluate data updated by the growers and to recommend control measures to growers and/or Coconut Development Officers (CDOs) of the location. The recommendation of control measures will be decided based on the severity level of the infestation.

3. The Coconut Development Officers (CDOs)

   They will use the application to inspect location data and execute control measures recommended by the research officers at CRI. Using the application time taken for communication that is, a pest infestation identified by coconut grower through CDO to CRI and the recommended control measure to the grower through CDO will be minimized. This will prevent the possibility of an outbreak of the pest.

4.5 Wireframes

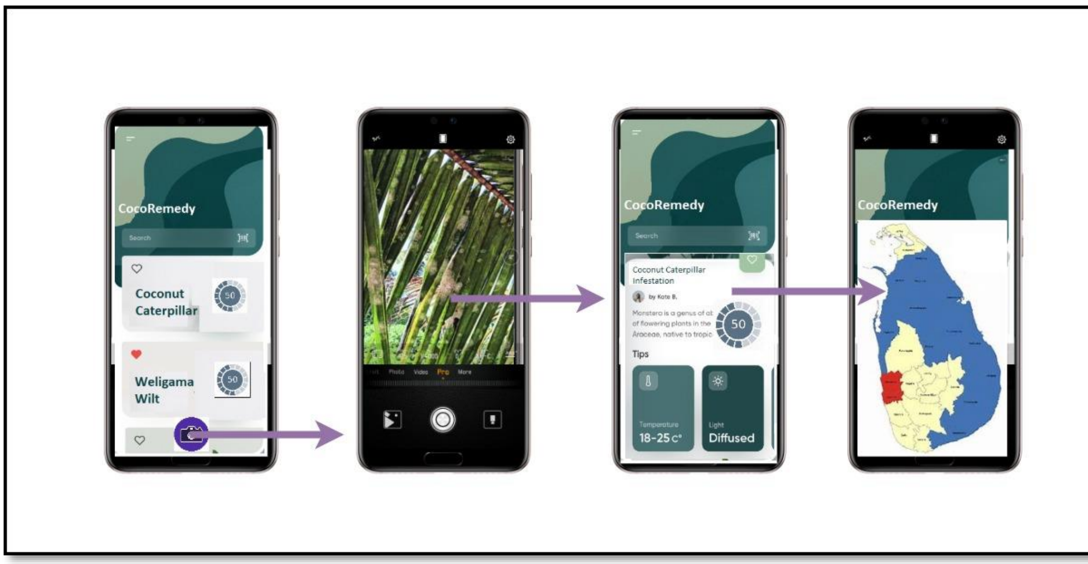

Figure 4. 1 : Wireframe of coconut caterpillar identification process

5. GANTT CHART

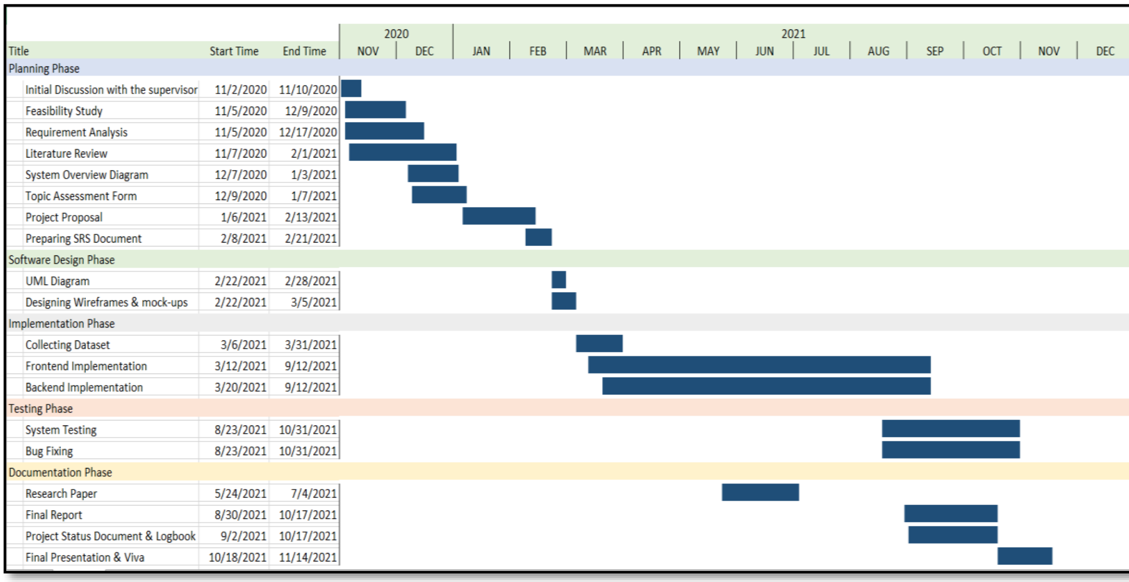

Figure 5. 1 : Gantt chart

5.1 Work Breakdown Structure (WBS)

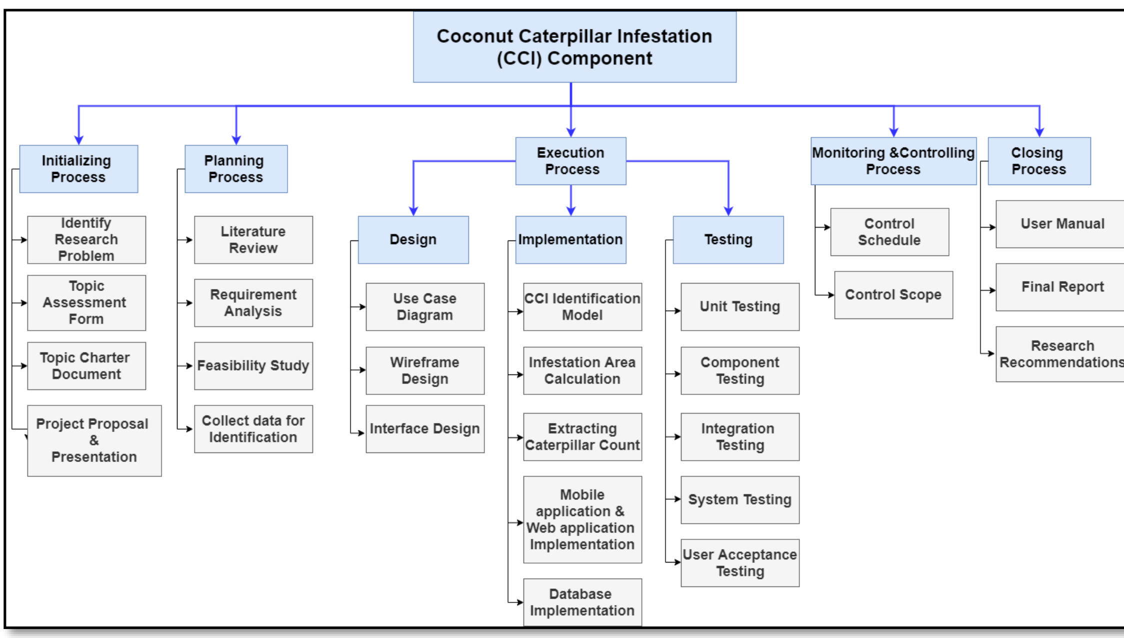

Figure 5. 2 : Work Breakdown Chart of CCI component

6. BUDGET AND BUGET JUSTIFICATION

The below table 6.1 depicts the overall budget of the entire proposed system

Table 6. 1 : Expenses for the proposed system

Expenses	
Requirement	**Cost (Rs.)**
Travelling cost for data collection	1,5000.00
Cost of Deployment	6,073.00/month
Cost of hosting in Play Store	4,898.00
Cost of hosting in App Store	19,294.00/month
Total Cost	**31,865.00**

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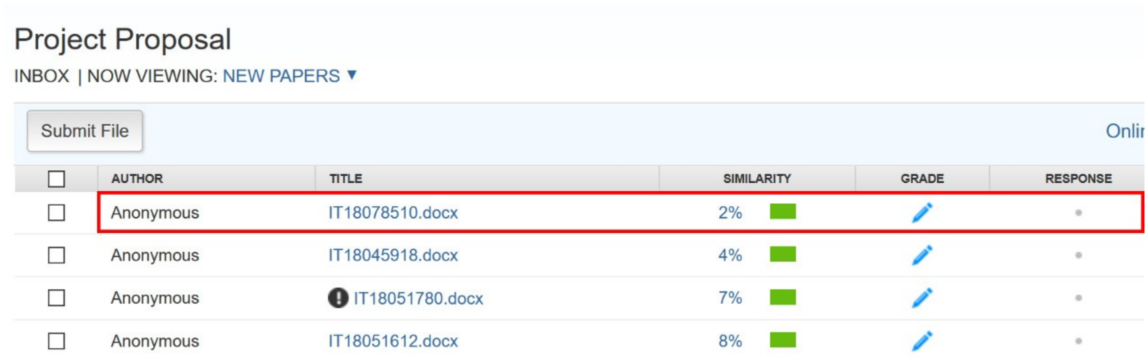
APPENDICES

Appendix - A : Plagiarism report



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Appendix - B : Sample Questionnaire

https://forms.gle/pXNQrAichCegcovi8