Smart Assistance for the Floriculture Industry

2023-133

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology Specialized in Data Science

Department of Information Technology

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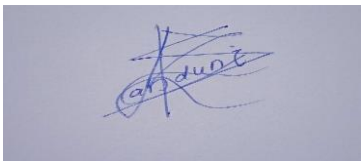
DECLARATION

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.

Name	**Student ID**	**Signature**
Liyanage S.R	IT20005726	

Signature of the Supervisor
(Dr. Sanvitha Kasthuriarachchi)

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Date

2023-04-05

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ABSTRACT

Sri Lanka's diverse climatic regions, abundant water sources, and fertile soil provide an ideal location for growing various plants. The floriculture industry has the potential to become a major player in the global market, and Sri Lanka is known for producing high-quality floral products. However, the industry is highly competitive and requires growers to produce high-quality ornamental plants at low production costs. Despite numerous studies on agricultural aspects and environmental factors affecting plant growth, there is a research gap in predicting the growth of ornamental plants and providing smart solutions for the floriculture industry's economic level. This research aims to provide a smart solution to the growth monitoring and predictions about the time required to grow up to the standard level. The proposed solution is a smart mobile-based system for growth monitoring and predictions, which aims to assist the Sri Lankan floriculture industry in monitoring plant growth, predicting growth time, and providing practical suggestions for improving plant growth. The research focuses on predicting the current state of growth in ornamental plants, identifying the relative growth rate of plant height, predicting the time it takes for plants to reach the required growth size, and providing suggestions for growing ornamental plants from their current state to the expected level. The research aims to identify the current growth state by considering essential facts like plant height, the number of leaves, temperature, planted date, etc. OpenCv and YOLO technologies will be used to detect the measurements from plants' pictures, and OpenWeather API weather details gathering. Classification techniques like decision tree, random forest, and gradient boosting will be used to calculate the time required to grow up to the expected level, and the best model will be used to develop the application. The research aims to consider environmental facts and measurements from the industries' point of view and provide a solution to the research problem. The proposed solution is expected to contribute to the floriculture industry's economic level in Sri Lanka, generating revenue, and creating employment opportunities.

Keywords: Floriculture industry, ornamental plants, growth monitoring, growth prediction, mobile-based system, Sri Lanka.

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LIST OF ABBREVIATIONS

Abbreviation	**Description**
OP	Ornamental Plants
NTP	Non-Thermal Plasma technology
APSIM	The Agricultural Production Systems sIMulator
CNN	Convolutional Neural Network
RGR	Relative Growth Rate
FI	Floriculture Industry
ML	Machine Learning
ROI	Region Of Interest
R-CNN	Region-Based Convolutional Neural Networks
YOLO	You Only Look Once
ROC Curve	Receiver operating characteristic curve
LKR	Sri Lankan Rupee
IoT	Internet of Things

1. INTRODUCTION

Sri Lanka is a beautiful gift of Mother Nature that has a rich biodiversity, where within a couple of hours different varieties of climatic regions can be seen. Not only the climatic benefits but also the good soil, rich water sources, and other related factors make Sri Lanka a good motherland for different kinds of plants. So the usage of natural factors and human interference with available technologies makes the path for the Sri Lankan floriculture industry to establish itself as a good competitor in the world market. Today, Sri Lanka is considered one of the best quality floriculture product makers, with a range of products from tropical to temperate flora. When it comes to the export market of the floriculture industry, Sri Lanka mainly aims at the European market, and as a percentage, it is 60%. Recently, other buyers have shown interest in Sri Lankan floriculture products, such as those from the Middle East, Japan, the USA, and Korea. [1]

During 1980-1981, Sri Lanka's export-oriented industry begins to take root. But gradually, the industry was able to develop not only the international demand but also the local demand as well. After the war situation and with the development of the tourism industry, including the hotels, the demand of the local sector for floriculture products also developed gradually. The main floriculture products can be categorized as
Ornamental Foliage Plants, Cut Decorative Foliage, Cut Flowers, Aquarium Plants, Landscaping Plants, Tissue Cultured Plants, and Flower Seeds. As a country, the industry mainly developed in the western province, central province, and Northwestern province. [2]

On the other hand, Sri Lanka is in a state where it should give more focus to other exporting industries than key exporting products. Floriculture is one of the important industries that help bring foreign currency to Sri Lanka since it has a direct foreign market. Not only the foreign sector but even the local market has a huge demand that sometimes

cannot even be met. However, as identified after going through various research papers and discussing with some exporting companies and domestic farmers, so far there has been a minimal impact of the IT industry on the floriculture industry. As a result, the proposed research aims to address some significant key areas of the floriculture industry for which there is no proper IT solution. The research is going to give a mobile application-based solution to monitor the growth of plants, identify pesticides, define the required environment, and manage the market based on demand and supply.

The floriculture industry is a very competitive industry, not only in the local sector but also in the export sector as well. So from the company's point of view, it is really important to provide the best quality products while minimizing the production cost. In that case, it is obvious that to achieve the facts above, it is essential to give more attention to the product when it is preparing for the supply level. In the floriculture industry, most of the time the primary product is a plant. Most of the floriculture products are based on ornamental plants because those are the plants used to collect cut foliage and cut flowers as well. Also, landscaping plants are a variety of ornamental plants, which have a considerable demand. So it is clear that constant attention to the ornamental plants is needed to provide a good product in the end. It means the monitoring of the growth of ornamental plants is a crucial factor that the industry should pay attention to.

According to the facts identified and after the discussion with the industry, it was clear that the market requires the products to be in a specific standard way. Normally, the industry grows more plants than is required. So to provide a standard product at the end, it is essential to monitor the growth. When it comes to growth monitoring, there should be a way to measure the current state of the ornamental plants. In that case, key factors like the number of leaves and plant height can be used to measure the current state of the ornamental plant. [3]On the other hand, it is more beneficial to provide an indicator to show the growth of the plant, and the relative growth rate is one of the key indicators. [4]

Since the floriculture industry mainly focuses on orders, it is necessary to know the time it will take to grow up to the standard supply level from the current stage.

The floriculture industry is huge, but the technologies used for it are less developed compared to other countries. But these technologies should be feasible as well. So a growth monitoring and prediction system will be beneficial to the Sri Lankan sector to develop the industry with the impact of the IT sector as well.

1.1 Background & Literature survey

The Sri Lankan floriculture sector has earned a renowned brand name as a reliable supplier of quality products across the world. This vast industry directly brings foreign currency into the country, alongside major exports such as tea, coconut, and rubber. The floriculture industry plays a considerable role in the Sri Lankan economy, and deals directly with the global market. In the past year alone, the industry has generated an income of more than US$14 million. [5]

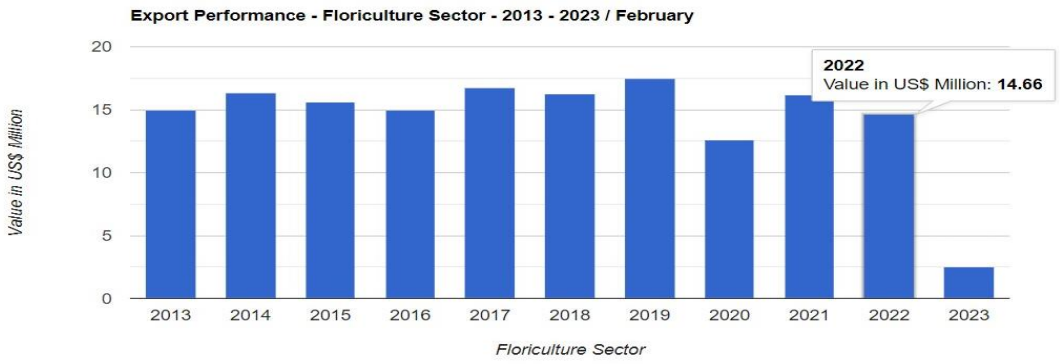

Figure 1-1 Export Performance of Floriculture Industry

The floriculture industry operates within a highly competitive global market. After consulting with several industry experts and reviewing relevant documents, it has been identified that this industry has significant potential, particularly in European countries, the Middle East, and Japan. Notably, the Netherlands, which is considered the world's

largest supplier in the floriculture industry, is a key customer of the Sri Lankan industry. [5]

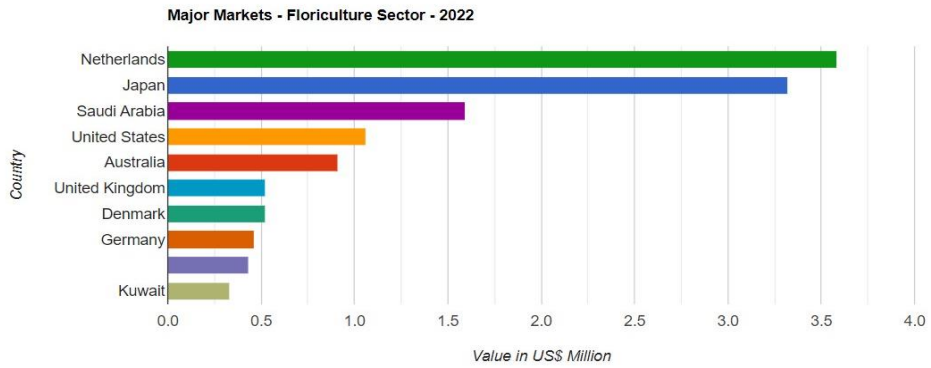

Figure 1-2 Major markets of the floriculture industry

Accordingly, it is clear that the floriculture industry clearly has a huge global market, which the country can try to expand as well. As per the Sri Lankan industries' point of view, the major products can be categorized as follows:

- Ornamental Foliage Plants,
- Cut Decorative Foliage,
- Cut Flowers,
- Aquarium Plants,
- Landscaping Plants,
- Tissue Cultured Plants,
- Flower Seeds.

Among the above products, the global market has a huge demand for ornamental plant-related products. Cut foliage and cut flowers are the product types that can get obtained from a quality ornamental plant. [5]

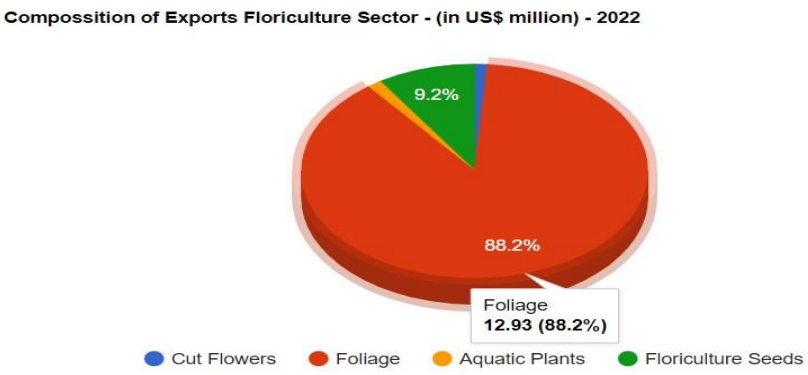

Figure 1-3 Major exported product types of the Floriculture Industry

Ornamental plants play a major role as one of the main floricultural products. But as mentioned above, it is important to grow a good ornamental plant that can reach the expected standard level of supply. In order to grow a plant to that level, constant attention and measurements are needed. So growth monitoring is a crucial point in the floriculture industry. Because with effective growth monitoring, only the primary stakeholders in the industry can ensure a quality product and steady supply.

Growth monitoring of the plants can be done using different methods. But here, it is essential to consider the industry requirements as well. Especially the global market requires specific conditions from the growers. For example, there is a plant called Livistonia rotundifoilia that has a huge demand and is commonly required to have 5-character leaves and a 25- to 30-cm plant height by the customers. [6] So it is important to grow the plants to meet the market's expectations.

Measuring plant growth can be done in different ways, and there should be traits to measure the expected level. Main plant traits for growth monitoring of OP can be considered stem height, stem diameter, leaf area, leaf length, leaf width, number of leaves, etc. [3] But some other important factors should be considered when monitoring growth as well. Those are the environmental factors that directly affect the growth of any kind of

plant. Mainly temperature, water, light, humidity, and nutrients directly affect the growth of ornamental plants. [7]

When it comes to the studies that have been conducted so far, it is common to see that most of the studies give priority to considering the environmental facts that affect plant growth. There is research being conducted to monitor the growth of plants using a soil moisture and temperature sensor and camera. The stress level of a plant is directly affected by its growth, and stress can be caused by many reasons. In there, the stress on a plant caused by lack of water, humidity, and temperature facts have been identified, and an IoT-based automatic solution has been proposed. [8] There was another study conducted that proposed an automation system for controlling and monitoring ornamental plants using the fuzzy logic method. In that case, they have considered only the temperature, air humidity, and soil humidity (water supply) and proposed an automated IoT-based system with expensive hardware. [9]

The 21st century is the pinnacle of the development of mankind with the revolution of IT. So as in any industry, while keeping agriculture as the mother industry, the floriculture industry also developed with new technologies. As with the topic of IoT, the smart greenhouse concept is not only considered in the agricultural sector but also in the floriculture sector as well. A study titled "Information technology-controlled greenhouse: A system architecture" proposed a smart green hose along with actuators. In that case, they have used NTP as a main technology and considered controlling main factors such as nutrients, soil moisture, temperature, and humidity. [10] There were so many studies conducted proposing the smart greenhouse concept, and since ornamental plants also belong to a plant type from an agricultural point of view, these can apply to the FI as well. Studies like [11], [12], [13], and [14] proposed smart greenhouse concepts with consideration of common growth monitoring-related facts like temperature, humidity, soil moisture, etc.

When it comes to the traits of growth monitoring, so far studies have been conducted solely considering that area. A study was conducted to predict the growth of plants based on the growth of plant leaves and roots. In this study, the researchers basically used deep learning models along with a generative adversarial network to forecast the growth of two main vegetable plants. [15] There was another study conducted to predict plant growth, mainly focusing on the growth of leaves. In that case, time series-related data augmentation methods like T-Mix-up and T-Copy-Paste had been used. But here also, they did not conduct this research for the OP. [16] Then there was a study conducted to identify the response of ornamental plants to saline irrigation water. In that case, the RGR of ornamental plants like Viburnum lucidum, Teucrium fruticose, and Eugenia myrtifolia was identified based on the dried weight of the plants. But practically, it is hard to achieve, and the RGR based on dry weight required the necessary tools for weight measurements as well. So if a grower wants to get an idea of the current growth rate of the plant, it is a bit difficult. [17]

Based on the literature survey and background discussed above, growth monitoring is an essential and important factor in the floriculture industry. However, research on this component is limited, as most studies have focused solely on environmental factors or measuring traits related to growth monitoring. Therefore, the industry would benefit from a system that can predict the current state of growth of ornamental plants based on both environmental factors and important traits. Furthermore, identifying the relative growth rate based on height would also be a useful indicator for making necessary decisions. In order to compete effectively and ensure a steady supply, it is crucial to know how long it will take for a plant to reach the required growth size for an order. Additionally, an inexperienced employee or beginner would benefit greatly from a suggestion system for growing the ornamental plant to the next level. As a solution, a proposed system that provides growth monitoring and prediction through a smart mobile-based platform would be highly beneficial.

1.2 Research Gap

The floriculture industry has seen significant development around the world, largely due to technological advancements. However, the impact of the IT sector on the industry has been limited to certain areas. The proposed component aims to develop a smart mobile-based solution for growth monitoring and prediction of ornamental plants, taking into account the capacity and feasibility of the floriculture industry in Sri Lanka. Based on the background and literature survey, a research gap has been identified between the studies conducted thus far and the proposed component.

The first research identified is namely "Early season prediction of within-field crop yield variability by assimilating CubeSat data into a crop model". In that research, the research party used CubeSat-based images and LAI maps. The images were integrated into APSIM using a particle filter. The final system can forecast how long the plants will take to reach the desired level of growth, and the approach overcomes the impacts of cloud cover on traditional satellite data. But when it comes to the practical situation in the Sri Lankan sector, it is hard to achieve such a system with a high-cost satellite-based image data set, and the study does not consider other facts like temperature, humidity, fertilizer level, etc. [18]

The second research is about an automated system for controlling and monitoring ornamental plants using the fuzzy logic method. In that case, the proposed system is an IoT-based solution with actuators to control the temperature, air humidity, and moisture level of the soil. For that solution, expensive sensors and a highly technologically controlled environment are required. [9] The study "Information technology-controlled greenhouse: A system architecture" introduced a smart greenhouse equipped with actuators, utilizing NTP technology to control main factors including nutrients, soil moisture, temperature, and humidity. [10]

The next research is titled "Deep Learning for Image-Based Plant Growth Monitoring: A Review". In that case, a model using deep learning like CNN or RNN is used to predict the current growth state of the plant. But the research done on vegetable plants like tomatoes, blueberries, etc. [19] The next research is about the manipulation of the rice L-galactose pathway. In that study, they have identified the relative growth rate of plant height, but the research aims at the paddy field and mainly considers the salt stress tolerance of the plant. [20]
Then there was research conducted to measure plant growth monitoring using wearable sensors. The system proposes two wearable sensors based on fiber Bragg gratings

(FBGs), which will capture environmental factors such as temperature and humidity. [21]

The next research considered is titled "Controlling and monitoring ornamental plant care remotely using the Android application". In that research, they have proposed a highly technical IoT-based solution for controlling temperature, air and soil humidity, and water supply. But it only considered controlling the environmental factors. [22] There was research conducted to monitor the growth of orchid plants to predict the room humidity for the orchids. In that case, an IoT-based solution is proposed with sensors and actuators mainly to identify the suitable temperature and humidity. [23]

Table 1-1 Comparison of former research

Application Reference	Identification of the current state of growth in ornamental plants	Identification of the relative growth rate of plant height	Identification of the temperature and humidity of the given growing location	Predicting the time required for plants to reach desired growth size for orders	Mobile app kind solution in Sri Lankan Sector
[18]	X	X	X	✓	X
[9]	X	X	✓	X	X
[10]	X	X	✓	X	X
[19]	✓	X	X	X	X
[20]	X	✓	X	X	X
[21]	X	X	✓	X	X
[22]	X	✓	X	X	✓
[23]	X	✓	X	X	X
Proposed System	✓	✓	✓	✓	✓

Based on the above results, it is clear that most research studies have focused on controlling environmental factors related to growth monitoring, with a focus on creating IoT-based automated solutions to control these factors. However, most of these studies were geared towards the agricultural sector rather than the floriculture industry. Additionally, only a few studies have considered growth monitoring traits such as plant height, number of leaves, leaf width, and length. Furthermore, no studies were found that focused on predicting the current stage of growth by considering both environmental factors and crucial trait measurements, along with the identification of RGR of plant height and prediction of the time required to grow to the expected level.

1.3 Research Problem

The floriculture industry plays a significant role in many countries economies, generating revenue through the production and export of high-quality ornamental plants. Globally it has a market that was USD 3.65 billion in 2020 and forecasted to climb up to USD 7.062 billion by the year 2028. [24] Additionally, the industry has the potential to create employment opportunities while strengthening the economy of the country. Moreover, the floriculture industry is a massive industry that has a good market in the local sector as well. Sri Lanka is currently at a stage in which the citizens should pay attention to more industries rather than being dependent on primary exports like tea, coconut, and rubber. Accordingly, from an economical point of view, the floriculture industry is an area that can be developed as a considerable partner and a foreign currency earning area of the Sri Lankan economy.

When it comes to the economic level of the floriculture industry, it is a competitive sector both locally and market-wise. In the FI, basically, the primary and key product is an ornamental plant, and the grower has to spend adequate resources to grow it to the expected level. So in order to give a quality product that satisfies the standard level of supply while facing competitiveness and minimizing the production cost, it is essential to monitor the growth of ornamental plants.

According to the literature survey and background studies discussed above, it is clear that most of the studies done so far have mainly focused on the agricultural side rather than the economic level. Also, most of the studies were done in foreign countries according to their environmental conditions. Further, most of the studies paid attention to controlling the environmental factors that affect the growth of plants. In that case, as a solution, most of the studies proposed IoT-based solutions with expensive sensors and smart greenhouse concepts. But from Sri Lanka’s point of view, moving toward that kind of smart greenhouse concept is not practical because of the high cost and lack of technology and hardware. On the other hand, there were few studies conducted to predict the current state of growth of ornamental plants using plant height and the number of leaf-like traits as measurements, but they missed the related environmental factors. Also, there were fewer studies conducted to predict the time taken by an ornamental plant to reach the expected growth size for an order. Also, there was no system to provide suggestions on how to grow the plants from their current state to the expected level. Especially there was a lack of mobile app-based solutions that are suitable for the Sri Lankan sector to resolve all the above obstacles together.

A survey was conducted to determine the relevance and importance of the proposed component. The results showed that over 80% of employees working in the floriculture industry consider growth monitoring of ornamental plants to be a crucial factor, as depicted in figures 1–4 below.

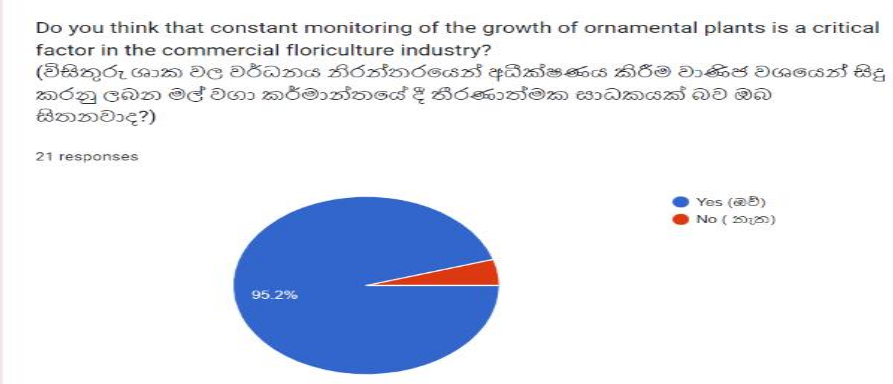

Figure 1-4 Survey to identify the importance of growth monitoring

Correspondingly, it was clear that there was a research problem. So the component of the growth monitoring and prediction system is going to address the above complications. The main goal of the research is to provide smart assistance to the floriculture industry on growth monitoring and predictions related to ornamental plants. Briefly, the growth monitoring and prediction system will provide a smart solution to the following two main problems:

- How can the growth of ornamental plants be monitored and their current state of growth predicted?

- How can the time it takes for ornamental plants to reach the required growth size for ordering be predicted?

Accordingly, the research problem will address four sub-objectives while maintaining the main goal of developing a growth monitoring and prediction system. In that case, under growth monitoring, the proposed system is going to predict the current state of growth of the ornamental plant. In that case, all the related environmental and feature facts, like plant height, number of leaves, temperature, and humidity of the growing location, are going to be considered. In that case, according to the survey results, farmers and employees give their ideas about the facts that should be considered in growth monitoring as shown in the Figure 1-5.

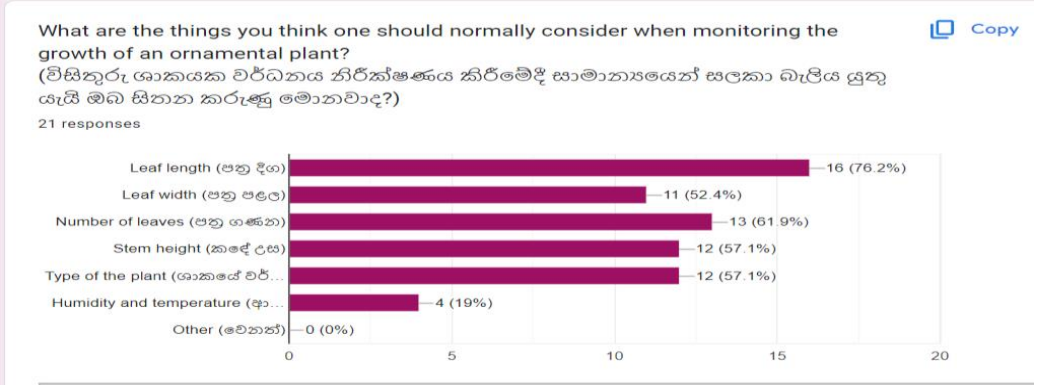

Figure 1-5 Survey about facts that should be considered in growth monitoring

The proposed system aims to identify the relative growth rate of plant height and predict the time required for the plant to grow from the current state to the expected supply level. The industry currently estimates this time based on experience, as revealed by the survey (Figure 1-6). Therefore, the proposed automated approach aims to address this issue.

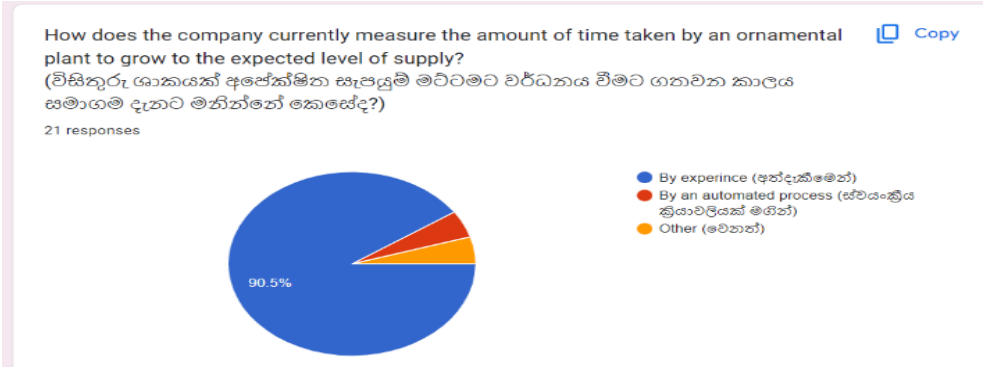

Figure 1-6 Survey about facts that should be considered in growth monitoring

In conclusion, the proposed growth monitoring and prediction system for ornamental plants aims to provide the industry with a smart mobile-based solution. The system is designed to identify the relative growth rate of plant height, predict the time required for the plant to reach the expected level of supply, and provide necessary suggestions for growing the ornamental plants to the next level.

2. OBJECTIVES

2.1 Main Objectives

- **Create a smart mobile-based system to Growth Monitoring and Predictions**

The proposed system aims to achieve the main goal of developing a smart mobile app-based solution for monitoring the current growth level of ornamental plants and predicting their current state, along with estimating the time required for them to reach the expected growth size.

2.2 Specific Objectives

- **Predicting the current state of growth in ornamental plants.**

Here the current state of the ornamental plant will be predicted. The relevant features to measure the current growth and relevant environmental factors and external supplements like fertilizer will be considered. Based on those facts the current state of the ornamental plant will be predicted.

- **Identification of the relative growth rate of plant height.**

Normally there are physical tools like auxanometers to measure the growth of the plant but it is practically hard to use. But the industry needs indicators about plant growth to make necessary decisions. In that case, there are several indicators like AGR, RGR, and CGR. [25] RGR is a good indicator rather than the AGR because it considers the time as well. Normally RGR calculates the dry weight of the plant at time1 and time2. But in the FI rather than destroying and disturbing a plant that grows well and takes tools to measure its weights, it will be more practical to measure the RGR with plant height. The RGR can

calculate the plant height as well. So as a good indicator, the RGR of plant height will be measured. [26]

- **Predicting how long it will take for plants to meet the required growth size for an order.**

The FI basically grow their plants based on orders but there are some occasions they have to supply sudden orders as well. In both cases, if the system can predict a plant how long take to reach the desired standard level it will be beneficial to make necessary decisions.

- **Giving suggestions to grow up to the next level of the ornamental plant**

The industry always expands with new employees and farmers. So it will be beneficial for them to get suggestions about the things they should do to grow an ornamental plant to the next stage.

3. METHODOLOGY

The proposed smart assistance system for the floriculture industry is going to be designed as a mobile app solution. In this case, React Native will be used as the main technology. Throughout the project, the plan is to follow the traditional software development life cycle as the foundation, and agile methodology will be followed as the key concept. Since the project has to be developed as a group, agile software development is the best way to get maximum outcomes from each member and to increase efficiency. Moreover, since the group is supposed to do presentations throughout the project period to develop the system along with all individual components, the agile approach is the best way. Finally, the team plans to deliver a quality product while maintaining a collaborative and flexible environment. So, the agile methodology is the best approach to achieving that.

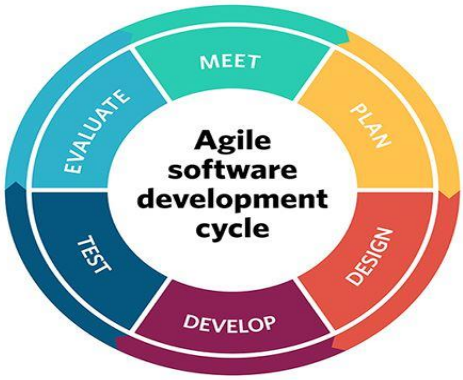

Figure 3-1 Agile Software Development Life Cycle

The growth monitoring and prediction system for ornamental plants is going to be developed as a separate component of the overall system. The stages to be followed in accordance with the traditional software development life cycle and the agile development approach are described below.

3.1 Requirement gathering

The proposed growth monitoring and Prediction system going to be developed mainly using a machine learning approach. So it is necessary to have the required data sets from

the industry. Moreover, the survey was done while targeting the industry people to measure the importance of components as well.

3.1.1 Conducting a survey

A survey was conducted to determine the relative importance of all four components of the system. In this case, the survey was designed to obtain input from employees about their current methods of monitoring growth and predicting the time required to reach the expected level of supply. The finalized questionnaire was distributed to the target audience employees, and both verbal and manual methods were employed to gather the data.

3.1.2 Data Gathering Methods

The growth monitoring and prediction system component will primarily be developed using machine learning models. As such, data related to growth monitoring will be essential. This includes information such as plant type, variety, current growth category, fertilizer application, fertilizer ratio, weather data of the growing location, and more. The research will be conducted in collaboration with Omega Green (PVT) Ltd, one of Sri Lanka's leading floriculture companies located in Badalgama. The external supervisor, Mr. Anandatissa Illeperuma, a retired agricultural officer, will be providing guidance. Based on the desired component, it has been identified that the necessary data is available at the company.

3.2 Feasibility study (Planning)

The feasibility study evaluates the upcoming project's feasibility in three main aspects - economic, technical, and scheduling. Even before proposing the smart assistance for the floriculture industry project, the team discussed its costs. The entire project, along with the growth monitoring component, will be developed in a cost-effective way for both developers and end-users. Then the technical ability was thoroughly discussed, and the technologies that the team possesses are chosen. Omega Green (PVT) Ltd is already

contacted for the data requirements and industry experts' support. Finally, as per the scheduling, the system should be developed within the time frame given in Figure 5-1, along with the individual component.

3.3 Overall System Architecture

Smart assistance for the floriculture industry project consists of four major components. "Growth monitoring and predictions" is one of the main components among them. Altogether, the system will be designed with the purpose of providing valuable support to the industry in four aspects. Accordingly, the overall proposed system's diagram is shown below.

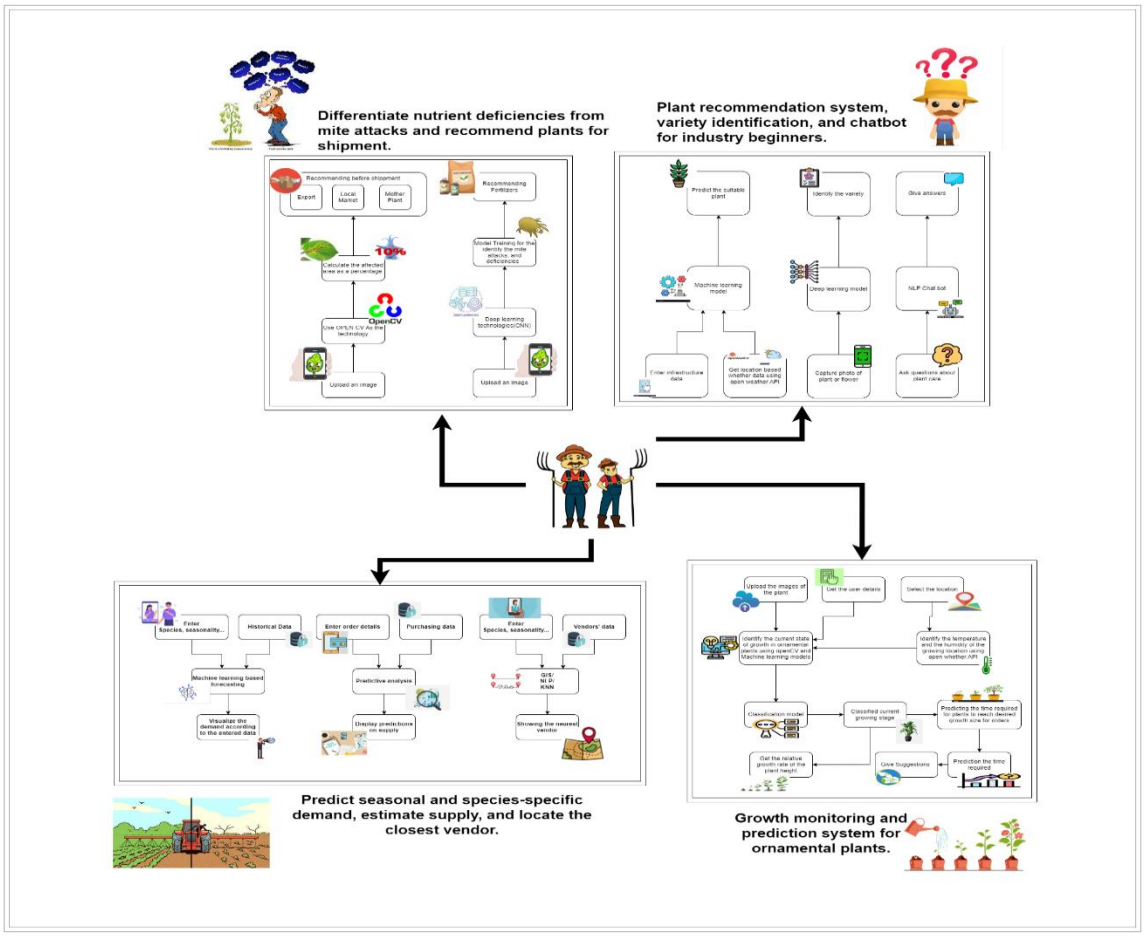

Figure 3-2 Overall System Diagram

3.4 Individual System Analysis (Development)

A growth monitoring and prediction system will be a major part of the proposed system, which is going to be developed to achieve the four sub objectives mentioned above. Correspondingly, the system is planned to be developed to achieve those goals with suitable technologies. The growth monitoring system diagram shown below describes more about the proposed architecture for the component.

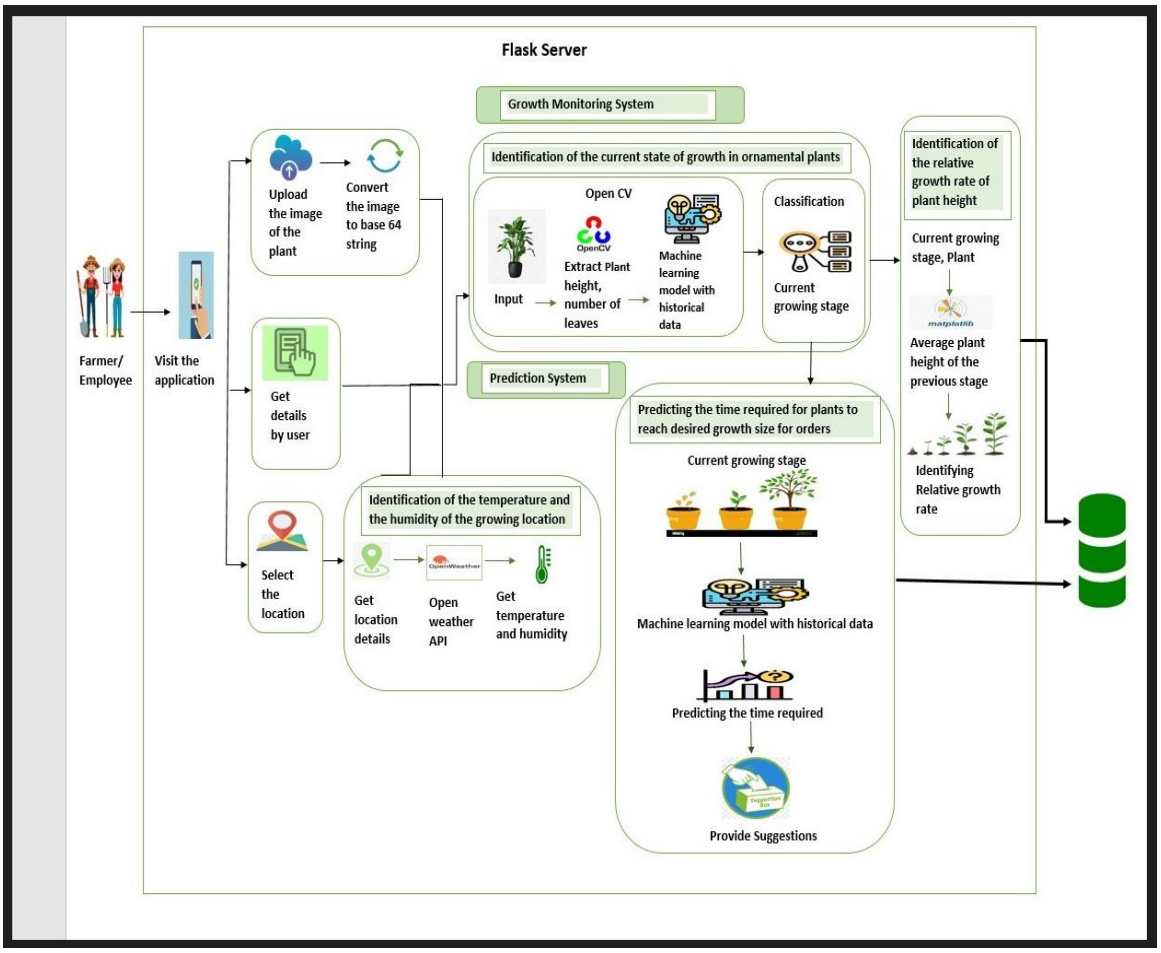

Figure 3-3 Growth Monitoring and Prediction system architecture

Moreover, in order to develop the proposed system, the technologies, algorithms, and techniques shown in the below table will be used.

Table 3-1 Proposed technologies, algorithms, architectures, and techniques

Technologies	**Algorithms & Architectures**	**Techniques**
React Native Python Tensorflow Matlab Flask Server Open CV Visual Studio Code Jupiter Notebook	Machine Learning models CNN YOLO	Transfer learning Data Augmentation Hyperparameter optimization Object detection and segmentation technique Feature Selection

3.4.1 Growth monitoring system of ornamental plants.

- Collecting Data

The growth monitoring system is going to predict the current state of growth of the ornamental plant and identify the RGR of plant height. The required data for the growth monitoring will be gathered from Omega Green (PVT) Ltd which is the contacted leading floriculture company. Here the historical data like plant type, variety, plant height, number of leaves, media grew, planted date, growth category, and current lifetime of plant will be collected from Omega Green (PVT) Ltd. More of the temperature and humidity of the past will be extracted through the open weather API as well. Then from the users' side based on the uploaded plant's photo and given location plant height, number of leaves, and temperature and humidity data will be extracted separately. Here for the features like plant height and the number of leaves, the object detection algorithms like YOLOv3, and CNN will be used appropriately.

- Extracting plant height and number of leaves

The user is supposed to provide a picture of the required plant. Then in that case OpenCV which has deep learning frameworks will be used and OpenCV 3.4 will be used. Because in order to make the system work fast and effectively the YOLOv3 is also going to use OpenCV which uses CNN to identify and detect objects. Accordingly using

OpenCV with YOLO the essential facts like plant height and number of leaves going to detect.

- Preprocessing the Data and Cleaning

The next step is going to be the cleaning and preprocessing the gathered data. Before that, the data collected from different formats will be prepared into CSV format and prepare a single data source. Then the required preprocessing techniques will be applied to create a more reliable data set. Here mainly the following things will be considered when preprocessing the data.

- Identifying and handling the missing values.
- Dropping irrelevant features.
- Encoding Categorical Data into numerical values.
- Filtering unwanted outliers.
- Visualize the data set to understand the cleaned data set.

After the preprocessing and cleaning the data set will be suitable for further development.

- Feature Selection and splitting the data set

Then to evaluate the importance of selected features and finally create an optimized model a feature selection test will be done. Here the first the correlation of features and class will be calculated. Then the Fisher's Score will be used to calculate the rank of selected features.
Finally, the data set will be split into two parts for training and testing purposes. X will be the feature or independent variable whereas Y will be the dependent variable. Accordingly, the Y will be the growth category. The ratio of training and testing will be 80:20 respectively.

- Choosing a suitable model

According to the problem finally, it should predict the current state of growth of the given ornamental plant. So suitable algorithms for multi-label classification will be used here. In that case, Decision tree, Random forest, and Gradient boosting algorithms are going to use. The most accurate algorithm will be evaluated and used for further development.

- Training the Model

Here using the above-mentioned algorithms the training data set will be trained accordingly.

- Evaluating the model

As the next step, the models will be evaluated to check the performance of each model. In that case, firstly the Accuracy of the model will be checked. Then the confusion matrix will be used and precision and recall will be checked. Then the ROC curve will be used to evaluate the models as well. The most suitable model will be chosen for further development.

- Parameter Tuning

As the last step of model creation to increase the accuracy, hyperparameter tuning will be done.

- Predicting the current state of growth

Finally, the current state of growth will be predicted using the chosen model.

- Identification of the relative growth rate of plant height.

As the last step of growth monitoring the user will be able to get the RGR of plant height. Here the extracted plant height will be used, Based on the plant's current state and most probable previous stage the RGR of plant height will be calculated using Python math libraries like NumPy and MatplotLib.

3.4.3 Prediction system to measure the time required to grow to the standard growth size

- Collecting the Required Data

The prediction system aims to develop a model that predicts the time required for an ornamental plant to grow up to the expected standard level of supply. This prediction

will be based on the plant's current state of growth, which will be estimated using previously predicted growth factors and other related factors. The historical data necessary for this system will be gathered from Omega Green (PVT) Ltd. The essential historical factors considered are plant name, variety, media grown, fertilizer applied, fertilizer ratio, shade provided, grown pot type, growth category, current lifetime, and time required.

- Preprocessing the Data and Cleaning

The subsequent phase will entail the purification and pre-processing of the accumulated data. Initially, the data gathered in diverse formats will be transformed into a CSV format and merged into a unified data source. Various methods will then be utilized to generate a more dependable dataset. These methods involve recognizing and managing absent values, discarding irrelevant characteristics, encoding categorical data into numeric values, excluding undesired anomalies, and visualizing the dataset to comprehend the cleaned data more proficiently. Following the pre-processing and purification process, the dataset will become appropriate for additional development.

- Feature Selection and Splitting the Data Set

In order to assess the significance of chosen characteristics and produce an improved model, a test for feature selection will be carried out. Initially, the association between the features and class will be measured. Next, the rank of the chosen features will be determined using Fisher's Score. Lastly, the data set will be divided into two parts for the purposes of training and testing. The feature or independent variable X will be selected, while the dependent variable Y will be the amount of time required. The training and testing will be divided in the ratio of 80:20, respectively.

- Choosing a Suitable Model

The prediction system aims to predict the time required to grow up to the expected supply level of an ornamental plant. Therefore, suitable algorithms for multi-label classification will be used, such as Decision trees, Random forest, and Gradient boosting algorithms. The most accurate algorithm will be evaluated and used for further development.

- Training the Model

The training data set will be trained using the above-mentioned algorithms.

- Evaluating the Model

The next step is to evaluate the models to check their performance. Firstly, the accuracy of the model will be checked. Then, the confusion matrix will be used, and precision and recall will be checked. The ROC curve will also be used to evaluate the models. The most suitable model will be chosen for further development.

- Parameter Tuning

The last step in model creation is hyperparameter tuning, which aims to increase the accuracy of the model.

- Predicting the Time Required to grow up to the Standard Supply Level

Finally, the chosen model will be used to predict the time required for the plant to reach the desired standard level.

- Providing Suggestions to grow up to the Next Level of the Plant

The last step of the system is to provide suggestions to grow up to the next level from the current state. Based on the plant's current state, suggestions will be provided from a previously created database based on industry expert knowledge.

3.5 Testing the Growth Monitoring and Prediction System

The growth monitoring and prediction system will be developed as a separate component of the overall system being created for smart assistance in the floriculture industry. Once developed, the system will be tested to assess its performance and identify and fix any bugs. The component will be capable of individual prediction as well as functioning as a part of the whole system. Additionally, the system will be tested with industry experts to gain valuable insights and feedback.

3.6 Commercialization and Business plan of Growth Monitoring and Prediction System

- Commodity Version:

- The system has the capability to predict the current state of growth in ornamental plants.
- It can also identify the relative growth rate of plant height.

- Premium Version:

- With the Premium Version, the system can predict the time it will take for a plant to reach the required growth size for an order.
- It also provides suggestions to promote growth and advance the ornamental plant to the next level.

- Target Audience:

- The system caters to floriculture businesses of all scales - small, medium, & large.
- It is also suitable for farmers and gardeners who grow ornamental plants.
- Horticulture enthusiasts can also benefit from using this system.
- Research and educational institutions can use the system for research and learning purposes.

- Marketing Plan:

- The marketing plan includes social media marketing on popular platforms such as Facebook, Instagram, and Twitter.
- The system will also be promoted through Google Ads and search engine optimization (SEO).
- Email marketing campaigns will be used to reach potential customers and keep existing customers updated.
- Sharing leaflets is another way to spread the word about the system.

4. PROJECT REQUIREMENTS

4.1 Functional requirements of Growth Monitoring and Prediction System

- The mobile application should allow users to upload images of ornamental plants for analysis.
- It should be able to measure plant height and number of leaves from uploaded images.
- The system should provide current state of growth prediction for the uploaded plant.
- It should be able to predict the time it takes for the plant to reach the required growth size for an order.
- The system should provide suggestions for improving the growth of the ornamental plant.
- User data and image analysis results should be stored in a database for future reference.

4.2 Non-functional requirements of Growth Monitoring and Prediction System

- The application should have a user-friendly and visually appealing interface.
- It should be responsive and provide results in a timely manner.
- The system should be compatible with both iOS and Android operating systems.
- It should be accurate and provide reliable predictions.
- The performance should be fast.
- User data should be secure and protected.

4.3 Personal requirements of Growth Monitoring and Prediction System

- Resources and required data sets of the ornamental plants regarding the growth monitoring should be available.
- Required images of the ornamental plants at different stages should be obtained.
- The project will involve Omega Green (PVT) Ltd, Mullayaya Estate, Godigamuwa, Badalgama, Sri Lanka.
- The assistance of Mr. Anandatissa Illeperuma (Director, Retired Agricultural Officer) will be required.

4.4 System requirements of Growth Monitoring and Prediction System

- React Native, Flask Server, Visual Studio code, Jupyter Notebook, Python, and TensorFlow will be used for the development of the system.

5. GANTT CHART

Figure 5-1 shows the Gantt chart, which illustrates the time plan for the development of the whole system along with the growth monitoring and prediction component.

Figure 5-1 Gantt chart of the system

5.1 Work Breakdown Structure (WBS)

The following figure 5-2 depicts the breakdown structure for the growth monitoring and prediction system.

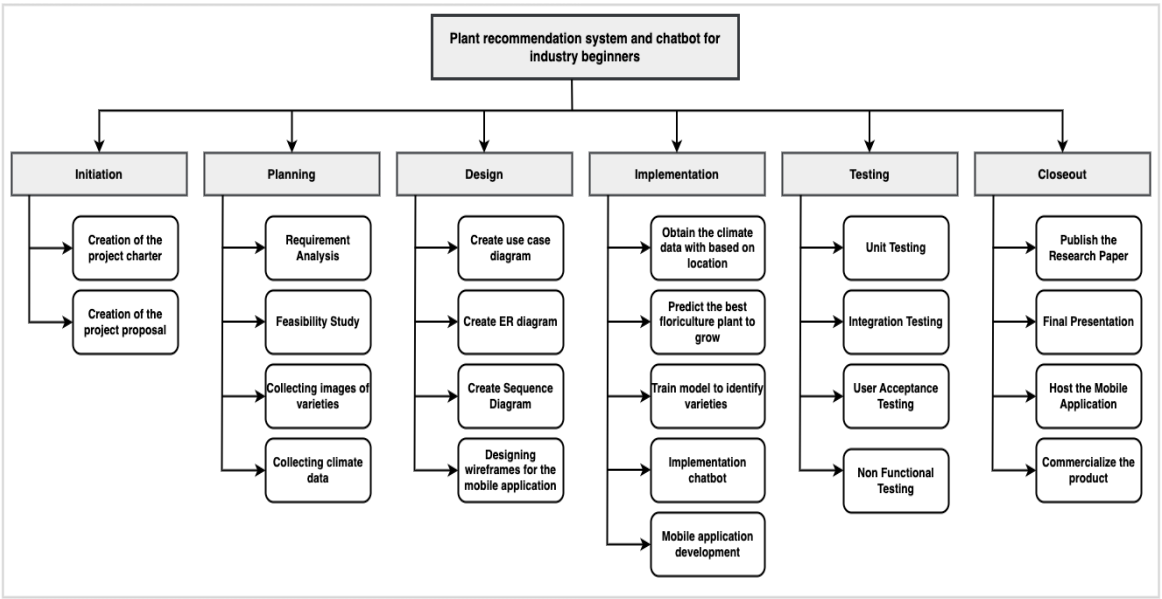

Figure 5-2 WBS of the Growth Monitoring and prediction system

6. BUDGET OF GROWTH MONITORING AND PREDICTION SYSTEM

Table 6-1 Budget of individual component

Component	**Price (LKR)**
Development of image analysis algorithm	2000.00
Integration of image analysis algorithm into mobile application	2500.00
Development of growth prediction model	2000.00
Integration of growth prediction model into mobile application:	2500.00
Travelling Cost and other expenses for the research Team	15000.00
Crowdsourcing	
Deployment Cost	2000.00/monthly
Open Weather Map API	1960.00/location

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APPENDICES

Appendix A: The survey on the floral industry

Link: https://forms.gle/qRtsndBhecpUqmFL8