International Journal of
Advanced Science Computing and Engineering

Journal Homepage www.ijasce.org/index.php/ijasce

GrainBot: An Android-Controlled Rice Grain Collector Robot

Sunshine L. Masiado [a], Anna D. Constantino [a], Jaelord F. Cajurao [a], Jayboy V. Valenciano [a], Joe Vincent Lagayao [a], John Sharwin S. Dasmariñas [a], Renly Jade S. Laud [a,*]

[a] *College of Information and Communications Technology, Iloilo State University of Fisheries Science and Technology, Iloilo, Philippines*

Corresponding author: [*]laudrenlyjade@yahoo.com

***Abstract*—Rice, a fundamental dietary staple for over three billion people around the globe, remains subject to significant postharvest losses, even as advancements in production techniques continue to evolve. Traditional sun drying, although cost-effective and environmentally friendly, presents a range of challenges. It requires considerable labor, exposes farmers to potential health hazards, and often results in uneven drying, which adversely affects grain quality. In response to these pressing issues, this research unveils "GrainBot: An Android Controlled Rice Grain Collector Robot," an innovative solution designed to revolutionize rice collection. This agile, two-wheeled robot employs a sophisticated suction mechanism to efficiently collect sun-dried rice, while being wirelessly controlled via a custom-designed Android application. The functionality, usability, efficiency, compatibility, maintainability, reliability, and portability of this system were rigorously assessed against ISO 25010, with input from a diverse group of users, including farmers, agricultural specialists, and IT professionals. The findings from this comprehensive evaluation revealed a grand mean score of 4.61, indicating an "excellent" rating. This indicates not only a high level of user satisfaction but also underscores the system's effectiveness in automating and refining the rice grain collection process. Ultimately, the proposed GrainBot represents a promising technological advancement, poised to significantly reduce manual labor, minimize health risks for farmers, and enhance the overall efficiency of postharvest rice handling.**

***Keywords*—Rice grain collector robot; android controlled; automation; mobile application; suction mechanism; wireless control.**

Manuscript received 5 Dec. 2024; revised 29 Apr. 2025; accepted 14 Jun. 2025. Date of publication 30 Aug. 2025.

I. Introduction

Over three billion people worldwide rely on rice as their primary food source. Despite significant advances in breeding and production techniques, postharvest handling losses remain substantial. Sun drying is a traditional technique in which paddy grains are spread in the sun to reduce moisture content. The pace at which water evaporates from grains is accelerated by the heating of the grains and the surrounding air caused by solar radiation. Due to its affordability relative to mechanical drying, it is the most commonly used drying technique in Asia. Because it uses the sun as a heat source and doesn't emit CO2, it is inexpensive and environmentally benign [1].

Despite being accustomed to laboring in their farms under the intense sun, Filipino farmers are susceptible to heat stroke, according to Manny Galvez [2], Science City of Muñoz, Nueva Ecija, Philippines. Head of the University of the Philippines-Manila's institutional bio-safety and bio-security committee and an expert in infectious disease and internal medicine, Raul Destura, cautioned farmers about the dangers of heat stroke, also referred to as sunstroke, and advised them to take the appropriate safety measures. Destura, who spoke at the Philippine Rice Research Institute on the health hazards associated with rice farming, instructed farmers on recognizing the symptoms of heat stroke, as the disease is frequently overlooked or misdiagnosed even in rural health facilities.

Sun drying of rice grains is common, particularly in small- to medium-sized batches. Uneven grain spreading and overheating on the drying mat can cause grains to become tough and lose nutrients. As a result, some grains may remain damp or under-dried, while others become prematurely dry, leading to uneven grain spread, inadequate exposure to sunlight, and variable weather conditions. As a result, some grains may remain damp or under-dried while others become overly dry, leading to uneven quality and potential spoilage. Achieving uniform drying is crucial to ensuring the longevity and market value of the rice crop. However, sun-drying has a limited capacity and is typically labor-intensive. This method's temperature control is highly challenging, and the grains are prone to cracking due to overheating, resulting in poor milling quality. Farmers may also be at risk of heat stroke, dehydration, skin cancer, back pain, strains, and sprains due to sun-drying [3], [4], [5].

Based on the problem statement, we came up an solution this is to build a two wheeled robot for the movement, have a suction this vacuum that can collect the grains at sun-drying mat, have battery at the back of the robot that source of the electricity, switch for the on/off buttons, and the mobile application for the wireless connectivity of the robot, have a container at the back for packing process if its full. The robot's suction has limitations; it is suitable only for small grains such as rice, corn, and beans. This robot will reduce farmers' workload, which could be highly beneficial for them.

This study aimed to develop the "GrainBot: An Android-Controlled Rice Grain Collector Robot". The objective was to construct a two-wheel-drive robot equipped with a rice-suction mechanism for harvesting sun-dried rice. Additionally, a mobile application was designed to control the robot's motion and vacuuming. The system was subsequently evaluated against ISO 25010, considering functionality, usability, efficiency, compatibility, maintainability, reliability, and portability.

The Input-Process-Output (IPO) model is a widely used approach in systems analysis and software engineering for describing the structure of an information-processing program or other process [6]. Fig. 1 presents the conceptual framework of the Grainbot: Smartphone-Controlled Rice Grain Collector Robot.

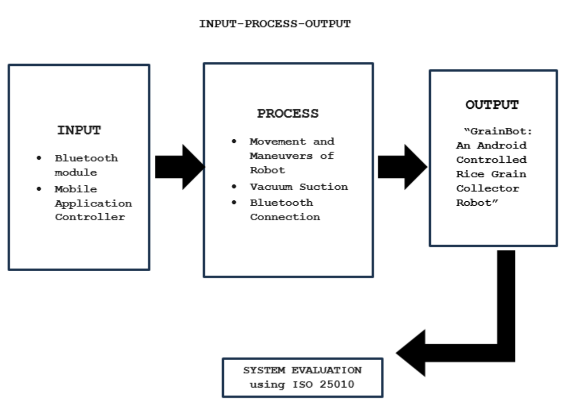

Fig. 1 The Conceptual Framework of GrainBot: Smartphone-Controlled Rice Grain Collector Robot

The system initiates with the Input stage as shown in Figure 1, in which a Bluetooth module provides a wireless connection for the mobile application to connect to the Hardware, a Mobile application controller that allows the user to control the movement of the Robot. In the Process, a smartphone sends wireless control commands to the Hardware via a Bluetooth Module, using an Arduino Uno to control the robot's movement and the function for collecting rice grains. The Output is the GrainBot: an Android-controlled rice grain-collecting robot. In System Evaluation, researchers use ISO 25010 to evaluate functionality, performance, compatibility, usability, reliability, maintainability, and portability.

A smartphone-controlled rice grain-collecting robot for collecting dried grains. The robot has two wheels and a collection mechanism, a suction vacuum, which is for collecting at a drying mat, while an application would provide wireless control, allowing the users to control the movement of the robot. This application and robot development has the potential to revolutionize the way farmers or laborers do the sun-drying procedure. This reduces manual labor for farmers, eases physical strain on employees, and improves health and well-being by mitigating labor costs and the physically taxing nature of grain collection. The goal of this study is to maximize the effectiveness of the post-drying gathering procedure during the collection phase. A robot prototype equipped with a collection-suction vacuum to gather grains from the sun-drying surface will be designed and tested as part of the project.

We present a review of the prior art, which provides additional insights and a clearer understanding of the research objectives. Dale et al. [7]developed a vacuum grain collector, bagging and weighing machine to improve efficiency and cost-effectiveness in grain collection. The machine employs a mechanical system with gears, eliminating the need for external power sources such as electricity. This system enables efficient grain collection, paddy stacking, and cleaning, thereby enhancing overall efficiency in agricultural fields and mills. The study presents a novel mechanical solution for automating rice harvesting. We developed a vacuum-powered grain collector and weighing machine that operate on a sprocket-wheel system, making them independent of external power sources. This approach offers a sustainable and cost-effective alternative to traditional labor-intensive methods. Unlike robotic systems that may require complex smartphone controls, this design utilizes a simple vacuum system for efficient grain collection, streamlining the harvesting process and increasing overall productivity.

Mahanavar et al [8] developed a manual grain-collector and bagging equipment for collecting dried paddy grains from concrete pavements. The machine uses handwheels and local manufacturing technologies to move grains horizontally and upward, pushing them into a dustpan during bagging. The design improved collection capacity, noise level, efficiency, air velocity, and cracked grain percentage. In their study, a manually controlled device for effectively gathering dried paddy grains from concrete surfaces is shown. The collected grains can be easily transported using the machine's handwheel, which can move both vertically and horizontally. The collected grains are transferred from the machine onto a dustpan and then poured into an open bag during bagging. In contrast to automated systems that frequently employ vacuum technology and smartphone control for grain collection, this machine is operated manually, providing farmers with a more straightforward and convenient option.

Santosh and Sunilkumara [9] developed and evaluated a manual grain collector and bagger for collecting and packing dried paddy grains on concrete surfaces. The device comprises a frame, a wheel, a long pipe, a collector, a vertical stand frame, horizontal bars, and a bag. The design was developed through calculations, estimations, construction, testing, and evaluation. We found significant differences in air speed, noise level, capacity, collection efficiency, and cracked grain percentage during testing.

Their study focuses on the development of a manual grain collector and bagger designed to efficiently collect dried paddy grains from concrete surfaces. The device, classified as farm machinery, comprises a frame, a wheel, a long pipe, a collector, a vertical stand frame, horizontal bars, and a bag. The manual system differs from smartphone-controlled rice grain spreader and collector robots in several key aspects. While both use wheels for locomotion, robot systems often incorporate vacuum technology for grain collection and are controlled via an Android application installed on a smartphone. The manual device, however, relies on physical labor for grain collection, offering a simpler and more accessible solution for farmers.

Kumar et al. [10] developed an automated system for seedling and irrigation in agriculture, aiming to reduce labor costs and improve efficiency. The system uses Arduino MEGA and Arduino UNO as core control units, with obstacle-detection and soil-moisture sensors. It includes a seeding funnel and field moisture sensors for irrigation, enhancing overall efficiency in agricultural practices. An automated method for agricultural irrigation and seeding is presented in their paper. In addition to sensors for obstacle detection and soil moisture monitoring, we used an Arduino Mega and an Arduino Uno as the central control units. A robot with a sowing funnel and field moisture sensors for watering is part of the system. The use of an Arduino Uno, which streamlines hardware and software development and improves system usability, is a significant distinction between this system and smartphone-controlled rice grain spreader and collection robots.

Vijaykumar et al. [11] developed an Arduino-controlled agribot for agricultural tasks such as watering, seeding, and plowing. The robot measures soil moisture using a moisture sensor and employs ultrasonic localization to navigate between farming strips. The goal is to increase farming productivity, reduce costs, and boost earnings.

We developed an autonomous robot, Agribot, to perform agricultural operations such as watering, seeding, and plowing, controlled by an Arduino. We used ultrasonic detection, and the robot travels rapidly. The difference between the smartphone-controlled rice grain spreader and the collector robot is that it uses an Arduino Uno. The Arduino Uno is an open-source electronic platform based on easy-to-use hardware and software. It reads the sensor's input light and sends it to the hardware. The output activates a motor and converts it into an LED.

Afreen and Kumar [12] developed the TerraBot robot for precision agriculture, providing remote monitoring and task simplification. The device, which is managed by an Arduino Uno and features removable attachments for activities such as sowing and weeding, moves over surfaces using caterpillar tracks. It is operated wirelessly via a NodeMCU, thereby making gardening more accessible to people with physical disabilities. Researchers developed a robot called TeraBot, it used for smart farming it remotely controlled. The robot features detachable parts for tasks such as sowing and weeding, and it traverses different surfaces using caterpillar tracks. We used an Arduino Uno to control the device via a wireless controller with NodeCU; it is user-friendly for farmers. The difference between the smartphone-controlled rice grain spreader and collector robot is that the former is used in the sun-drying process of rice grains. It also includes an Arduino Uno for control and a wireless connection to a smartphone. This is also easy for farmers to use.

Xu and Huang [13] developed an agricultural picking robot based on an Arduino circuit board, featuring modules for power, control, steering, motor driving, and Bluetooth connectivity. The robot's movement, positioning, and object selection can be manually controlled via software and hardware, enabling rapid, precise, and user-friendly operations. We developed an agricultural picking robot, including its body design, picking function implementation, and effective operational control. Their system comprises an Arduino circuit board, around which modules for power, control, steering, motor driving, and Bluetooth connectivity are mounted. The difference between the smartphone-controlled rice grain spreader and collector robot, the robot collects rice using a vacuum and spreads it using a feeder. It is controlled by a smartphone via an Android application via a Bluetooth connection, which controls the hardware's movements.

Fadhael et al.[14] developed a robot for agricultural applications, which measures seed spacing to reduce water waste and assesses the need for fertilization using a soil pH sensor. It is controlled via Android Bluetooth through an HC-05 module and utilizes a Raspberry Pi 3 B+ for video streaming and object detection. We developed a robot for agricultural applications, which measures seed spacing to reduce water waste and assesses the need for fertilization using a soil sensor. The difference between the smartphone-controlled rice grain spreader and the collector robot is that the Android application, via a Bluetooth wireless connection, controls the robot's movement. The farmers will control the robot's movement via a smartphone.

Abana et al. [15] presented Rakebot, a robotic rake designed for the traditional sun-drying method used in Asia for paddy. Rakebot can be operated either automatically via pre-recorded movements or manually via a mobile app. Motors and a microcontroller drive them, and their movements are recorded on a memory card. The efficacy of Rakebot in concurrently lowering paddy moisture content during drying is confirmed by objective evaluations. We developed a rakebot. Rakebot can be operated either automatically via pre-recorded movements or manually via a mobile app. The system is driven by motors and a microcontroller, and its movements are recorded on a memory card. The difference between the smartphone-controlled rice grain spreader and collector robot is manually operated via an Android application. While it also has a microcontroller, it does not record the robot's movements.

Ghafar et al. [16] developed a cost-effective agricultural robot that can monitor crop health, apply pesticides and fertilizers, and cover fewer crops than a human worker. The two-wheeled robot, equipped with a camera, wireless controller, spraying mechanism, and mobile base, demonstrates significant labor cost savings by operating autonomously and requiring only human assistance at the start of the crop route. We developed a cost-effective agricultural robot capable of checking crop health and applying pesticides and fertilizers. Their prototype is a two-wheeled robot equipped with a camera for pest and crop monitoring, a wireless controller, a spraying mechanism, and a mobile base. Unlike the smartphone-controlled rice grain spreader and collector robot, which is designed to spread and collect sun-dried grains, this robot is used for crop health monitoring and pesticide/fertilizer application. It utilizes two wheels for movement and is wirelessly controlled via a mobile application.

Kachor et al. [17] created an Agribot, a robot intended for use in agricultural operations such as planting, sorting, and spraying pomegranate crops. An Arduino Mega board equipped with an Atmega 2560 microcontroller powers it. Their robot employs precision cultivation techniques to increase crop productivity. An Android application is being developed to monitor and manage the pump, and connectivity options include Bluetooth and GSM. We created Agribot, a robot for planting, sorting, and spraying pomegranate crops. We used an Arduino Mega board equipped with an ATmega2560 microcontroller. We used an Android app to monitor and control the pump, with connectivity via Bluetooth and GSM. The difference between the smartphone-controlled rice grain spreader and collector robot is that the robot is designed for the sun-drying process used by agricultural farmers. This robot uses Arduino Uno and a smart smartphone, and an Android application via Bluetooth.

Khuantham and Sonthitham [18] developed a spraying robot for pepper farms that is controlled via a smartphone application. encouraging the development of agricultural instruments and assisting farmers in reducing labor in agricultural production. Reduce exposure to traditional chemicals, which are highly toxic to the body. We developed a spraying robot for pepper farmers that is operated via a smartphone application, reducing labor in agricultural fields. The difference between the smartphone-controlled rice grain spreader and collector robot is that the robot is used for rice grains: it spreads them for the sun-drying process and collects them. It’s operated by an Android application via Bluetooth connection.

Rajarathnam et al. [19]developed a color-sensing robot for labor-intensive agricultural tasks, such as fruit and vegetable harvesting. The robot employs advanced color-detection technology, controls objects based on color characteristics, and is programmed in Arduino. The robot aims to streamline processes, increase productivity, minimize damage, and optimize labor resources in agriculture. We developed a color-sensing robot. Their robot used color detection to identify and control objects based on their color characteristics. Controlled through a mobile application via Bluetooth and programmed with Arduino. Unlike the smartphone-controlled rice grain spreader and collector robot, this robot is designed for a narrow range of rice-cultivation tasks. This robot is also used for sundried grains. The connection between the hardware and the software via the Android application using Bluetooth.

Kavya et al [20] developed a robotic system for agriculture, aiming to streamline tasks and reduce labor. The system can perform tasks such as plowing, seeding, soil leveling, irrigation, and crop harvesting. The Android app allows user control via Bluetooth. The paper explores the potential of autonomous vehicles in agriculture, suggesting that smaller machines could be more efficient than traditional tractors and human labor. We developed a robotic system for agriculture. Their robot performs plowing, seeding, leveling mud, spraying water, and harvesting crops. We used an Android app for user control via Bluetooth wireless connection. The difference between the smartphone-controlled rice grain spreader and collector robot is it is used for the sun-drying process for the farmers. The robot is wirelessly connected to the hardware and controlled by the smartphone application via Bluetooth.

Azmi et al. [21]designed a prototype robot for seeding agricultural fields, covering its circuit design, control algorithm, and practical implementation. Their robot features a small drilling unit to create seed pits, with drilling depth remotely adjustable via Bluetooth. A rear-mounted metal plate covers the seeds with sand as the robot advances, while a DC servomotor regulates seed feed. The control algorithm enables users to modify the seeding depth and quantity at each position as needed. Using Bluetooth, the robot communicates with a smartphone app for control, enabling various tasks.

We designed a prototype robot for seeding agricultural fields, incorporating a circuit and an algorithm. Their robot features a small drilling unit to create pits, with drilling depth remotely adjustable via Bluetooth. Unlike the smartphone-controlled rice grain spreader and collector robot, this robot is designed for two main purposes: spreading rice grains evenly across a surface, such as a drying field. Then another collects grains from the mat. But both robots can be controlled via a smartphone.

Bhuyarkar et al [22] designed a robot that can be controlled wirelessly using an Android app. Control is implemented via a Bluetooth module and an Arduino board, with the Android smartphone serving as the remote. The robot's movement is controlled by DC motors, with commands received via the Android app. We designed a robot that can be controlled wirelessly using an Android app. An Android smartphone serves as the remote control. Their robot movements are controlled by the DC motor, with the commands received from the Android app. We learned that we could use an Android application and DC motor for smartphone smartphone-controlled rice grain spreader and collector robot.

Murtaza et al. [23] developed a robot equipped with sensors, a microcontroller, and a mobile application. This robot is capable of measuring soil moisture, harvesting crops, sowing seeds, monitoring crops with a camera sensor, and navigating using GPS. The mobile application enables remote control of the robot. The tasks performed by this robotic system encompass a wide range of agricultural activities, including ploughing, soil analysis, seed sowing, crop monitoring, and harvesting. We developed a robot equipped with a sensor, a microcontroller, and a mobile application. This robot is capable of measuring soil moisture, harvesting crops, sowing seeds, monitoring crops with a camera sensor, and navigating using GPS. The mobile application enables remote control and operation of the robot. Key differences from smartphone-controlled rice grain spreader and collector robots include: 1) the use of a microcontroller, a small computer chip that facilitates a wide range of electronic functions; 2) the incorporation of sensors to collect and transmit data; and 3) the inclusion of GPS for autonomous navigation, whereas smartphone-controlled robots often lack this feature and rely on manual user control.

Gokul et al. [24] developed a trainable automatic robot to assist in the removal of unwanted weeds from agricultural fields. This robot utilizes gesture control to operate a three-axis robotic arm mounted on a rover. The rover itself is wirelessly controlled via Bluetooth. The robotic arm is trained to perform repetitive motions using a hand glove, enabling it to execute the required tasks effectively. We conducted thorough testing and evaluation of their complete setup, including the rover and the attached robotic arm, under typical environmental conditions. The research focuses on developing a trainable robotic system to assist in removing unwanted seeds from agricultural fields. The rover component of this system is wirelessly controlled via Bluetooth. The robotic arm is trained to perform repetitive motions using hand gloves, enabling it to execute the required tasks effectively. A key distinction between this system and smartphone-controlled rice grain spreader and collector robots lies in its use of a Bluetooth module to enable wireless communication between hardware and software components.

The objectives of this research are as follows:

- To build a 2-wheel-drive robot with a rice-suction function for collecting sun-dried rice.
- Developing a mobile application that controls the movement and vacuum switch of a 2WD Robot
- To evaluate the system using ISO 25010 in terms of the system's characteristics: functionality, usability, efficiency, compatibility, and maintainability. reliability, and portability

II. Materials and Methods

In this chapter, the methods used to develop the GrainBot: An Android-Controlled Rice Grain Collector Robot are presented to assess the system's usability and efficiency. It consist of (1) Project Description, which describes the system, its function and how it work; (2) Requirements Analysis, which contains different diagrams of the system; (3) Design Specification, which contains the user interface of the system; (4) Testing and Operation, which states the method used and (5) Project Evaluation, which is based in ISO 25010.

A. Project Description

The goal of this project is to develop a two-wheel-drive robot that can be controlled via an Android Application to harvest sun-dried rice grains. The robot has a vacuum system that allows it to suction sun-dried rice grains. Using a Bluetooth module and an Android application, the user can remotely control the robot's movement and vacuum-switching. The system represents a breakthrough in timesaving, labor-efficient agricultural technology.

B. Development Process

In developing the system, we used the prototyping-based model. The prototyping model is more suitable to be use in a system or software that is created based on certain requests and needs (even situations or conditions) or that are customized . Meeting activities are routine procedures that are often conducted, especially within a school agency. The meeting serves to identify a solution to the problem, reach a consensus, and make a decision.

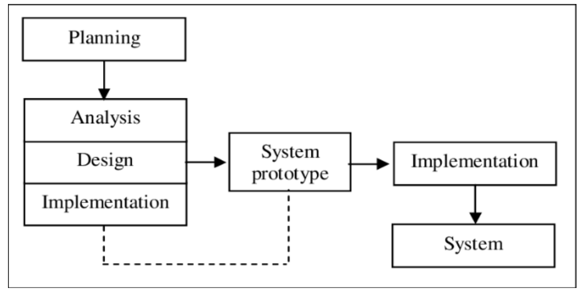

Fig. 2 The Prototyping-based Model

An initial version of the system or product is constructed, tested, and improved depending on user feedback until an acceptable prototype is achieved. This process is known as the prototyping model. To iteratively improve the prototype, developers and users collaborate throughout the process. We use a prototyping-based strategy to develop the system, beginning with the planning stage, in which we define the system's requirements and expected outcomes. We then analyze the system's potential outcomes during the analysis phase. We create the prototype model and system functionality in the design phase. Construction of the System Prototype for Testing and Implementation follows the Design phase. After the system has been tested and found to be error-free and revision-free, it moves on to project implementation, where it is made available to end users. The system prototype is then assessed against the ISO 25010 evaluation requirements during the System Evaluation Test, which follows the Implementation Phase.

C. Requirement Analysis

1) Planning:

We set the system's goal at this stage of planning: to reduce the labor required to collect sun-dried rice grains. Farmers may remotely manage rice grain collection using an Android application that controls the hardware's operation. Based on their analysis, we developed a concept for a specific type of technological innovation to enhance the standard rice grain collector. The grain collector would be controlled by an Android application.

2) Analysis:

At this stage of the project, we focused on collecting data to understand how the rice grain collector robot operates. We collected various types of information on the robot's operation, including technical specifications, operational efficiency, and user needs. This data collection was crucial to ensure that the final product would meet user requirements. Once the necessary data was gathered, we created visual representations of the information. This facilitated their interpretation of the data and enabled them to identify patterns and insights that could inform their design choices. Analyzing the data outcomes enabled us to assess the strengths and weaknesses of various aspects of the system.

With a clearer understanding of the robot's function, the team organized the development process to align with the insights gained from their data analysis. We developed a structured plan detailing each step required to build the system effectively. This plan included timelines, resource allocation, and specific goals for each phase of development.

The primary purpose of collecting this information was to develop technology to streamline the collection of sun-dried rice grains. By understanding the practical aspects and challenges of rice grain collection, we aimed to develop a robot to simplify and improve this task. The integration of smart technologies would not only enhance efficiency but also reduce the manual labor required for rice harvesting.

3) Design

During the System Design Phase, we focus on defining the system's key features, expected outcomes, and visual design. This involves deciding how the system will work, what it will achieve, and how users will interact with it. To structure the system's design, we employ the Unified Modeling Language, or UML. This language helps to visualize and organize the design process effectively. The UML encompasses several important diagrams. An Activity Diagram illustrates the system's workflow. It shows the various actions and their order of occurrence. A Use Case Diagram highlights the interactions between users and the system and defines the specific tasks the system should perform. A Sequence Diagram depicts the sequence of messages exchanged among system components. This helps clarify how components communicate with one another. The Deployment Diagram outlines how the system will be set up in a physical environment. It provides a clear view of the locations of the different components.

Additionally, a block diagram provides a high-level overview of the system's major components and their relationships. It is useful for understanding the overall structure. Finally, a Graphical User Interface Diagram depicts the system's interface. This diagram is crucial for designing a user-friendly experience. Together, these UML diagrams provide a comprehensive framework for the system's design, ensuring that all functionality, outcomes, and visual elements are well-defined and interconnected.

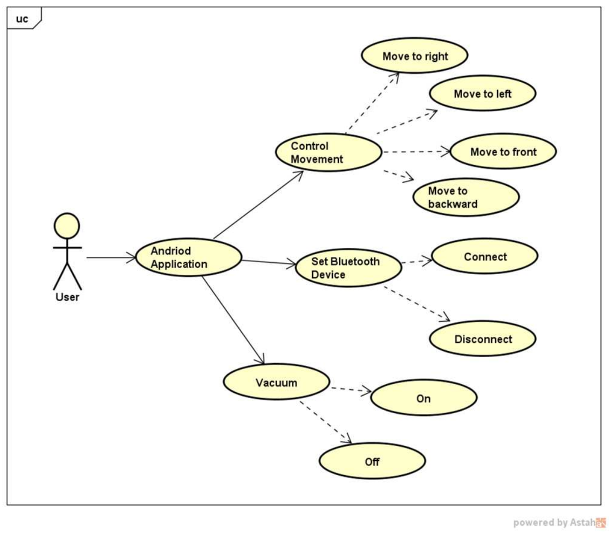

Fig. 3 Use case diagram of the user and smartphone-controlled rice grain collector robot

Figure 3 shows the case diagram of the Android app controller rice grain collector robot. It includes Bluetooth buttons for connecting to and disabling a Bluetooth device. The machine will move in all directions—left, right, forward, and backward—under the control of the Android app. Furthermore, the Android app will manage the vacuum's features, such as turning it on and off.

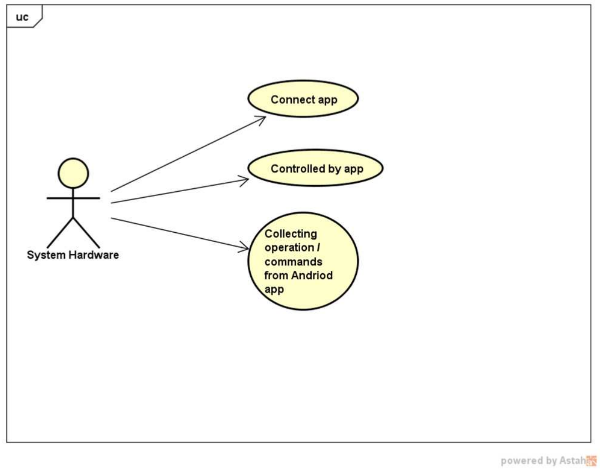

Fig. 4 Use Case Diagram of the System of GraintBot: Smart Phone Controlled Rice Grain Collector Robot

Figure 4 shows the use case diagram of GrainBot: Smartphone Controlled Rice Grain Collector. Through a Bluetooth connection, the Android app will establish a link with the system hardware, enabling it to accept orders and commands from the Android app and execute them on the system. There are four directions the system can move: left, right, forward, and backward. Pressing the on/off button in the Android app activates the suction-generating vacuum.

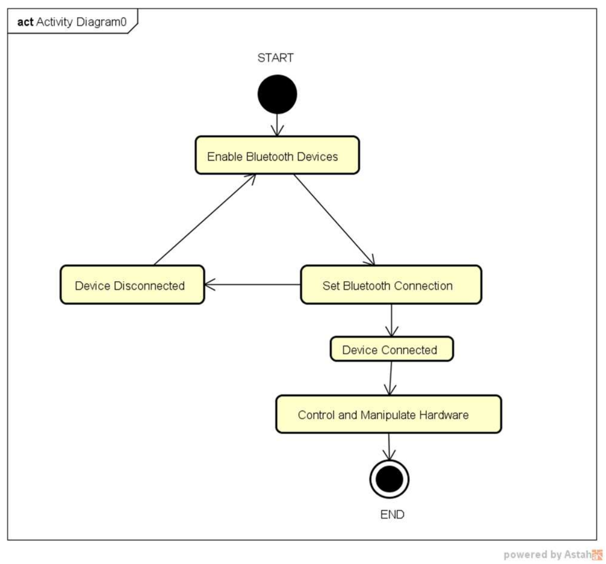

Fig. 5 Android Application Activity Diagram

Figure 5 shows the Android Application Activity Diagram of the System. The application must enable Bluetooth and configure the Bluetooth device to connect to the hardware for the system to function effectively. The user can now control and modify the device's movement and functionality once the application is connected to the hardware.

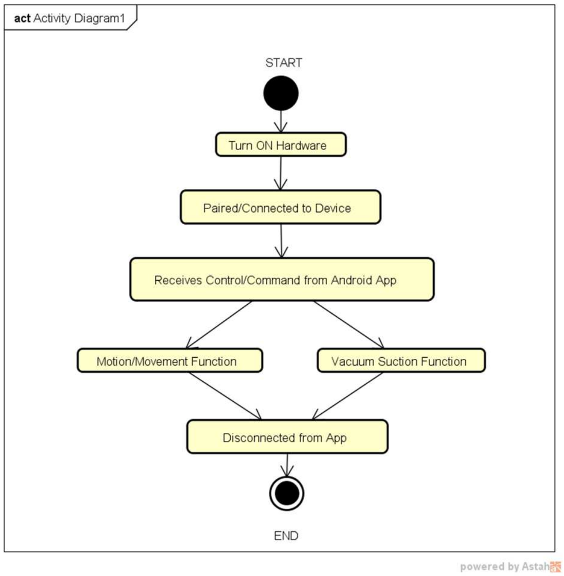

Fig. 6 Activity Diagram of the System Hardware

Figure 6 shows the Activity Diagram of the System Hardware. The hardware must be turned ON to enable the Bluetooth module. Then the Application must pair the Hardware's Bluetooth device. Once connected, the app can control the hardware's functionality and motion by sending commands to the Bluetooth module, which the main microcontroller interprets.

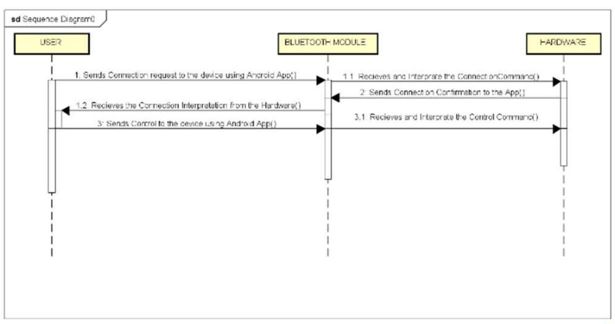

Fig. 7 Sequence Diagram of the System

Figure 7 shows the Sequence of the Rice grain collector robot system. The user sends a connection request to the hardware via an Android application over Bluetooth. The Hardware receives the connection request and automatically connects to the Devices. Once the Device is connected, the user can control the Hardware by pressing the button in the Android Application to enable movement and vacuum suction. The commands are sent to the Bluetooth module and interpreted by the System's main microcontroller.

Figure 8 depicts the system deployment diagram. To manage and operate the system's various operations, a user interacts with an Android app that communicates wirelessly via a Bluetooth module. The Arduino microcontroller then receives and executes user commands.

Figure 9 shows the Circuit Diagram Connection of the System Hardware. The hardware circuit diagram for the system is displayed in the figure. where the switch is attached to the positive terminal line to turn the components ON and OFF, and the power source is a 12v DC rechargeable battery. A 12v DC battery powers the Arduino R3, voltmeter, cooling fan, DC Buck inverter, and 7A 160W motor driver module. While the cooling fan cools the components to prevent overheating, the voltmeter measures the battery voltage. To supply the Arduino Uno with appropriate current and voltage, the DC Buck inverter reduces the battery's voltage and current. The switch that turns the Vacuum on and off is the relay module. To send and receive command signals from Android phones, the Arduino Uno's RX and TX digital pins are also connected to the Bluetooth module. While the power is directly connected to the DC battery to provide the required voltage and current to operate the DC motors, the Motor Driver Module Input Pins are connected to the Arduino Uno to send a command signal that reverses the DC motors.

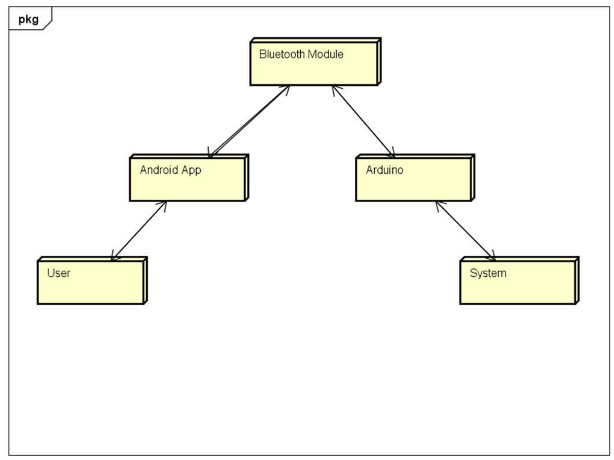

Fig. 8 Deployment Diagram of the System

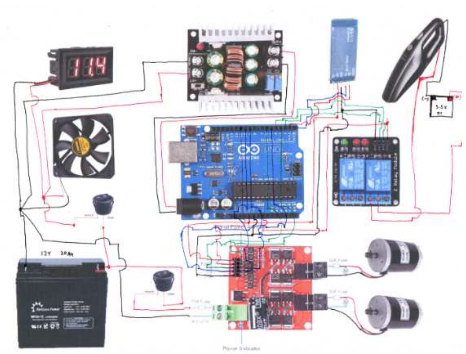

Fig. 9 Circuit Diagram of the System Hardware

Fig. 10 Graphical User Interface (GUI)

Figure 10 shows the GUI of the rice grain vacuum controller robot. The Interface displays three clickable Bluetooth icons: Enable Bluetooth to turn on the device's Bluetooth; Bluetooth Connect to send a connection request to the hardware; and Bluetooth Disable to disconnect and turn off the Bluetooth connection. It also has four arrow buttons for maneuver control, enabling the hardware to move forward, backward, left, and right. Vacuum button to turn the hardware's vacuum suction on or off.

4) Implementation:

Implementation refers to the series of actions needed to launch a program successfully. This process begins with gaining support and acceptance from those involved. It is crucial to ensure that all stakeholders understand the program's purpose and potential benefits. Implementation involves the activities of putting the program into place, from gaining acceptance to making revisions when it is not working as planned. In summary, implementation is not just about starting a program. It is an ongoing process that includes securing support, implementing the plan, and making necessary revisions based on feedback and results.

5) Testing and Operation:

Before deploying the system hardware, we conducted extensive testing to ensure optimal performance and reliability. To ensure the system functions as intended, it is extensively tested during this phase. Test plans are developed, user acceptance tests are conducted, and any system flaws are remedied. One step in identifying the application's flaws and mistakes is testing. These errors may occur at the system or unit level. You can avoid bugs that may harm your application by employing multiple testing phases.

6) Project evaluation:

The system was evaluated in accordance with the International Organization for Standardization (ISO) 25010 standard. ISO/IEC 25010 is a widely recognized international standard that provides a framework for evaluating the quality of software products. It defines a set of quality characteristics, such as functional suitability, performance efficiency, usability, security, reliability, maintainability, portability, compatibility, and accessibility. The smartphone-controlled rice grain-collecting robot was evaluated in accordance with ISO 25010. The study's evaluators were 30 randomly selected individuals composed of ten (10) farmers, ten (10) IT experts, and ten (10) agriculturists. The data were collected using valid and reliable survey questionnaires. The system was evaluated using a 5-point scale, such as 5 Excellent, 4 Very Good, 3 Good, 2 Fair, and 1 Poor.

III. Results and Discussion

This chapter presents and discusses the "Grainbot," an Android-controlled rice-grain-collecting robot. The system was designed to develop an Android-controlled robot collector capable of collecting rice grains, controlled via a mobile application via Bluetooth. The grainbot includes hardware with a rechargeable battery to power the system, a buck inverter to reduce current to the components' required levels, and protection against damage. It also includes a programmable microcontroller that controls the motor driver module, which powers the DC motors attached to the wheels, thereby controlling the robot's movement. Additionally, it includes a voltmeter to measure voltage and a relay module to turn the hoover on and off. The system software includes a feature that enables Bluetooth connectivity, allowing the Android app to connect to and disconnect from the system hardware. It features a button switch for hoover control and a button for movement control.

A. Objective 1

The primary goal of this project was to develop a two-wheel-drive robot equipped with a rice-suction function to gather sun-dried rice. This would enable rice farmers to use technological innovations to efficiently collect sun-dried rice.

Fig. 11 Vacuum Suction and two-wheel drive feature of a Rice Grain Collecting Robot

B. Objective 2

The second objective of the study is to develop a mobile application that controls the 2WD robot's movement and vacuum switch via a Bluetooth connection. Figure 12 below shows the Android Application Controller of the system.

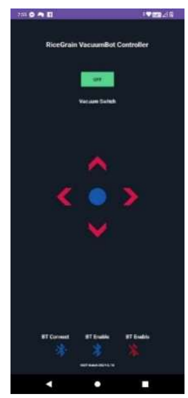

Fig. 12 Mobile Application Design of the GrainBot: An Android-Controlled Rice Grain Collector Robot

Fig. 13 Hardware of the GrainBot: An Android-Controlled Rice Grain Collector Robot

This software includes buttons to enable Bluetooth on the Android phone, connect to the Rice Grain Collecting Robot's Bluetooth device, and disable Bluetooth to disconnect the Android phone from the system hardware. The Rice Grain Collecting Robot is controlled by four arrow buttons on the Android application.

C. *Objective 3*

1) *System Performance in Terms of Functionality:*

A set of characteristics that depends on the presence of a set of functions and their designated characteristics is called functionality. These are the functions that meet explicit or implicit needs. The system's functionality is presented in Table I. Based on assessments by farmers, agricultural specialists, and IT specialists, the system received a grand mean of 4.61, indicating an Excellent rating. Farmers, Experts, and IT Experts awarded the system the highest mean score of 4.82 for Suitability among the three functionalities.

TABLE I
RESULT OF THE FUNCTIONALITY OF THE SYSTEM

Functionality Sub-Characteristics	Farmers Mean	Agri-Experts Mean	IT Experts Mean	Grand Mean Description
Suitability	4.8	4.67	4.8	4.75 Excellent
Accurateness	4.87	4.5	4.6	4.66 Excellent
Interoperability	4.8	4.00	4.4	4.44 Very Good
TOTAL Mean	4.82	4.39	4.6	4.61 Excellent

Table 1 presents the system's functionality; it received a grand mean of 4.61 (excellent) based on evaluations by farmers, agricultural experts, and IT experts. Across the four functional areas, the system achieved the highest mean accuracy of 4.87 among farmers. At the same time, the lowest rating the system received was 4.00 for interoperability from agricultural experts.

2) *System Performance in Terms of Reliability:*

Table 2 indicates that farmers (4.8), agricultural experts (4.5), and IT experts (4.4) all rated the system very good for dependability. The outcome demonstrated the system's reliability as a tool, particularly in its functionality, usefulness, maintainability, efficiency, and portability.

TABLE II
RESULT OF THE RELIABILITY OF THE SYSTEM

Reliability Sub-Characteristics	Farmers Mean	Agri-Experts Mean	IT Experts Mean	Grand Mean Description
Compatibility	4.73	4.33	4.2	4.42 Very Good
Operability	4.87	4.67	4.6	4.71 Excellent
TOTAL Mean	4.8	4.5	4.4	4.56 Excellent

3) *System Performance in Terms of Usability:*

Farmers, agricultural experts, and IT specialists evaluated the system and found it useful for controlling the mobile application. The outcome demonstrated that the robot's rice-grain harvesting met the user's requirements.

TABLE III
RESULT OF THE USABILITY OF THE SYSTEM

Usability Sub-Characteristics	Farmers Mean	Agri-Experts Mean	IT-Experts Mean	Grand Mean Description
Understandability	4.87	4.67	4.6	4.71 Excellent
Operability	4.87	4.33	4.6	4.6 Excellent
TOTAL MEAN	4.87	4.5	4.6	4.66 Excellent

4) *System Performance in Terms of Maintainability:*

The results of the system's maintainability are displayed in Table 4. With a mean rating of 4.51, the system received positive evaluations from farmers, agricultural experts, and IT specialists. Based on the evaluation rating, the outcome demonstrated that the system is maintainable. Errors in the system's software and hardware can be upgraded and changed to suit the farmers' desired system functionality.

TABLE IV
RESULT OF THE MAINTAINABILITY OF THE SYSTEM

Maintainability Sub-Characteristics	Farmers Mean	Agri-Experts Mean	IT-Experts Mean	Grand Mean Description
Stability	4.73	4.33	4.5	4.52 Very Good
Analyzability	4.8	4.67	4.5	4.66 Very Good
Changeability	4.8	4.00	4.75	4.51 Very Good
TOTAL Mean	4.77	4.33	4.58	4.56 Very Good

5) *System Performance in terms of Efficiency:*

The system's efficiency is displayed in Table 5. With an overall grand mean of 4.61, the system was rated excellent. The system produces as much as possible while minimizing lost time in gathering sun-dried rice.

TABLE V
RESULT OF THE EFFICIENCY OF THE SYSTEM

Efficiency Sub-Characteristics	Farmers Mean	Agri Experts Mean	IT-Expert s Mean	Grand Mean Description
Scalability	4.86	4.33	4.6	4.59 Excellent
Reliability	4.86	4.66	4.4	4.64 Excellent
TOTAL Mean	4.86	4.49	4.5	4.61 Excellent

6) *System Performance in Terms of Portability:*

The outcome of system portability is displayed in Table 6. Overall, the system received high ratings of 4.84 from farmers, 4.55 from agriculture professionals, and 4.73 from IT specialists. Because the user can simply use the app after connecting it to the system, the results indicate that the system is compatible.

TABLE VI
RESULT OF THE PORTABILITY OF THE SYSTEM

Usability Sub-Characteristics	Farmers Mean	Agri-Experts Mean	IT-Experts Mean	Grand Mean Description
Adaptability	4.86	4.66	4.6	4.70 Excellent
Installability	4.8	4.66	4.8	4.75 Excellent
Compatibility	4.86	4.33	4.8	4.66 Excellent
TOTAL Mean	4.84	4.55	4.73	4.70 Excellent

7) *Overall Evaluation of the System*

The system evaluation demonstrated highly positive results, achieving the study's primary objective: developing a "GrainBot," a smartphone-controlled robot for collecting rice grains. This validated the GrainBot prototype's functionality and proved the feasibility of remotely controlling a rice-harvesting robot using an Android application. A key success factor was the farmer's ability to remotely control the robot's movement via the application, enabling field navigation without manual intervention and significantly enhancing operational efficiency. While the evaluation identified some limitations, such as occasional malfunctions, these are typical of early prototypes and provide valuable insights for future iterations, guiding improvements in robustness, reliability, and overall system stability. Despite these minor setbacks, the successful demonstration of remote control capabilities and the overall positive evaluation underscore the GrainBot's significant potential to revolutionize rice farming by increasing productivity, reducing labor costs, and minimizing physical strain on farmers. Continuous refinement of the GrainBot will facilitate the widespread adoption of this innovative technology, thereby increasing efficiency and improving farmers' livelihoods.

TABLE VI
OVERALL RESULT OF THE SYSTEM EVALUATION

Characteristics	Farmers Mean	Agri-Experts Mean	IT-Experts Mean	Grand Mean Description
Functionality	4.82	4.39	4.5	4.61 Excellent
Reliability	4.8	4.5	4.4	4.56 Excellent
Usability	4.87	4.5	4.6	4.66 Excellent
Maintainability	4.77	4.33	4.58	4.56 Excellent
Efficiency	4.86	4.49	4.5	4.61 Excellent
Portability	4.84	4.55	4.73	4.70 Excellent
TOTAL Mean	4.83	4.46	4.55	4.61 Excellent

This study aimed to develop a GrainBot: a Smartphone-Controlled Rice Grain-Collecting Robot. Specifically, 1. To build a 2wheel drive robot with rice suction function for collecting dried rice. 2. To create a mobile application that controls the movement and vacuum switch of 2WD Robot. 3. To develop a system that has a programmable microcontroller powered by a Rechargeable Battery. 4.To evaluate the system using ISO 25010 in terms of functionality, usability, efficiency, compatibility, maintainability, reliability, and portability.

To design the software for this system, we employed a prototype model. The ISO 25010 standard quality model was used to assess the system's quality. Functionality (how well the system accomplishes its intended purpose), reliability (ability to function as expected under specified conditions), usability (ease of use and learning for users), maintainability (ease of modifying or fixing the system), efficiency (resource utilisation), and portability (ease of adapting the system to different environments) are the six main characteristics evaluated by this thorough framework. This rigorous evaluation approach ensured a complete assessment of the system's overall quality and identified areas for improvement.

The system was evaluated by 40 respondents, comprising farmers, agricultural experts, and IT specialists. The system achieved a grand mean score of 4.61, which is interpreted as "excellent" based on the evaluation criteria, indicating high levels of user satisfaction and system effectiveness.

IV. CONCLUSION

We conclude that the system has effectively achieved its goals, producing a hardware and software solution that is both efficient and easy to use. This solution offers farmers an intuitive and convenient approach for managing the movement of the robot used in gathering sun-dried rice using an Android Application in an Android Phone. (The research team confidently concluded that the developed system had successfully fulfilled its precise design parameters. Completing this required specialized hardware and software designed to operate efficiently with the complex process of collecting rice that was laid out to dry in the sun. The solution directly addresses most of the issues encountered in traditional sun-drying, providing farmers with a rapid, technological approach to the drying process. To this end, an Android-based application acts as the main control station, enabling farmers to remotely direct the movements of a purpose-built robotic unit. The robot tiptoes to the edge of the drying mats to carefully pick up the sun-dried rice grains. This system is no longer ideal for conventional techniques, as it minimizes manual effort while maximizing the efficiency of the collection process. We noted that the system was specifically designed to be friendly to farmers, who can use their Android smartphones to track and make changes to the robot on the go, so that we can all-important task of collecting on the sun-dried rice.)

We recommend upgrading this system by incorporating features such as automated spreading of sun-dried rice on the drying mat, obstacle-avoidance capabilities to enhance safety and navigation, increased storage capacity for collected dried rice, and a conversion to four-wheel drive to improve power and load-carrying capacity. These enhancements would significantly improve the system's functionality and broaden its applicability in real-world farming scenarios. The system can be further improved by maximizing the spread of sun-dried rice on the drying mat; implementing obstacle avoidance to enhance safety and navigation; increasing the volume of collected dried rice; and upgrading to a four-wheel-drive system to improve power and carrying capacity. These enhancements would significantly improve the system's functionality and broaden its applicability in real-world farming scenarios. We argue that the current system should be updated to serve as a one-stop agricultural solution. We deliver rice automatically by spreading it to ensure uniform sun-drying and to achieve high grain quality. Your training also demonstrates advanced obstacle avoidance to ensure safe ground under varying field conditions. Increasing the onboard storage capacity for harvested dried rice is important for reducing downtime and improving efficiency. A four-wheel-drive system would enhance power and load-carrying capacity, enabling passage through rugged terrain and improving productivity. These upgrades are designed to move the grid from just a specialized collection device to a general-purpose tool, increasing productivity and lowering labor costs.

REFERENCES

[1] H. Kidane, I. Farkas, and J. Buzás, "Characterizing agricultural product drying in solar systems using thin-layer drying models: Comprehensive review," *Discov. Food*, vol. 5, no. 1, p. 84, Mar. 2025, doi: 10.1007/s44187-025-00362-1.

[2] M. Galvez, "Filipino farmers vulnerable to heat stroke," *Philippine Star*, Mar. 18, 2016. [Online]. Available: https://www.philstar.com/headlines/2016/03/18/1564428/filipino-farmers-vulnerable-heat-stroke.

[3] V. Tomar, G. N. Tiwari, and B. Norton, "Solar dryers for tropical food preservation: Thermophysics of crops, systems and components," *Sol.*

Energy, vol. 154, pp. 2–13, Sep. 2017, doi:10.1016/j.solener.2017.05.066.

[4] T. F. N. Thoruwa, J. E. Smith, A. D. Grant, and C. M. Johnstone, "Developments in solar drying using forced ventilation and solar regenerated desiccant materials," *Renew. Energy*, vol. 9, no. 1-4, pp. 686–689, Sep. 1996, doi: 10.1016/0960-1481(96)88378-9.

[5] J. Mumba, "Development of a photovoltaic powered forced circulation grain dryer for use in the tropics," *Renew. Energy*, vol. 6, no. 7, pp. 855–862, Oct. 1995, doi: 10.1016/0960-1481(94)00088-N.

[6] K. L. Busbee and D. Braunschweig, *Programming Fundamentals: A Modular Structured Approach*. Rebus Community, 2018.

[7] M. S. Dale *et al.*, "Vacuum grain collector bagging and weighing machine," *Int. J. Innov. Eng. Res. Technol.*, vol. 8, no. 7, pp. 298–301, 2021.

[8] S. Mahanavar, R. Sonwane, and S. M. Pise, "Development of the grain collecting trolley," *Int. J. Eng. Res. Technol.*, vol. 9, no. 5, pp. 123–127, 2020.

[9] M. B. Santosh and H. Sunilkumara, "Design and fabrication of grain collector," *Int. J. Eng. Res. Technol.*, vol. 7, no. 7, pp. 1–5, 2019.

[10] A. Kumar and H. Rajagopal, "Automated seeding and irrigation system using Arduino," *J. Robot. Netw. Artif. Life*, vol. 8, no. 4, pp. 259–262, 2022, doi: 10.2991/jrnal.k.211108.006.

[11] G. Vijaykumar *et al.*, "Automatic Arduino controlled agribot for multi-purpose cultivation," in *Proc. Int. Conf. Adv. Res. Innov. (ICARI)*, New Delhi, India, 2020, doi: 10.2139/ssrn.3643592.

[12] S. Afreen and M. Kumar, "Multi-terrain backyard farming manually controlled Arduino bot," in *Proc. IEEE Int. Conf. Mach. Learn. Appl. Netw. Technol. (ICMLANT)*, San Salvador, El Salvador, Dec. 2020, pp. 1–6, doi: 10.1109/icmlant50963.2020.9355705.

[13] Y. Xu and Z. Huang, "Design of an agricultural picking robot based on Arduino," in *Proc. Asia Conf. Algorithms, Comput. Mach. Learn. (CACML)*, Hangzhou, China, Jan. 2022, pp. 305–309, doi:10.1109/CACML55074.2022.00058.

[14] T. Fadhaeel *et al.*, "Design and development an agriculture robot for seed sowing, water spray and fertigation," in *Proc. Int. Conf. Comput. Intell. Sustain. Eng. Solutions (CISES)*, Greater Noida, India, May 2022, pp. 148–153, doi: 10.1109/cises54857.2022.9844341.

[15] E. Abana *et al.*, "Rakebot: A robotic rake for mixing paddy in sun drying," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 14, no. 3, pp. 1165–1170, 2019, doi: 10.11591/ijeecs.v14.i3.pp1165-1170.

[16] A. S. A. Ghafar *et al.*, "Design and development of a robot for spraying fertilizers and pesticides for agriculture," *Mater. Today: Proc.*, vol. 81, pp. 242–248, 2023, doi: 10.1016/j.matpr.2021.03.174.

[17] A. Y. Kachor and K. Ghodinde, "Design of microcontroller based agribot for fertigation and plantation," in *Proc. Int. Conf. Intell. Comput. Control Syst. (ICCS)*, Madurai, India, May 2019, pp. 1215–1219, doi: 10.1109/iccs45141.2019.9065768.

[18] C. Khuantham and A. Sonthitham, "Spraying robot controlled by application smartphone for pepper farm," in *Proc. Int. Conf. Power, Energy Innov. (ICPEI)*, Nakhon Ratchasima, Thailand, Oct. 2020, pp. 225–228, doi: 10.1109/icpei49860.2020.9431544.

[19] R. Rajarathnam *et al.*, "Smart agri bot for multi-crop harvesting," *Int. Res. J. Adv. Eng. Hub*, vol. 2, no. 3, pp. 596–602, Mar. 2024, doi:10.47392/irjaeh.2024.0086.

[20] K. A. P. *et al.*, "Android operated mobile robot for agriculture purpose," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 10, no. 6, pp. 3142–3145, Jun. 2022, doi: 10.22214/ijraset.2022.44446.

[21] H. N. Azmi *et al.*, "Design and fabrication of an agricultural robot for crop seeding," *Mater. Today: Proc.*, vol. 81, pp. 283–289, 2023, doi:10.1016/j.matpr.2021.03.191.

[22] S. Bhuyarkar *et al.*, "Design and implementation mobile control robot," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 10, no. 4, pp. 1487–1490, 2022, doi: 10.22214/ijraset.2022.41487.

[23] I. Murtaza *et al.*, "Design and development of a multifunctional robotic system for enhanced farm management," in *Proc. Int. Conf. Emerging Technol. Electron., Comput., Commun. (ICETECC)*, Hyderabad, India, Apr. 2025, pp. 1–5, doi:10.1109/icetecc65365.2025.11070308.

[24] S. Gokul *et al.*, "Gesture controlled wireless agricultural weeding robot," in *Proc. 5th Int. Conf. Adv. Comput. Commun. Syst. (ICACCS)*, Coimbatore, India, Mar. 2019, pp. 926–929, doi:10.1109/icaccs.2019.8728429.