KRISHIMITRA: USING IOT FOR DIRECT FARM-TO-CONSUMER SALES WITH QUALITY-BASED PRICING AND MARKET API

A PROJECT REPORT

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in partial fulfillment for the award of the degree of

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IN
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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

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CERTIFICATE

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **"Krishimitra : Using Iot For Direct Farm-To-Consumer Sales With Quality-Based Pricing And Market Api"** in partial fulfillment for the award of Degree of **Bachelor of Technology** in **Computer Science and Engineering**, is a record of our own investigations carried under the guidance of **Dr. N. Syed Siraj Ahmed, Assosiate Professor (Selection Grade), School of Information Science, Presidency University, Bengaluru.**

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ABSTRACT

Some of the problems that the agricultural supply chain suffers from include inefficiency in distribution, price volatility, and huge loss in quality due to inadequate storage and handling. Models of traditional commerce in agriculture usually involve the services of intermediaries, thus decreasing the profitability of the farmers while compromising the freshness and quality of the produce to be served to the consumer. The KrishiMitra project proposes an IoT-enabled platform that would allow farm-to-consumer direct sales through real-time collection of data and dynamic quality-based pricing.

The heart of the KrishiMitra system is integrating several IoT sensors that continuously monitor the quality and condition of the agricultural produce being stored and transported, namely, MQ-135 gas sensor, TCS3200 color sensor, and capacitive moisture sensor.

The sensor types here measure parameters, such as gas emissions that indicate spoilage, color variations related to maturity of a product, and moisture content that will influence shelf life. Real-time data collected from these sensors are collected and processed within a centralized platform that changes the price of products according to the quality of produce as well as market conditions.

Thereby, KrishiMitra system connects a market API that fetches updated real time market price updates for particular kinds of crops and produce sold today. Verified sources by it might be a local agricultural market and government boards regarding price from all, fetch reliable and up to date values for the farmer.

It integrates the market API, and so the farmers do not have to depend on middlemen to decide on the fair price. This will allow the farmers to make a better decision to provide high-quality produce to the consumers at the right price as per the market trend.

KrishiMitra is an intermediary-free platform, where farmers can sell directly to the consumers. This implies that the farmer gets a bigger share of the sale price, and the consumer gets fresh quality produce at fair prices. As for price transparency, the quality assessment is real-time, and the farmer can adjust his or her pricing models accordingly.

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CHAPTER-1
INTRODUCTION

1.1 General Overview

In this section, provide an in-depth discussion of the agricultural sector's challenges, particularly in the supply chain. Highlight how middlemen, price fluctuation, and quality degradation effect both farmers and consumers. Introduce KrishiMitra as the solution to these problems, explaining the importance of leveraging IoT (Internet of Things) technologies to streamline the sales process and ensure quality-based pricing.

Table 1.1 Challenges in the Agricultural Supply Chain

Sl. No.	Challenges in the Agricultural Supply Chain	Impact
1	Middlemen in the supply chain	Reduces farmer profitability, adds cost
2	Lack of real-time quality monitoring	Quality degradation, lower consumer trust
3	Price volatility	Unfair pricing for farmers, inconsistent income
4	Waste and spoilage	Significant loss in revenue due to poor storage and handling

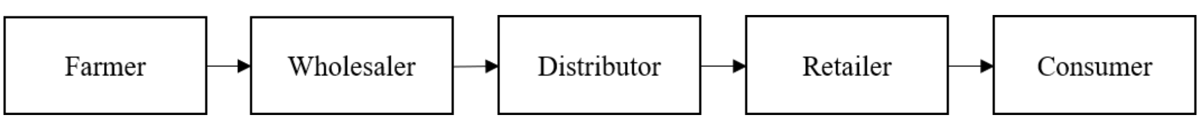


Figure 1.1.1 Traditional Supply Chain with Middlemen:

1.1.1 Traditional Supply Chain:

- The farmer sells to a wholesaler, who sells to a distributor, who sells to a retailer, and finally, the consumer buys from the retailer.
- At each stage, costs increase due to the involvement of middlemen, and the quality of the product may degrade due to longer storage and transport times.

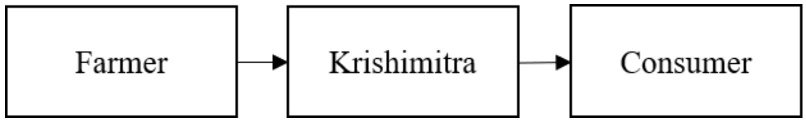


Figure 1.1.2 Direct Farm-to-Consumer Model

1.1.2 Direct Farm-to-Consumer Model:

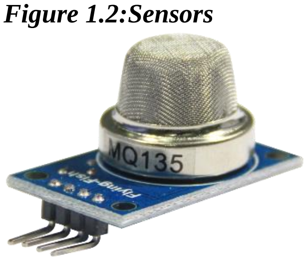
- In this model, the farmer sells directly to consumers via the KrishiMitra platform.
- Prices are real-time and dynamic based on quality (monitored by IoT sensors), and the produce remains fresher, reaching consumers with minimal intermediaries

Objective	Expected Outcome
Direct farmer-to-consumer sales	Increased farmer profit margins, no middlemen involvement
Real-time dynamic pricing	Prices fluctuate based on quality and market demand, benefiting both farmer and consumer
IoT-driven quality control	Improved product quality and reduced spoilage, ensuring higher customer satisfaction
Sustainability and waste reduction	Reduction in agricultural waste due to real-time monitoring of freshness

Table 1.2:Expected Outcome

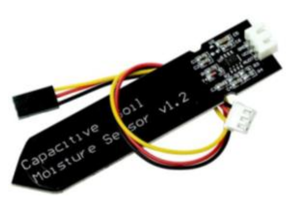
1.2 Sensors

Figure 1.2:Sensors



Gas Sensor: MQ-135

Color Sensor: TCS3200



Capacitive Moisture Sensor

1.2.1 MQ-135:

The MQ-135 gas sensor is part of the MQ series of gas sensors developed by Haojin (a subsidiary of Hanwei Electronics). It's widely used in various applications where detecting the concentration of gases is critical. Specifically, the MQ-135 is designed to detect a variety of gases, including carbon dioxide (CO_2), ammonia (NH_3), benzene (C_6H_6), and several other volatile organic compounds (VOCs) and gases that are byproducts of biological activity, such as those associated with organic material spoilage.

In the context of agricultural storage, the MQ-135 sensor is invaluable for real-time monitoring of gases that may indicate spoilage, contamination, or poor storage conditions. The sensor is most effective in environments such as grain silos, storage bins, greenhouses, and post-harvest storage areas, where early detection of spoilage can prevent major losses and enhance the quality and shelf life of the produce.

1.2.1.1 Key Features of the MQ-135 Sensor

1. **Gas Detection Range**: The MQ-135 is sensitive to a wide range of gases, including but not limited to:
    - Ammonia (NH_3)
    - Benzene (C_6H_6)
    - Carbon dioxide (CO_2)
    - Alcohol vapours
    - Nitrogen oxides (NOx)
2. **Detection Principle**: The MQ-135 operates on a **semiconductor principle**, using a **heating element** and a **sensitive layer** made of **tin dioxide (SnO_2)**. When gases like CO_2 come into contact with this layer, they alter its conductivity, which is then measured by the sensor and translated into a specific gas concentration reading.
3. **Sensitivity**: The sensor has a relatively high sensitivity to the gases it detects, especially in environments where spoilage or chemical changes are a concern. It can detect gas concentrations ranging from **10 ppm** (parts per million) up to **1000 ppm** in the case of CO_2 and other gases.
4. **Low Power Consumption**: The MQ-135 sensor is energy-efficient, making it suitable for continuous monitoring in storage systems that require long-term operation with low

power consumption.

5. **Long Lifespan**: The MQ-135 is designed to last for extended periods under normal conditions. However, its lifespan can vary depending on the gases it is exposed to, and the need for periodic calibration to maintain accuracy.

1.2.1.2 How MQ-135 Helps in KrishiMitra

In the context of agriculture, the MQ-135 sensor is most beneficial for monitoring the quality of stored produce by detecting spoilage indicators early. The key gases it can detect, such as CO_2, are important because their presence can signal:

- **Biological Activity**: As organic material like seeds or grains begin to spoil, they release gases like CO_2, ammonia, and VOCs. The MQ-135 can pick up these gases in real-time, allowing farmers or storage facility operators to identify potential spoilage before it becomes a more significant problem.
- **Microbial Growth**: Spoilage often results from microbial activity, such as fungal or bacterial growth. As these microbes break down organic material, they generate gases like CO_2 and ammonia. Detecting these gases early gives farmers an opportunity to intervene, for instance, by adjusting temperature, humidity, or ventilation to slow down the spoilage process.
- **Air Quality Monitoring**: In addition to spoilage detection, the MQ-135 can help monitor overall air quality in storage facilities. A rise in ammonia or benzene levels can indicate poor air quality or the presence of pollutants, which might negatively impact the produce and the facility environment.

1.2.1.3 Advantages of MQ-135:

1. **Early spoilage detection** through real-time gas monitoring.
2. **Improved shelf life** by maintaining optimal storage conditions.
3. **Reduced waste** by identifying spoiled produce early.
4. **Cost savings** by preventing losses and reducing the need for extra storage solutions.
5. **Sustainability** through more efficient resource use and waste management.

1.2.1.4 Limitations of MQ-135:

1. **Requires regular calibration** for accurate readings.
2. **Cross-sensitivity** to multiple gases can affect precision.
3. **Environmental factors** (temperature, humidity) can impact sensor performance.
4. **Limited specificity** in detecting certain gases in complex environments.
5. **Long-term exposure** to high concentrations of certain gases can degrade the sensor.

1.2.2 Color Sensor (TCS3200):

TCS3200 is a very versatile color sensor that detects and measures the color of objects by reflecting their light. This sensor captures the light intensity by using photodiodes in an array with color filters in red, green, blue, and clear to translate it into a digital signal representing the RGB (Red, Green, Blue) color values. The TCS3200 is used in virtually all applications that require color detection, such as sorting machines, quality control, agricultural uses, and seed color monitoring.

For agriculture application purposes, especially seed quality check-up, TCS3200 is helpful to assess the color of the seeds for maturity, freshness, or even if they fulfill any quality standards before their packaging for sale. Real-time color-based monitoring and automatic quality assurance with actionable insight for optimizing seed quality and storage conditions can be easily attained by integrating the TCS3200 with an IoT system.

1.2.2.1 Key Features of TCS3200 Color Sensor

1.RGB Color Sensing: The sensor gives frequency signals corresponding to the strength of the sensed color. The sensor comprises

- **Red, Green, Blue, and Clear Filters**: Every photodiode in the array is filtered using one of these colors for measuring the intensity of light that falls in these specific wavelengths

2.Adjustable Sensitivity: This sensor provides adjustment of gain control (amplitudes) via external components including resistors to fine tune the sensor for the purpose of using it on varied types of seeds or products undergoing testing.

3.Output Frequency: The TCS3200 outputs an output frequency proportional to the color intensity. It is very easy to interface such an output with a microcontroller like Arduino or Raspberry Pi for processing and analysis.

4.Compact and Low-Cost: The TCS3200 is small and low cost, thus ideal for being used in automated systems of agriculture in a wide variety of applications.

1.2.2.2 How TCS3200 aids Seed Color Check

Seed color in seed quality control serves as one of the vital indicators for the maturity and freshness of the seed. The sensor TCS3200 can be put into a system to measure these color changes. This is how it works:

1. Seed maturity: It is often determined by the color of the seed. For example, seeds that are green may be immature, but once they turn brown or have a dark color, then it may imply ripeness or over ripeness. The TCS3200 can measure such color changes well.

2. Freshness Monitoring: If the seeds have to be fresh and bright for plantation, then the TCS3200 can recognize slight changes in color, like the seed losing the color because of degradation of storage or spoilage. The farmers can remove such unsuitable seeds from the batch.

3.**Sorting**: The TCS3200 can be used for automatic seed sorting systems. Using this, seeds can be sorted in order of color, and then only the seeds with proper color along with quality will reach the packing stage. This is specifically required for uniformity in agricultural practices and to attain market standards.

4. **Integration with Quality Standards**: In some crops or varieties, the seeds need to satisfy color standards. Through this, the farmer will make it possible to automate quality checking so that seeds attain color-based quality parameters at the time of selling.

1.2.2.3 Benefits of TCS3200 Color Sensor

1.High Accuracy: It assures to deliver accurate and reliable color measurements so that seed quality is checked and confirmed for quality always.

2.**Cost-effective**: TCS3200 is relatively a less expensive device in the color-sensing technology and can be adopted by small and medium-sized agriculture operations more affordably.

3.**Real-Time Monitoring:** IoT integration ensures that the color of seeds is constantly and constantly monitored for any quality-related issues to be responded at an earliest.

4.**Automation**: TCS3200 can be used for developing automatic seed sorting and quality checking systems, thereby reducing human interference and increasing productivity.

5.**Quality Control**: The selection of high-quality, properly colored seeds for sale or planting ensures uniformity and success rates of crops.

1.2.2.4 Limitations of the TCS3200 Color Sensor

1.**Ambient Light:** The measurements from the TCS3200 are light dependent and may require controlled light conditions to measure its samples.

2.**Lack of Sensitivity:** While the TCS3200 may be sufficient for simple color detection, it may fall short in some applications wherein high sensitivity is required to separate colors that are very nearly similar, such as differences within subtle shades of color between quality seeds.

3.**Not sensitive to Non-Visible Light**: TCS3200 is sensitive only to visible light. This will limit it to usage in specific usage, such as UV and infrared lights, which are not detected by this color sensor.

4.**Sensitive to Surface Texture**: The readings could have slight changes due to reflections based on the seed texture and surface finish.

1.2.3 Capacitive Moisture Sensor v1.2:

Capacitive Moisture Sensor V1.2 is the type of soil moisture sensor that detects the moisture level in the soil or any organic matter using capacitive measurement. The sensor works according to the principle of capacitance, that is, the ability of a material to store an electrical charge. The sensor is comprised of a pair of electrodes that operate as a capacitor, whose dielectric constant changes with a change in moisture content. By measuring the changes in the material's dielectric constant, the sensor determines the moisture level in the material.

The Capacitive Moisture Sensor V1.2 is particularly useful in agricultural applications, where it allows monitoring of soil moisture levels so that the irrigation system could be adjusted accordingly. Unlike traditional resistive moisture sensors, this sensor is more rugged and accurate because it does not corrode or degrade over time through contact with soil.

In the context of seed quality control, moisture is a critical factor. Seeds with too much moisture are prone to mold and spoilage, while seeds that are too dry may lose viability. While the Capacitive Moisture Sensor V1.2 is not designed specifically for color detection, its role in assessing the moisture content of seeds can be integrated with color-check systems (e.g., TCS3200) to provide comprehensive monitoring of seed quality.

1.2.3.1 Key Features of the Capacitive Moisture Sensor V1.2

1. **Capacitive Measurement:** Capacitive measurement is more accurate and long-lasting than that in the resistive moisture sensor. It is also not so easily corroded from the water or soil.
2. **Wide Detection Range:** The sensor is capable of detecting a very wide range of moisture levels between 0% and 100% as the dielectric constant of the material being measured directly corresponds to the level of moisture it contains.
3. **Low Power Consumption:** The capacitive sensor is energy-efficient, hence it can be used for long-term applications like continuous soil or seed monitoring without draining the batteries.
4. **Stable and Durable**: The sensor is made of high-quality materials and is more resistant to corrosion and wear than traditional resistive moisture sensors, hence its longer lifespan.
5. **Analog Output:** The sensor produces analog output voltage relating to the moisture content within the material in which it measures. It further allows interfacing to such microcontrollers like Arduino or Raspberry Pi to carry additional processing and analysis.
6. **Easy-to-use Sensor:** This sensor has been made so as not to be challenging for integrations into IoT-based systems and into automation setups in any monitoring aspect of precision agriculture or in general monitoring situations.
7. **Flexibility:** Even though the sensor is primarily designed for soil, it can be used for the measurement of moisture in seeds, grains, and other organic materials.

1.2.3.2 How Capacitive Moisture Sensor Aids Seed Quality Control

With seed health, viability, and conditions during storage being critical indicators for its suitability for agricultural applications, the Capacitive Moisture Sensor V1.2 helps by getting accurate moisture readings for the seeds. This directly determines their ability to germinate, as well as their shelf life, all of which are integrated aspects of seed quality control:

1**. Seed Moisture Monitoring:** Seeds can become excessively moist, causing fungal growth, mold, or degradation, while seeds that are too dry may lose their germination ability. The Capacitive Moisture Sensor allows for real-time monitoring of the moisture content of seeds so that they are stored under the best conditions.

2. **Prevention of Spoilage and Mold:** The sensor can be able to detect conditions that could lead to spoilage or microbial growth by continuously measuring the moisture content in seeds, thus enabling farmers or storage managers to take appropriate corrective actions, such as adjustments in humidity or drying conditions.

3.**Optimal Seed Storage**: Proper seed storage will always demand maintaining the moisture in the range. The Capacitive Moisture Sensor gives an opportunity to monitor and control the environmental factors, which influence the seed's moisture level, and thus maintaining its conditions for optimal long-term storage.

4. **Color Monitoring Integration**: The sensor does not check the color of seeds directly, as that is a function more suitable for a color sensor such as the TCS3200. However, it can be used in conjunction with color sensors to give a better seed quality assessment. For instance:

- If it identifies high moisture, the capacitive moisture sensor can turn on the TCS3200 color sensor to analyze whether the seed color has started changing because of spoilage or fungal infection.
- Where the seeds are at a point of optimal moisture and color stability would mean quality seeds, and when the moisture content is high but colors change, there is something that has gone wrong.

1.2.3.3 Benefits of the Capacitive Moisture Sensor V1.2

1. **High Accuracy**: It ensures a reliable moisture measurement with negligible drift over time and can be very accurate in any agricultural application.

2. **Non-Corrosive**: Unlike resistive sensors, there will not be any corrosion because of water or soil, thereby resulting in a longer lifespan and a stable reading.

3. **Low Power Consumption:** The sensor is low-power-consuming; hence, it can be used in monitoring systems without overusing energy for a longer period of time.

4.**Real Time Monitoring**: Moisture in the seeds preserved can be monitored continuously by a sensor to provide real time data that can be processed to decide and intervene correctly.

5.**Integratability:** The easy interface of its analog output with micro-controllers such as Arduino and Raspberry Pi, and IoT platforms among others makes the sensor highly adoptable in most systems in agriculture.

6.**Robust and Durable**: Highly durable even if exposed to agricultural environments, so long as it is watertight or waterproof.

1.2.3.4 Limitations of the Capacitive Moisture Sensor V1.2

1. **Sensitivity to Environmental Conditions**: The readings that the sensor produces can vary with temperature and salinity change. For instance, increased salinity in the soil material under test will affect dielectric properties and thus impair the accuracy of the output readings.

2**. Requires Calibration:** Although the sensor is highly accurate, it still needs periodic calibration to keep it accurate. This applies especially if used in various environments or different types of seeds.

3. **Only moisture detection:** The sensor only has the capability to be used for moisture content and not for any other information such as seed color and viability. It must be complemented with other sensors like color sensor or germination test for a complete seed quality determination.

4.**Material-Specific Calibration:** Different seeds or organic materials may behave in different ways with moisture. The sensor may need calibrations or specific adjustment according to types of seeds, especially in those cases where moisture content and dielectric properties vary.

5.**Size and Installation**: While the sensor is relatively compact, large-scale applications of this sensor, like the monitoring of large bins or silos, may demand installing multiple sensors for total coverage, which increases the system complexity and costs.

1.3 IoT in Agriculture:

In recent years, IoT technology, or the Internet of Things, has been seen to be an innovative power of change in the agricultural world. The technology enables sensors and devices that are connected via a network that facilitates collecting, analysing, and making real-time decisions. It thus changes the nature of farming from monitoring environmental conditions to crop health and product quality to give the farmers valuable information that may well increase productivity, reduce waste, and bring more profitability into the bottom line.

The IoT sensors that have been integrated into KrishiMitra, which is a digital platform or service for farmers, make the use of innovative approaches towards sustainable and data-driven farming. It would ensure the constant monitoring of every phase in the process from seed to harvest and even post-harvest.

1.3.1 IoT Sensors in Agriculture:

IoT sensors can be deployed in agricultural environments that assist farmers to monitor and act to changes in environmental conditions, which might affect the crop health, yield, or quality. These can be used across different stages of farming, including pre-harvest, harvest, and post-harvesting for crops to grow under optimum conditions, ensure high-quality harvest produce, and ensure that storage conditions are appropriate for preservation.

1. Environmental Sensors (Temperature, Humidity, and Light)

- **Temperature and Humidity Sensors:** Such sensors assist in crop growth conditions monitoring, keeping the temperature and humidity in the field or greenhouse at optimal ranges for plant health. For example, many crops require specific temperatures and humidity, and IoT sensors can provide farmers with real-time feedback to avoid conditions that may cause crop stress or disease.
- **Light Sensors:** These measure the intensity and duration of sunlight, which directly impacts plant photosynthesis. By monitoring light levels, farmers can optimize greenhouse conditions or adjust irrigation schedules to maximize crop growth.

2.Soil Moisture Sensors (Capacitive Moisture Sensor V1.2)

- Capacitive Moisture Sensors measure the moisture content in the soil, providing critical data on irrigation needs. Moisture levels directly affect seed germination, root growth, and overall plant health. In agriculture, keeping the right amount of moisture would be essential to achieve proper crop yield. Over-watering or under-watering stresses the plants, reduces their yield, or even crop failure. By monitoring soil moisture with capacitive sensors, water resources can be used at the right time, therefore minimizing waste and optimizing crops.

3. Air Quality Sensors (MQ-135)

- The MQ-135 gas sensor tracks gases like CO_2, ammonia (NH_3), and others that can be an indicator of spoilage or degradation in stored agricultural products such as grains, fruits, and vegetables. Spoiled crops emit gases like carbon dioxide and ammonia, which the MQ-135 can detect in real-time. By monitoring air quality in storage facilities, farmers can prevent spoilage, extend the shelf life of their products, and ensure that only high-quality goods reach the market.

4. Visual Quality Sensors (TCS3200 Color Sensor)

- The TCS3200 color sensor detects the color of grains, such as rice and wheat, and fruits. Color is one of the indicators of ripeness and quality; for instance, inconsistent or off-colour grains could be a sign of fungal contamination, over-ripeness, or poor storage.

1.3.2 Dynamic Pricing Based on Quality and Real-Time Data

One of the strongest use cases for IoT in agriculture is in dynamic pricing on real-time produce quality. In effect, it can continue monitoring environmental conditions, seed quality, moisture content, and spoilage indicators that provide quality scores for the product. Quality scores can now go straight to influence the price of the products by its true value in the marketplace based on real-time assessments.

Example:

- **High-Quality Produce:** If IoT sensors confirm that the produce has been stored under optimal conditions (e.g., correct moisture levels, appropriate temperature, no spoilage gases detected, and optimal color consistency), the farmer can adjust their pricing to reflect the high quality of their crops, attracting premium prices.
- **Lower-Quality Produce:** Problems such as spoilage, moisture content imbalances, or unsatisfactory color consistency can sometimes be addressed by automatically lowering the price in relation to decreased quality. This will encourage farmers to sell the produce while losing less money due to decreased quality.

CHAPTER-2

LITERATURE SURVEY

This paper titled "Research on the Development of E-commerce Model of Agricultural Products" by Jaswanth Reddy Vulchi deals with a very evolving area of agricultural e-commerce. The significance of e-commerce in elevating the sales and circulation of agricultural products is presented with a large growth in sales and participants in such platforms as Alibaba. It analyzes a few notable e-commerce models, such as Tootoo Industrial Commune, Original Life, and Suichang Model, with the product-driven, marketing-driven, and service platform-driven e-commerce models respectively. It talks about the framework of their operations, strengths, and weaknesses on seven dimensions such as logistics, quality standards, government support, etc. The authors detect gaps in quality control, farmer engagement, and government intervention from such comparisons. They provide practical advice to farmers, e-commerce companies, and policy makers to improve the quality, availability, and governance of agricultural products in China. The paper explains that e-commerce is very viable in terms of income improvement for farmers, satisfaction of consumers' demands, and establishment of efficient supply chains.

This paper "Research on the Development of E-commerce Model of Agricultural Products" by Yaping Huo, Huiping Mu contributes to the ever-growing literature of agricultural e-commerce. While the studies mostly focus on general frameworks for e-commerce and their application in various industries, research in e-commerce models especially designed for agricultural products remains a missing link. Previous studies include Zhao Ping and Luo Yi (2011), who discuss service orientation and brand building in agricultural e-commerce. They emphasize that it is necessary to improve farmers' incomes and establish closed-loop operations from production to distribution. Luo Yi (2012) continued the discussion on the development strategies for agricultural e-commerce enterprises, including government support and supply chain integration. In the context of the product-driven approach, case studies on specific models like Tootoo Industrial Commune and Originally Life Network by Cui Jing in 2013 and Zhi Ying in 2014, respectively, have been undertaken. However, it fails to offer a comparative analysis of the multifaceted impacts of various e-commerce models and their differentiating impacts on quality control, logistics, and government policies. This paper systematically bridges those gaps by comparing and analysing three different e-commerce models from seven critical aspects- Tootoo Industrial Commune, Original Life, and Suichang Model-by thus providing holistic recommendations to the farmer, e-commerce company, and policymakers. It provides new comparative insights based on synthesized existing research for enriching the understanding of successful strategies for sustainable agricultural e-commerce growth in China.

The paper, "Key Factors in Forming an E-Marketplace: An Empirical Analysis," is focused on the enhancement of efficiency in Taiwan's floral industry based on the adoption of mechanisms of e-commerce. Its focus is on the literature survey concerning the problems of traditional wholesale markets due to low service quality and problems associated with collecting price information. It identifies the potential of e-marketplaces in enhancing trading efficiency, reducing costs, and simplifying operations for suppliers and retailers. Works done by Ratchford et al. and O'Keefe and Loebbecke have demonstrated that the Internet may have potential utility for other industries for efficient information dissemination, so do not apply virtual solutions unless and until the market preferences have been understood. The developed work applies advanced decision techniques, such as Fuzzy Delphi and Fuzzy Multiple Criteria Decision Making in the identification of critical factors which include order accuracy, processing efficiency, and collaboration of urgent orders. The insights are combined with cooperation modes like joint price negotiations and active order placement to propose an adaptive operational framework. Taking into account empirical analysis, it extends existing e-commerce study and provides actionable strategies regarding the development of an efficient online marketplace for Taiwan's floral business.

This paper, "An Intelligent IoT-Based Food Quality Monitoring Approach Using Low-Cost Sensors," discussed the advancement in the monitoring technology related to an issue concerning food safety, whereby integrating the internet of things with smart sensors ensured quality food. Previous researches have discussed the usage of IoT in different fields and its role in monitoring food systems including electronic noses, RFID-enabled packaging, and smart sensors for the detection of microbial growth or oxidation. Inexpensive sensors like MQ series and environmental units like BME680 have given an opportunity to monitor packaged food in real-time regarding temperature, humidity, gases, and pressure in vacuum-packed conditions. This paper contributes to smart packaging by utilizing LabVIEW interfaces with WSN in processing and visualizing the collected data. It differs from traditional systems that primarily depend on static food characteristics by being integrated with IoT for dynamic, non-destructive analysis of novel applications in food preservation as well as the reduction of post-harvest losses. This system of the study is validated by experimenting on onions, which has the following practical implications on food safety and usability in both domestic and commercial settings.

A Summary of Literature Review for a Paper, "How will the Internet of Things Support Augmented Personalized Health?" by Amit Sheth; Utkarshani Jaimini; Hong Yung Yip A New Revolutionary Force in healthcare - from reactive to pro-actively preventive medicine that will eventually replace traditional patterns in health care. For such, the literature bases this necessity on economic imperatives as well as social; a pressing need that presents in escalating healthcare costs plus widespread adaptation in global geographies. The IoT has enabled integration with wearable and environmental sensors, thus opening unprecedented possibilities for patient health monitoring, providing continuous collection and analysis of data, which offers personalized insights. APH is based on this foundation, utilizing AI and smart data to enable proactive health management. The studies pointed out the role of PGHD, wearable technologies, and environmental sensors in collecting rich physiological and contextual data for improved clinical decision-making. The challenges that kept on arising include data interoperability, privacy, and transformation of raw data into actionable insights. Further, Health initiatives are examples of the practical application of IoT in personalized care, thus highlighting the need for semantic data models and machine learning to realize the full potential of APH. Thus, the reviewed literature sets a clear trajectory for the role of IoT in advancing healthcare while also identifying key technological and ethical considerations.

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

Agriculture, despite the progress the sector has made, still poses many systemic problems that undermine both farm profitability and consumer satisfaction. The main cause of this failure is the inefficiencies and lack of transparency in supply chains for traditional agriculture. The following are some key issues:

3.1. Lack of Transparency

The agricultural supply chain is by nature opaque, thereby hiding much of the actual costs, quality, and pricing of products for agriculture. This can mean that price and quality information are kept from the farmers and consumers, and thereby leading to:

- **Lack of trust between the farmer and the consumer:** Consumers do not know how much produce costs while, on the other hand, farmers are usually exploited through the intermediaries capturing much value in the supply chain.
- **Price manipulation**: A lack of transparency in the price may facilitate opportunistic inflation in the price by middlemen, resulting in no compensation to the farmer for his labour and produce.

3.2 Middlemen and Unfair Pricing

Farmers are susceptible to the mercy of middlemen in a traditional supply chain who buy the produce from them at low rates and sell it at inflated prices in the market.

- **Unfair revenue share:** Due to the extensive role played by middlemen in the whole value chain of agriculture produce, the final selling price reached by farmers is rarely reached by the farmers themselves due to their small share from the sales.
- **Bargaining weakness:** Because of the direct lack of access to the markets for the farmers, their bargaining power in negotiating more favourable prices or quality regulation in the market is diminished.

3.3 Quality Regulation Issues

Traditional agricultural systems do not have in-place, real-time, standardized systems to grade the produce. This has led to:

- **Wastage and deterioration**: Since there is no system of real-time monitoring, the produce can deteriorate, get spoiled, and become contaminated in storage and transportation.
- **Poor tracking of product status**: The real condition of the produce often reaches farmers and consumers at the point of sale, leaving them frustrated and wasting their resources.

3.4 Inefficient Supply Chains

Today's agricultural supply chains are mostly inefficient, leading to avoidable food loss, high cost, and long transit times

- **Transportation spoilage:** Bad infrastructure, lack of temperature control, and poor logistics lead to produce being spoiled during transport, and with huge losses.
- **No real-time monitoring:** The absence of equipment for constant monitoring of environmental factors such as temperature, humidity, and risk of spoilage leaves the supply chain vulnerable to inefficiencies and waste.

CHAPTER-4
PROPOSED METHODOLOGY

KrishiMitra is a novel platform, which seeks to bridge these research gaps through the use of IoT technologies, real-time data, and direct farmer-to-consumer sales. This solution will make the agricultural supply chain more efficient, transparent, and sustainable. Here's how KrishiMitra fills the critical gaps in existing agricultural methods:

4.1 IoT Sensor Integration: Real-Time Quality Monitoring

At the core of KrishiMitra’ s solution is the integration of various IoT sensors that continuously monitor the quality of agricultural produce throughout the entire supply chain. Such sensors give real-time data on spoilage gases, moisture levels, and visual appearance that allow for dynamic quality assessment. The key IoT sensors include:

- **MQ-135 (Gas Detection for Spoilage):** This sensor detects gases including CO_2, ammonia, and benzene. The system will determine if the produce has been spoiled and degraded based on the detection of higher concentrations of these gases. It helps farmers and consumers avoid buying spoiled or low-quality produce.
- **TCS3200 (Color Sensor for Quality Assessment):** TCS3200 tracks the color of grains, fruits, and vegetables ensuring that their color matches the market standards. Color consistency is an important indicator for freshness and quality. Keeping a track of color in real time will ensure that only eye-catching and high-quality produce arrives at the consumers' end.
- **Capacitive Moisture Sensor (Moisture Control):** This sensor measures the moisture content of seeds, grains, and other agricultural products. Moisture content is a crucial factor for maintaining seed viability and preventing spoilage. KrishiMitra provides real-time moisture readings, helping farmers store their produce in optimal conditions and avoid excessive spoilage due to high moisture content.

These sensors integrate to provide an overall picture of the quality of produce from harvest, storage, and transport stages.

4.2 Dynamic Pricing Algorithm: Price Based on Real-Time Quality Data

One of the notable features of the KrishiMitra platform is its dynamic pricing algorithm, which adjusts prices according to the quality of the produce in real-time. The data provided by the IoT sensors power this pricing model and provide several benefits:

- **Equitable pricing for farmers and consumers alike**: Prices is determined based on the actual quality of the product rather than arbitrary markups. For example, produce that shows higher quality (e.g., optimally moist, no spoilage gases detectable, color uniform) will price more, indicating its worth. Conversely, low-quality produce will be priced accordingly. Consumers will pay fairly for what they have received.
- **Quality-based pricing**: Quality will incentivize farmers to maintain good standards because high-quality produce fetches more money. This promotes sustainable farming and good crop management.
- **Transparent pricing**: KrishiMitra, through IoT-based quality monitoring, ensures that the pricing is transparent and based on measurable factors. This reduces the power of intermediaries to inflate prices. Consumers can be confident that the price they pay reflects the true value of the produce, while farmers get a fair share of the market price.

4.3 Direct Market Access: Bypassing Middlemen

KrishiMitra creates a direct link between farmers and consumers, bypassing traditional middlemen and increasing transparency and fairness throughout the supply chain:

- **Farmers receive fair prices:** By connecting farmers directly with consumers (or retailers), KrishiMitra ensures that farmers get a larger share of the final sale price, as there are no middlemen taking a cut.
- **Direct communication**: The platform facilitates direct communication between farmers and consumers, which increases trust and reduces chances of miscommunication or exploitation by middlemen.
- **Consumer confidence**: With the provision of real-time quality data by the IoT sensors, consumers are better informed about the quality of produce they purchase. This transparency builds trust among farmers and consumers, leading to long-term relationships and customer loyalty.

4.4 Real-Time Data Analytics for Decision-Making

KrishiMitra employs analytics from data generated by the millions of data being received by IoT sensors. It uses the data in question to help farmers and consumers make good decisions based on real-time data insights

- **Help Farmers in Making Decisions**: Given that the data obtained would be in real time, farmers could choose when to irrigate or harvest crops, store crops according to strategies that give off best possible produce.
- **Preventing spoilage**: Real-time environmental condition monitoring (temperature, humidity, spoilage gases, etc.) will help farmers prevent the spoilage by adjusting storage conditions, handling practices, and transportation methods accordingly.
- **Supply chain optimization:** The flow of produce from farm to consumer will be tracked, ensuring that each step in the supply chain is optimized for freshness and efficiency. This reduces the risk of spoilage, increases shelf-life, and prevents food waste.

CHAPTER-5

OBJECTIVES

5.1 Direct Farmer-to-Consumer Sales:

- **Farmer Profit Maximization through Reduced Intermediary Numbers:** Direct sales from the farm to the consumer will save farmers the middlemen (wholesalers, distributors, etc.). It ensures that a bigger chunk of the sale price reaches the farmer and not to various middlemen in the chain of supply.
- **Price Transparency**: Direct sales show consumers the actual price of the product. There is a correlation between the effort the farmer has put in and the amount paid for that produce.
- **Consumer Loyalty**: The more connections the farmer has with their clients, the more they retain customers to buy again from them. This will create loyalty because the customer appreciates knowing the source of the food, hence enhancing their confidence in the brand.
- **Local Economy Boost:** This model benefits the local economy because farmers' earnings stay within the community instead of draining to supply chains outside the community.
- **Flexibility and Control:** By having more control over prices, marketing, and distribution of their products, farmers will find the power to adapt their products if a consumer preference or market change should occur.
- **Expected Outcome:**
    - Farmers would have higher profit margins with which they could invest in better farming practices, equipment, or land development.
    - Consumers get fresher produce, often at a lower cost than when buying from a retail store.

5.2 Real-Time Dynamic Pricing: IoT Data

- **Objective:** The real-time dynamic pricing is decided through the data that has been collected from the IoT sensors.
- **IoT Sensors on Market Demand:** IoT sensors, such as MQ-135 used to detect air quality and TCS 3200 used in detecting color, can monitor all environmental conditions or the freshness of the produce or levels of possible contamination. Such information feeds into

the intelligent pricing model.

- **Adjusts with price dynamically:** This product will change price with time because the quality of fresh produce will change with time, especially due to external factors such as changes in the weather and those in the supply chain. The product can sell the tomatoes at a premium because they will be the freshest batch in stock, whereas near-spoilage products should sell at a very discounted price so that customers consume them immediately.
- **Consumer Knowledge:** Consumers know what they are buying. In this respect, consumers feel fulfilled. For instance, overripe fruit that is undervalued by a few dollars will attract customers who think of nutritional value rather than the aesthetic appearance.
- **Fair Pricing and Sustainability**: If consumers pay for better crops, then farmers will get more; lower-quality produce will be sold at a fairer price rather than being wasted.
- **Expected Outcome:**
    - **Price Transparency:** Both consumers and farmers profit when the price is fair but reflects the real quality of a product and the conditions under which it is sold
    - **Economic Efficiency:** Farmers and consumers will, therefore, make informed decisions such that waste will be diminished and resources better allocated.

5.3 IoT-Inspired Quality Control:

- **Real-time quality monitoring:** IoT can monitor a range of aspects, such as humidity, temperature, color, ripeness, and gas emissions, which indicate spoilage. For example, ethylene gas is emitted when fruits or vegetables start to spoil. This way, fruits and vegetables are harvested at the right time, and then kept in proper conditions to have a lower chance of spoilage.
- **Consistency and Traceability:** The produce, from farm to table, will be traceable to consumers, knowing that the same has been kept in right conditions and free from contaminants.
- **Reduced spoilage and waste:** Continual monitoring of the freshness of the produce can help farmers in optimizing their harvest schedules and inventory management, thereby minimizing waste.
- **Equitable Pricing According to Quality**: IoT solutions can be used to classify produce into quality, thus ensuring the consumer pays for what he or she gets, which is premium

pricing for fresh, grade-A produce. Lower prices can be charged on overripe or slightly damaged produce, thereby preventing waste and making the produce more affordable**.**

- **Increased Customer Satisfaction:** With fresh, high-quality produce, the possibility of repeat customers will be increased. Quality produce supports healthy eating and sustainable living.
- **Expected Outcome:**
    - **Less Waste:** The farmer will handle the produce better and avoid wasting a lot since only quality goods will reach the consumers.
    - **Customer Confidence**: The system creates consumer loyalty by offering quality-controlled produce all the time.

5.4 Sustainability:

- **Objective**: Sustainable practice by reducing spoilage and waste and encouraging sustainable farming practice
- **Reduced Waste:** Monitoring of the freshness and quality through IoT devices will reduce food wastage as the products are sold in an optimal freshness and avoiding excessive wastage. The spoilt produce can be routed to composting or marketed elsewhere like biofuels and animal feed.
- **Wiser Use of Available Resources:** Live usage data for water and soil health as well as on weather conditions would make the agricultural farmers improve the irrigation cycle and fertilization cycle that reduces wastage of such natural resources. Thus carbon footprint of farm operations diminishes.
- **Energy Efficient Packaging:** Through IoT, it is even possible to optimize packaging also by ensuring proper material use where freshness loss would be evaded and also the entire environmental impact could be mitigated.
- **Sustainable Crop Rotation and Biodiversity:** With an assessment of the quality and health of the soil, a better crop rotation practice would be practiced that would boost soil fertility and biodiversity while minimizing chemical fertilizers and pesticides.
- **Reduced Carbon Footprint in Transportation:** Selling to the consumer eliminates extra mileage as the food is sold at its source reducing the carbon footprint associated with transportation.

CHAPTER-6
WORKING

6.1 System Architecture

The KrishiMitra system integrates a variety of IoT sensors, a data aggregation layer, and a **platform interface** to enable real-time monitoring of agricultural produce quality and dynamic pricing based on sensor data. The system's architecture ensures that data flows seamlessly from the **farm** (where sensors collect data) to the cloud-based platform (where data is processed and pricing is updated in real time).

6.1.1 Data Flow: Collection, Transmission, and Processing

The data flow in the KrishiMitra system follows a clear path, from the collection of raw data on the farm, through real-time processing, to actionable insights on the platform. Here's a step-by-step overview:

Step 1: Data Collection at the Farm

- **IoT Sensors**: The first step involves the deployment of various sensors at the farm or storage location. These sensors include:
  - **MQ-135** (gas sensor) for detecting gases like CO_2, ammonia, and other spoilage-related compounds.
  - **TCS3200** (color sensor) to monitor the visual quality and color consistency of crops such as grains, fruits, or vegetables.
  - **Capacitive Moisture Sensors** for monitoring moisture content in seeds, grains, and other products that may affect storage and shelf life.

Step 2: Data Transmission to the Data Aggregator

- **Transmission Layer**: The sensor data is transmitted via wireless communication technologies such as Wi-Fi, Lora WAN, or NB-IoT to a data aggregator. These technologies ensure that data can be sent over long distances with minimal power consumption, which is ideal for rural and remote farming areas.

Step 3: Data Aggregation and Preprocessing

- **Data Aggregator**: The aggregator serves as the intermediary between the IoT sensors and the cloud platform. It collects data from the various sensors, aggregates it, and performs any necessary preprocessing (e.g., smoothing, noise reduction, or timestamping). The data is then ready for real-time analysis.

Step 4: Data Processing and Dynamic Pricing

- **Cloud-based Platform**: The processed data is transmitted to a **cloud server** where it is analysed using **machine learning** or **data analytics algorithms**. This analysis evaluates the quality parameters such as:
    - Moisture content.
    - Gas composition (spoilage gases).
    - Color consistency (based on sensor inputs from the TCS3200).

Based on this analysis, a dynamic pricing algorithm calculates a fair market price for the produce based on the quality score derived from the sensor data. Prices may vary depending on the freshness, color, moisture content, and overall quality.

Step 5: Price Display and Consumer Interaction

- **Platform Interface**: The final pricing information is displayed on the KrishiMitra platform (either a mobile app or web portal) for consumers to view. Farmers are also able to access the platform to monitor the quality and price of their produce. This interface enables:
    - **Farmers** to track the quality of their produce in real-time.
    - **Consumers** to view and purchase the produce based on its real-time quality and pricing information.
- **API Integration**: The system supports API integration, enabling seamless data exchange between the platform, external applications, and payment gateways. For example, the dynamic pricing information can be sent to external agricultural marketplaces or used by e-commerce systems to enable online purchasing.

6.1.2 System Components

The KrishiMitra system is built on a combination of hardware and software components that work together to ensure smooth data flow, real-time analysis, and pricing updates.

6.1.2.1 Hardware Components:

- **IoT Sensors**: These are the primary data collection devices in the system. They monitor various quality parameters of the agricultural produce. Key hardware components include:
  - **MQ-135 Gas Sensor**: Detects gases like **CO_2** and **ammonia** that indicate spoilage. These gases can be used to assess whether produce is degrading or is in optimal condition.
  - **TCS3200 Color Sensor**: Measures the **color** of grains or fruits, helping assess their ripeness or freshness. For example, in grains like rice, color consistency is an indicator of harvest timing and storage quality.
  - **Capacitive Moisture Sensor**: Monitors the **moisture content** in grains or seeds to prevent spoilage. Excess moisture levels can lead to fungal growth and degradation, so this sensor ensures produce is stored at optimal moisture levels.
- **Microcontroller**: The microcontroller (e.g., Arduino, Raspberry Pi, or ESP32) collects the data from these sensors, processes it (e.g., performs basic filtering), and transmits the processed data to the cloud or data aggregator. The microcontroller may also handle local storage of data in case of connectivity loss.
- **Data Aggregator**: This component can be a gateway device (e.g., a Raspberry Pi or dedicated IoT gateway) that collects data from the sensors via Wi-Fi, Bluetooth, or Zigbee, aggregates it, and then transmits it to the cloud for further processing. The aggregator might also handle preprocessing tasks like smoothing sensor readings.

6.1.2.2 Software Components:

- **API Integration**: The KrishiMitra platform features **API (Application Programming Interface)** integrations that allow for:
  - **Third-Party Integrations**: Connecting with external marketplaces or e-commerce systems where consumers can view and purchase products.
  - **Payment Gateway**: Enabling secure transactions for farm-to-consumer purchases directly through the platform.
  - **Real-Time Data Synchronization**: Ensuring that pricing and quality information is kept up-to-date across all devices and systems.
- **User Interface (UI)**: The platform offers a **web-based** or **mobile application**

interface for both farmers and consumers. Features include:

- **For Farmers**: Ability to view real-time data from sensors, track pricing changes based on product quality, and manage inventory and sales.
- **For Consumers**: Access to detailed product quality information, real-time pricing based on freshness and quality, and the ability to make purchases directly from the platform.

Table 6.1: Software Components

Component	Role
IoT Sensors	Monitor quality parameters (gas, color, moisture)
Data Aggregator	Collects and processes sensor data in real-time
API Integration	Provides dynamic pricing and updates based on real-time data
Platform Interface	User interface for farmers and consumers to access data and make transactions

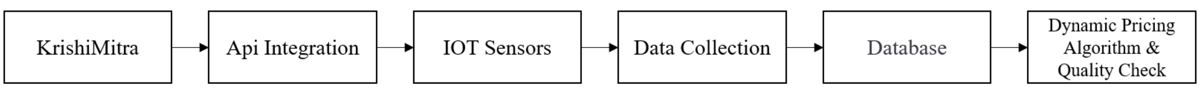


Figure 6.1: ***System Architecture of KrishiMitra***

6.2 Sensor Integration

- **Data Collection**: Describe how each sensor gathers real-time data and the frequency of data collection.
- **Data Transmission**: Explain how sensor data is transmitted to the cloud or central platform using APIs.
- **Calibration and Accuracy**: Explain the challenges of calibrating each sensor to ensure accuracy in different environmental conditions.

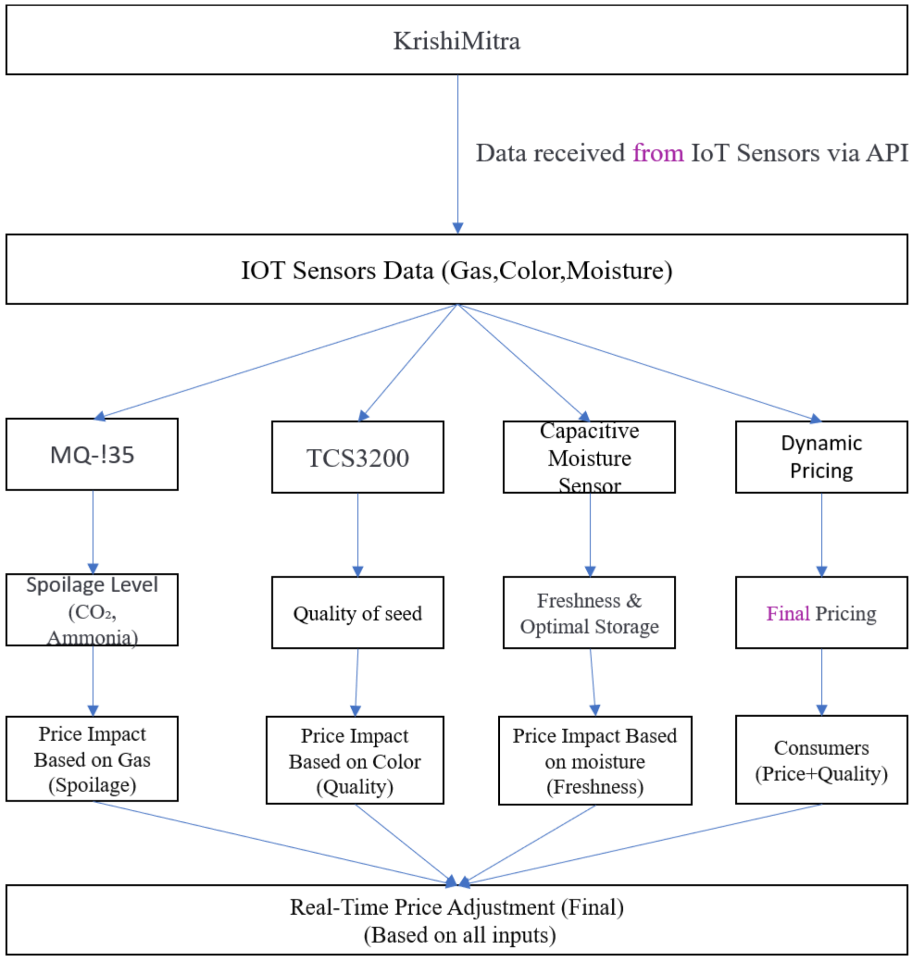


Figure 6.2: *Sensor Data Flow*

Table 6.2: Threshold for Quality Control

Sensor	**Data Collected**	**Threshold for Quality Control**
MQ-135 Gas Sensor	Ammonia, CO_2, and other spoilage gases	High gas levels indicate spoilage or poor storage
TCS3200 Color Sensor	Color consistency and visual quality	Color deviations indicate ripeness or maturity
Capacitive Moisture Sensor	Moisture content in grains and seeds	Excess moisture indicates possible spoilage

CHAPTER-7

SYSTEM IMPLEMENTATION

7.1 Hardware Components

Hardware components are the main aspects of the KrishiMitra platform. The platform empowers the real-time quality monitoring of agricultural produces while also guaranteeing that both the farmer and the consumer obtain appropriate and timely information. It deals with all the prime hardware components which have been used in the system; these include the sensors, microcontroller, and mechanisms of connectivity.

7.1.1.Sensor's integration

The KrishiMitra system is based on the monitoring of agricultural produce quality and condition using various IoT sensors in real time. These sensors help to detect spoilage, moisture content, and the quality of seeds or grains. Among the three primary sensors in this system, there are the following:

1.MQ-135 Gas Sensor

• **Purpose**: Spoilage gases from the products, such as CO_2 and NH_3 along with benzene, generated in the biochemical degradation of crops in cold storage, will be measured by the MQ-135 sensor. Their concentration represents the spoilage level and can be translated into adjusted prices for better sale at the appropriate levels of freshness.

- **Specifications**:
  - **Gas Detection Range**: 10 ppm to 1000 ppm for gases like CO_2, ammonia, and other volatile organic compounds (VOCs).
  - **Sensitivity**: High sensitivity to gases, allowing it to detect low-level spoilage at an early stage.
  - **Applications**: Used in storage areas, transport containers, and warehouses to continuously monitor the quality of produce.

2. TCS3200 Color Sensor

- **Purpose**: The TCS3200 color sensor is used to measure the color consistency of grains, fruits, and vegetables. Color consistency provides valuable insights into the maturity, ripeness, and overall quality of produce. A uniform and optimal color often indicates better quality produce, which can fetch a higher price.

- **Specifications:**
  - **Resolution**: 16-bit resolution, which provides high accuracy in detecting color variations.
  - **Color Detecting Ability**: It has the capability to detect a lot of colours and differentiate slight changes in the color of fresh produce.
  - **Applications**: The sensor is applied when checking the color of cereals (such as rice, wheat), fruits and vegetables for farmers to tell maturity and uniformity levels.

3. Capacitive Moisture Sensor

- **Objective**: Capacitive moisture sensors measure the moisture content in agriculture products, such as seeds, grains, and fruits. Moisture content becomes a determining factor for how fresh or fresh the product is because too much water causes it to spoil. However, optimal moisture conserves freshness.
- **Features**:
  - **Sensitivity**: 0-100% moisture content with high sensitivity, meaning that the exact amount of moisture in seeds and grains can be measured.
  - **Ranges**: Suitable for monitoring wide ranges of produce, from cereals, legumes to fruits.
  - **Applications**: They are used in the storage conditions to keep moisture levels within acceptable ranges such that spoilage does not take place and maintains quality in the produce.

7.1.2 Microcontroller

The microcontroller plays an important role in the collection and transmission of data within the KrishiMitra system. It is a central processing unit that interfaces with the sensors, collects the data, and then transmits it to the cloud-based platform for analysis. The most commonly used microcontrollers in IoT applications like KrishiMitra are Arduino, which are cost-effective, easy to integrate, and highly capable for handling real-time sensor data.

Arduino (Arduino Uno or Arduino Nano)

Purpose The Arduino is applied for connecting sensors, collecting data, and communicating with the central server. Due to its simplicity of architecture, Arduino can easily be used for agriculture-related IoT projects, which necessitate real-time data gathering and processing.

Features:

- **Digital and Analog I/O Pins**: Deals with both digital and analog sensors making it compatible with vast amounts of sensors like the MQ-135, TCS3200, as well as capacitive moisture sensors.
- **Processing Power**: Suitable for dealing with real-time data, though not much processing required since it will be sending over data to the cloud or onto some central platform.
- **Ease of Use**: The Arduino platform is widely used in IoT applications and has extensive community support, making it easy to integrate with other IoT devices and software.

Table 7.1: Hardware Components

Component	Purpose	Specifications
MQ-135 Gas Sensor	Monitors spoilage gases	Range: 10 ppm to 1000 ppm for various gases
TCS3200 Color Sensor	Measures color consistency in grains	Resolution: 16-bit, color detection accuracy
Capacitive Moisture Sensor	Measures moisture content in seeds	Sensitivity: 0-100% moisture content
Arduino (Uno)	Microcontroller for data collection	5V, 16 MHz clock speed, Digital/Analog I/O pins

CHAPTER-8

TIMELINE FOR EXECUTION OF PROJECT (GANTT CHART)

Figure 8.1: *Gantt chart*

- **Project Planning and Research**: Week 1, Week 2
- **Define Project Scope and Objectives**: Week 1
- **Requirement Gathering**: Week 1, Week 2
- **Finalize Project Plan and Timeline**: Week 3
- **Development Phase:** Week 4, Week 5, Week 6, Week 7, Week 8, Week 9
- **Backend Development:** Week 4, Week 5, Week 6
- **Frontend Development:** Week 4, Week 5, Week 6, Week 7
- **IoT Integration:** Week 8
- **Testing:** Week 9, Week 10, Week 11

CHAPTER-9
OUTCOMES

9.1 Economic Gains

Improved farmer income: Without middlemen, farmers get more of the proceeds from the sales. The money can be put back into their farms, enabling them to boost productivity and go about farming in more sustainable ways.

The clear prices for consumers allow them to make good value out of their money since they understand the quality and freshness of the produce. They, therefore, make more informed and confident purchasing decisions.

9.2 Quality Control and Consumer Satisfaction

Real-Time Quality Checks-Constant monitoring of produce by IoT sensors will ensure only fresh and quality items reach the marketplace. The customers will thus be satisfied, loyal, and not shy away from repeat purchases.

Lesser amounts of waste; fresher product: tracking conditions such as gases, moisture content, and even color allow it to recognize deterioration at the beginning stages. Such action results in less waste with fresher product being sold by farmers to happy consumers.

9.3 Economic Benefits

Better Income for Farmers: The farmers receive higher proceeds directly from the sale without middlemen. The money can then be reinvested into their farms, thus increasing productivity and allowing farmers to carry out farming in more environmentally friendly ways.

In general, clear price information to consumers enables them to make good value out of their money since they understand the quality and freshness of the produce. They, therefore, make more informed and confident purchasing decisions.

9.4 Sustainability

More efficient utilization of resources: IoT monitoring enhances the decision to water, fertilize, and harvest. Such a process consumes fewer resources in terms of water and soil; hence, saving costs and being environmentally friendly.

Carbon footprint minimization promotes local sale and reduces transport over long distances, which lowers carbon emissions. Better monitoring and management also lower food waste to create a better environment.

9.5 Technological innovation

Harnessing IoT for Agriculture: KrishiMitra underlines how the IoT technology revolutionizes traditional farming. The use of real-time data and advanced analytics sets the new standard of innovation in agriculture.

CHAPTER-10

RESULTS AND DISCUSSION

10.1 Pilot to Actual Farm Setup for Field Testing and KrishiMitra Validation

KrishiMitra was piloted to an actual farm setup with a view to field testing it to enhance the farm-to-consumer supply chain. This pilot exercise was so designed to be a "proof-of-concept," to establish whether quality at the source is guaranteed agricultural produce, mainly seeds and grains, captured through IoT sensors as well as dynamic pricing driven by quality metrics.

10.2 Sensor Performance

- **Gas Sensor MQ-135:** In the storage and transportation environment, the MQ-135 gas sensor was tested for its response to spoilage gases like ammonia, carbon dioxide, and benzene. It performed well in detecting the spoilage gases with good sensitivity. Real-time readings enabled farmers to detect early signs of spoilage and take corrective actions before considerable quality loss occurred.
- **TCS3200 Color Sensor:** Color has been the determining factor for the quality of seeds and grains because it assesses maturity and uniformity levels. The sensor readings were almost the same as the visual evaluation of the seeds' quality. The product condition was objectively analysed in real-time through the sensor reading. Such variation in color corresponds to maturity stages and product quality, thus confirming the usefulness of the sensor in agriculture.
- **Capacitive Moisture Sensor:** Capacitance moisture sensor measured accurately the moisture levels of grains and seeds. It provided timely response on the quantity of moisture, hence maintaining them within ideal storage conditions. It ensured that farmers achieved lesser percentages of spoilage or maintained it at or around ideal levels of moisture. The sensor further controlled the spoilage due to its ability to prevent over drying and excessive accumulation of moisture that leads to breakdown.

10.3 Dynamic Pricing Performance

Another significant positive consequence of the KrishiMitra platform was that it utilized real-time IoT sensor collected data to provide dynamic pricing. The formula operating the pricing calculation takes into account various factors:

- **Freshness**: Products with more less spoiled gas readings; therefore products with higher levels of freshness are priced more expensively.
- **Colour Uniformity:** The finer the colour uniformity of the grains or seeds, the more it would fetch and better would be its maturity and quality.
- **Moisture Content:** Crops having an optimum moisture content-neither too dry nor wet-were sold at competitive prices ensuring that good-quality products were delivered to the consumers with no loss due to spoilage at the farmer's end.

In the test, the dynamic pricing model charges 15% to 20% on high-quality produce compared to low-quality produce. For the consumer, this provided them with fresh, prime products. It also ensured that the farmers were given a suitable price for their high-quality produce.

10.4 Farmer-Consumer Interaction and Platform Usability

The KrishiMitra platform was designed to be farmer-friendly and consumer-friendly at the same time. Generally, the feedback from users (farmers and consumers) was positive:

- Farmers appreciated the direct connection with consumers and the transparency. They could track the quality of their produce in real-time and set prices for it, which helped reduce losses and increase profitability.
- The customers were content that the website contained all information about the quality of the product in terms of freshness, moisture content, and color. Such information availability was deemed trust-enhancing and informed purchasing decisions. The ability to purchase directly from the farmers was regarded as a gateway to fresher products at reasonable prices.

10.5 Challenges and Limitations

Despite the success of the KrishiMitra system, some challenges were encountered during its implementation:

- **Infrastructure Challenges:** Connectivity for real-time data transmission via Wi-Fi or cellular networks was inconsistent in some remote rural areas. It caused delays in updating quality metrics and dynamic pricing on the platform.
- **Sensor Calibration:** Sensors in the experimental environment were too accurate; however,

real life conditions posed some limitation for this sensor calibration whereby the change in temperature or moisture during transport presented an inconvenient aspect. There's a need for fine-tuning whereby the sensors had to retain their accuracy irrespective of any environment they had to contend with.

- **Consumer Awareness:** Even though the quality was great and very fresh to monitor through, some people did not purchase through this new channel, as this was an entirely new means of accessing it.

10.6 Comparison to Traditional Supply Chains

The KrishiMitra platform had an enormous advantage over traditional supply chains that relied on middlemen. In the traditional system, farmers lose a great deal of the sale price because of the commissions paid to the intermediaries. In KrishiMitra, farmers are able to get a higher percentage of the sale price (which is usually 10-20% more) as they sell directly to the consumer.

Besides, consumers enjoy fresh produce at the fair price while enjoying assured quality. The dynamic pricing model based on real-time quality data ensures that the farmers and consumers are adequately paid-a factor that happens to most of the product sold through a traditional supply chain whose prices are normally fixed, without reflecting their actual product quality.

CHAPTER-11

CONCLUSION AND FUTURE WORK

The KrishiMitra project implemented a high-end IoT-based platform that enabled real-time monitoring of the quality of agricultural produce, farm-to-consumer sales directly, and dynamic pricing based on quality metrics. Key results and findings:

More Profitability for the Farmers: The removal of intermediaries has made it possible for KrishiMitra to ensure increased profitability at the farmer level. The dynamic pricing generated from real-time sensor data allowed farmers to be compensated according to the real quality of their produce and increase revenue by 15%-20% more than that would be gained from traditional methods.

The firm would therefore assured freshness and high quality of its products on the shelf of a consumer while it used details in its metrics regarding moisture content, uniformity in color, and spoilage gas. It, in turn, generated more confidence on the side of a consumer as their purchasing decisions were now influenced by fresh data.

11.1 Reduction in Spillages and Waste:

The use of IoT sensors, for example, MQ-135 gas sensor, TCS 3200 color sensor among others capacitive moisture sensors have helped detect good spoilage early. These helped correct mistakes such as correcting conditions of storage significantly contributed to the reduction in cases of post-harvest wastages. Generally, sensor performance was very accurate. The gas sensor detected ammonia and CO_2, gases associated with spoilage, at concentrations of 10-1000 ppm, with high sensitivity.

11.2 Impact on Sustainability:

The system ensured that there was the right condition for storage such that there would be little chance of excessive moisture or extreme temperature fluctuations that can result in spoilage. Thus, this contributed to sustainable agricultural practices, whereby there was efficient use of resources and minimal environmental waste.

11.3 Sensor Data Accuracy:

The MQ-135 gas sensor provided reliable data in terms of spoilage gases with an accuracy rate that was well above 90% regarding the detection of the changes in the concentration of gases.

The TCS3200 color sensor was shown to have performance with 16-bit resolution and its color recognition had a very close correlation to the actual visual quality as its error margin was predicted to be less than 5% when used on grains and fruits.

The capacitive moisture sensor was found to measure moisture content 0-100% sensitive and yielded more than 95% accuracy in maintaining moisture at optimal levels.

11.4 Future Work

Although the Krishi Mitra system proved to be very effective, innumerable areas exist wherein future enhancements and expansions have to be made:

11.5 Stronger Connectivity and Scalability:

In rural or even remote areas where internet connections are poor, data needs to be transmitted. Such zones can be covered efficiently with LPWAN such as LoRa WAN or NB-IoT.

The system must be designed to be able to operate in offline mode or periodically synchronize data when the internet is available so that the platform can operate in areas where the internet connection is sometimes available.

11.6 Advanced Predictive Analytics and Dynamic Pricing:

Machine learning algorithms can be further used to predict the demand in the market through historical sales data and seasonal trends. The system will automatically adjust the prices depending on the dynamics of supply and demand and expected conditions of the market.

The system can also utilize external market data to make price fluctuation predictions, which can then be incorporated into the dynamic pricing model.

11.7 Higher Adoption and Farmer Training:

To scale up the platform, the effort should be in training and outreach programs for farmers. It could be webinars, field workshops, or even online tutorials on using the platform efficiently.

Another potential step would be collaboration with agricultural cooperatives or governmental agencies to spread KrishiMitra further, adopting the technology at a higher scale with smallholder farmers.

11.8 More sensors integrated:

Even more, future versions of the system can include sensors like temperature and humidity and light sensors to give quality information for storage and conditions while on transport. This, therefore, would ensure better quality of a wider range of agricultural goods, especially perishables including fruits and vegetables.

A sophisticated sensor of soil condition or crop growth monitoring should be included for overall end-to-end checking of quality, from cultivation to marketplace.

11.9 User Experience and Interface Improvement:

This will increase adoption by improving the user interface of the platform for farmers and consumers. Real-time alert and notification features will improve and enhance the user experience through the tracking of supply chain logistics. More features such as voice assistance for literate farmers.

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APPENDIX-A

PSUEDOCODE

1.Farmer Adds Product to Platform

```
START
  // Farmer selects product category/commodity
  INPUT selected_commodity  // e.g., "Apple", "Tomato", "Carrot", etc.

  // Automatically assign the base price based on the selected commodity
  base_price = GetBasePrice(selected_commodity)

  // Collect sensor data for quality assessment
  INPUT sensor_data = GetSensorData()  // Get sensor readings (gas, color, moisture)

  // Analyze product quality based on sensor data
  quality_score = AnalyzeQuality(sensor_data)

  // Adjust price based on product quality
  adjusted_price = AdjustPrice(base_price, quality_score)

  // Add the product to the platform with the adjusted price
  POST product to platform with details:
    - product_name
    - quantity
    - description
    - selected_commodity
    - adjusted_price
    - sensor_data

  DISPLAY "Product successfully added with current price: " + adjusted_price
END
```

2. Get Base Price for Selected Commodity

```
FUNCTION GetBasePrice(commodity)
  // Define base prices for commodities in a database or list
  SWITCH commodity
    CASE "Apple":
      RETURN 100  // base price in currency units
    CASE "Tomato":
      RETURN 50
    CASE "Carrot":
      RETURN 30
    // Add more commodities and their base prices as needed
    DEFAULT:
      RETURN 0  // If commodity is not found, return 0 (error or undefined)
  END SWITCH
END FUNCTION
```

3. Analyze Product Quality

```
FUNCTION AnalyzeQuality(sensor_data)
  // Extract sensor data
  gas_level = sensor_data.gas_level
  color_value = sensor_data.color_value
  moisture_level = sensor_data.moisture_level

  // Define thresholds for quality based on sensor readings
  quality_score = 100  // Start with a perfect quality score of 100

  IF gas_level > threshold_spoilage THEN
    quality_score = quality_score - 30   // Deduct points for spoilage (poor quality)
  END IF
```

```
  IF color_value is outside acceptable range THEN
    quality_score = quality_score - 20   // Deduct points for color issues (e.g., overripe)
  END IF

  IF moisture_level < minimum_moisture_threshold THEN
    quality_score = quality_score - 25   // Deduct points for moisture loss (poor quality)
  END IF

  RETURN quality_score
END FUNCTION
```

4. Adjust Price Based on Quality

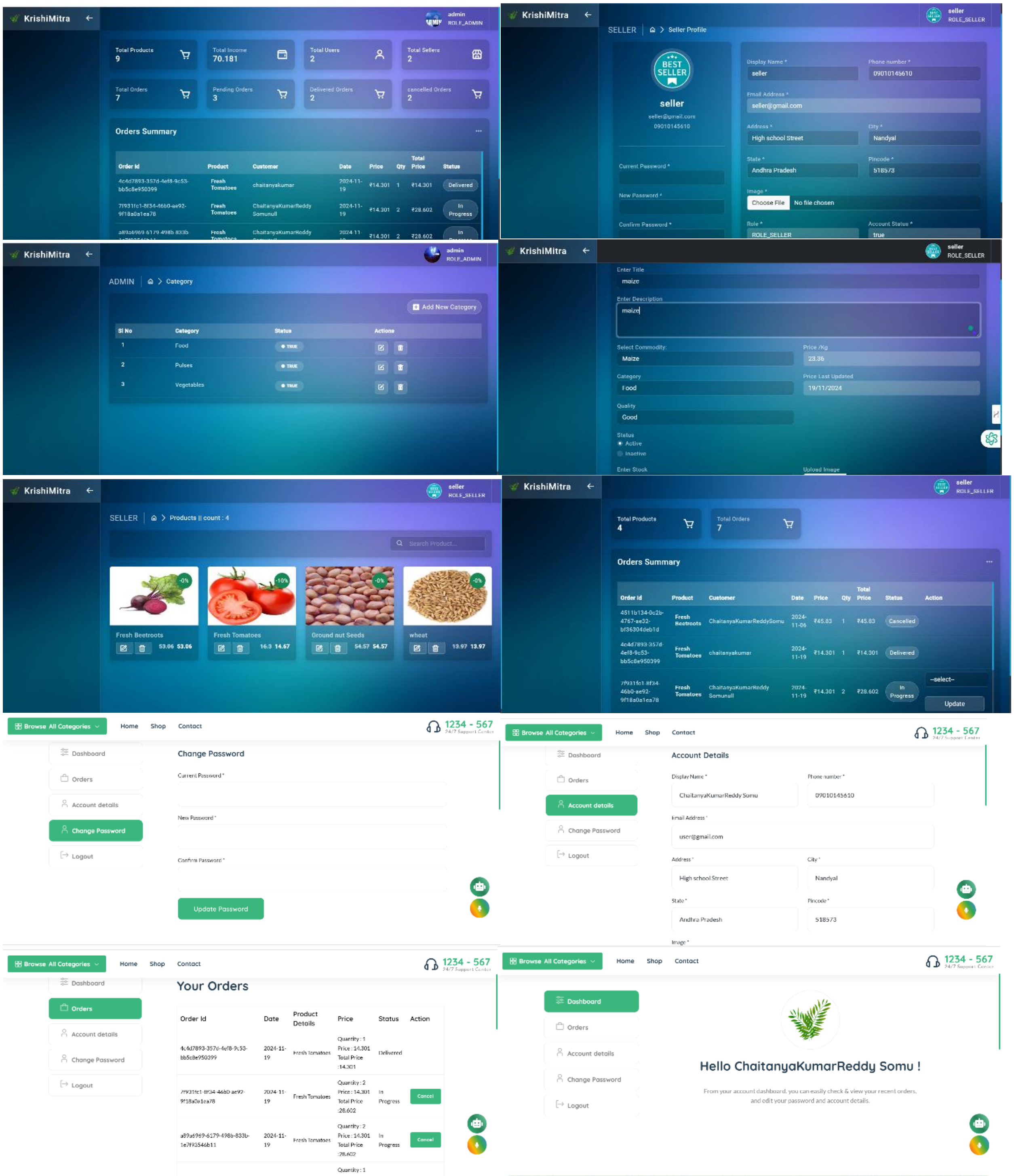
```
FUNCTION AdjustPrice(base_price, quality_score)
  // If quality score is below a certain threshold, reduce the price by 30-40%
  IF quality_score < acceptable_quality_threshold THEN
    // Reduce price by 30% to 40% depending on how low the quality score is
    discount_percentage = 0.30  // Default 30% discount for lower quality
    adjusted_price = base_price * (1 - discount_percentage)

    // If quality is extremely low, apply 40% discount
    IF quality_score < very_low_quality_threshold THEN
      discount_percentage = 0.40
      adjusted_price = base_price * (1 - discount_percentage)
    END IF
  ELSE
    adjusted_price = base_price  // No discount if quality is acceptable
  END IF

  RETURN adjusted_price
END FUNCTION
```

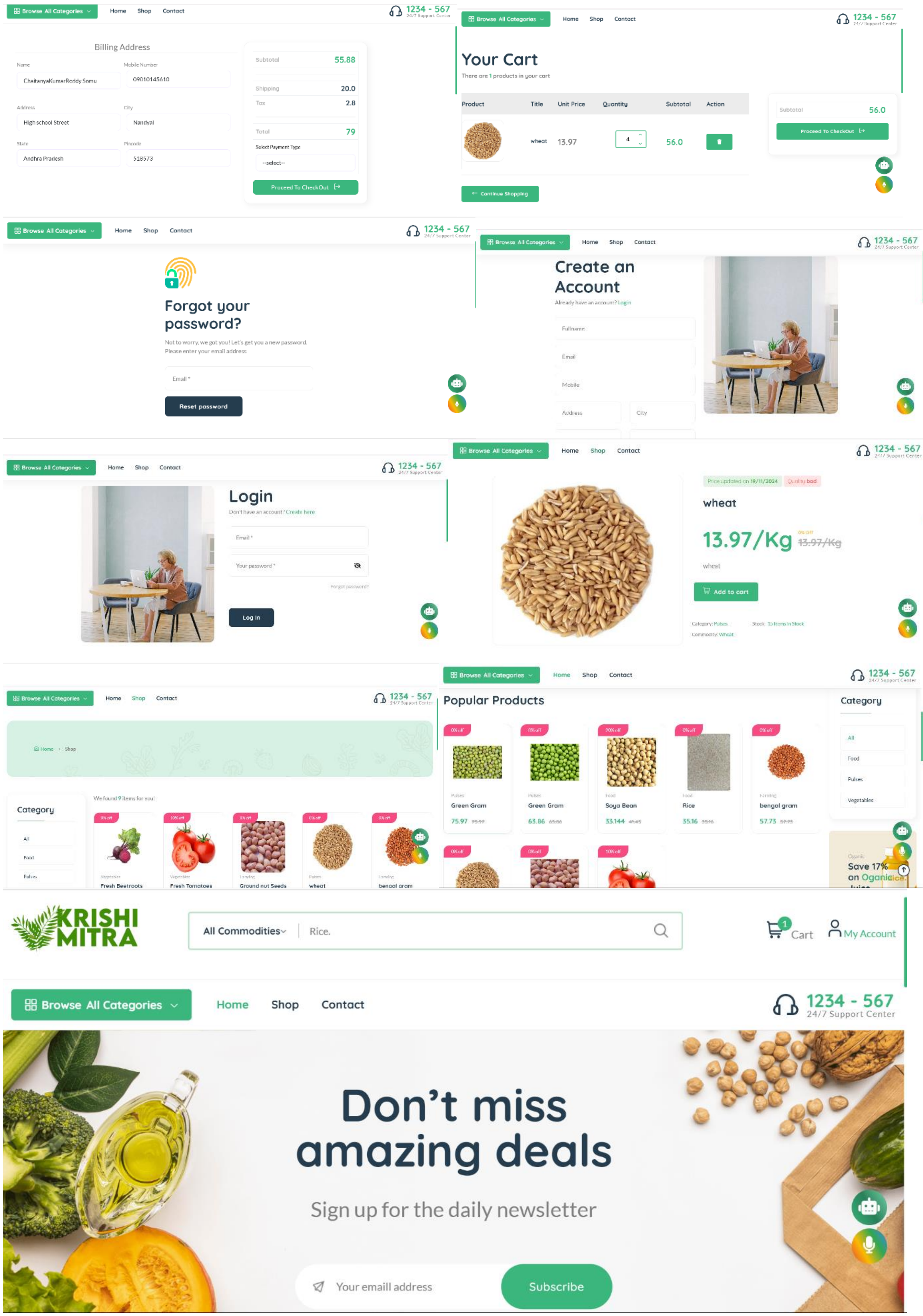
5. Buyer Purchases Product

```
START
  // Buyer browses available products
  DISPLAY product_list on the platform

  // Buyer selects a product to buy
  INPUT selected_product_id

  // Display selected product details (including adjusted price)
  product_details = GetProductDetails(selected_product_id)
  DISPLAY product_details

  // Buyer adds product to cart
  INPUT add_to_cart(selected_product_id, quantity)

  // Buyer proceeds to checkout
  INPUT buyer_details = GetBuyerDetails()   // Name, shipping address, payment details

  // Process payment
  payment_status = ProcessPayment(buyer_details, product_details)

  IF payment_status = "Success" THEN
    // Update inventory (decrease stock)
    UpdateInventory(selected_product_id, quantity)

    // Confirm purchase to buyer
    DISPLAY "Purchase Successful! Your product will be shipped soon."
  ELSE
    DISPLAY "Payment Failed. Please try again."
  END IF
END
```

APPENDIX-B

SCREENSHOTS




Browse All Categories
Home
Shop
Contact
1234 - 567
Billing Address
Proceed To CheckOut
Your Cart
There are 1 products in your cart
Product
Title
Unit Price
Quantity
Subtotal
Action
wheat
13.97
56.0
Continue Shopping
Forgot your password?
Reset password
Create an Account
Login
Log in
wheat
13.97/Kg
Add to cart
Popular Products
Category
Green Gram
Soya Bean
Rice
bengal gram
Fresh Beetroots
Fresh Tomatoes
Ground nut Seeds
KRISHI MITRA
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The agricultural supply chain is characterized by middlemen domination, price volatility, poor real-time quality monitoring, and considerable food loss. Farmers only get a small fraction of the retail price, and consumers are burdened with high prices and inconsistent product quality. This paper attempts to propose KrishiMitra, a digital platform utilizing IoT technology to create an efficient and transparent supply chain. The sensors track temperature, humidity, spoilage gases, and moisture in real-time conditions for dynamic pricing. Without the middlemen, all that revenue goes back to farmers and gives a good price to consumers with no or less waste. This also optimizes the conditions for storage and transportation. This paper explores the potential impact that KrishiMitra will have in transforming the agricultural supply chain and solving the sector's challenges.

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KRISHIMITRA: USING IOT FOR DIRECT FARM-TO-CONSUMER SALES WITH QUALITY-BASED PRICING AND MARKET API

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Abstract -- *The agricultural supply chain is characterized by middlemen domination, price volatility, poor real-time quality monitoring, and considerable food loss. Farmers only get a small fraction of the retail price, and consumers are burdened with high prices and inconsistent product quality. This paper attempts to propose KrishiMitra, a digital platform utilizing IoT technology to create an efficient and transparent supply chain. The sensors track temperature, humidity, spoilage gases, and moisture in real-time conditions for dynamic pricing. Without the middlemen, all that revenue goes back to farmers and gives a good price to consumers with no or less waste. This also optimizes the conditions for storage and transportation. This paper explores the potential impact that KrishiMitra will have in transforming the agricultural supply chain and solving the sector's challenges.*

Keywords – *Agriculture, Internet of Things, Api based Pricing, Ecommerce*

1.Introduction

The most crucial issues that have been affecting the supply chain between farmers and consumers include inefficiency, price swings, exploitation by middlemen, and erosion of quality. They appear to fleece and exploit the farmer for gain, for, at each point along the supply chain, wholesalers increase the prices and retailers do further along, taking away from farmers their potential income-they take away a pitiful fraction of the actual retail price paid by consumers. Besides losing money, there is also an element of vulnerability to price volatility arising from shifting demand in markets and inefficient supply chains. All these translate into unpredictable incomes, and, therefore, there is always an element of uncertainty for the farmer in planning how to go about his work. In consumers, transparency in the cost and quality of these products creates a disconnection. The different intermediaries included in the traditional supply chain resulted in inconsistent quality and price to the consumer. Transit and storage time further degradated the quality of an agricultural product, which brings low satisfaction and trust. The main drawback of this traditional model is that product quality cannot be monitored real-time.

Without trace systems for fresh, spoiled, or contamination, farmers and consumers remain ignorant about how fresh or spoiled a lot of the produce is. Ultimately, this leads to waste and discontent, because food is either wasted or sold at low prices that don't approximate its worth. Moreover, dynamic pricing with real-time quality data is not available, and hence the pricing is not fair; the consumer has to pay more for lower-quality produce, and the farmer does not get compensated for the premium quality crop. KrishiMitra presents an innovative solution to address these challenges by using IoT technology to transform the agricultural supply chain. Through integration with real-time sensors, it is able to track factors like temperature, humidity, moisture content, and spoilage gases from harvest to delivery. Thus, KrishiMitra helps farmers track the condition of their produce at each stage of harvest to delivery.The IoT-driven platform offers dynamic pricing based on the real-time quality of produce, hence ensuring that consumers pay a fair price for the freshness and condition of the product. KrishiMitra allows farmers to bypass middlemen and sell directly to consumers, capturing a larger share of the final sale price.

This increases farmer profitability but also promotes price transparency for consumers to make informed decisions about their purchases. Moreover, the real-time quality data from KrishiMitra makes for a more sustainable and effective supply chain by eliminating more waste and spoilage, lowering the risk of adulteration, and creating greater and more transparent product quality - and, therefore, fair pricing-to consumers. Working toward eradicating inefficiencies and lack of transparency in conventional agricultural supply chains, KrishiMitra offers scalable solutions that sustainably benefit the farmer but also the consumers at large, while providing healthy fresher produce and sustainable farming.

2.Literature Survey

This paper titled "Research on the Development of E-commerce Model of Agricultural Products" by Jaswanth Reddy Vulchi deals with a very evolving area of agricultural e-commerce. The significance of e-commerce in elevating the sales and circulation of agricultural products is presented with a large growth in sales and participants in such platforms as Alibaba. It analyzes a few notable e-commerce models, such as Tootoo Industrial Commune, Original Life, and Suichang Model, with the product-driven, marketing-driven, and service platform-driven e-commerce models respectively. It talks about the framework of their operations, strengths, and weaknesses on seven dimensions such as logistics, quality standards, government support, etc. The authors detect gaps in quality control, farmer engagement, and government intervention from such comparisons. They provide practical advice to farmers, e-commerce companies, and policy makers to improve the quality, availability, and governance of agricultural products in China. The paper explains that e-commerce is very viable in terms of income improvement for farmers, satisfaction of consumers' demands, and establishment of efficient supply chains.

This paper "Research on the Development of E-commerce Model of Agricultural Products" by Yaping Huo, Huiping Mu contributes to the ever-growing literature of agricultural e-commerce. While the studies mostly focus on general frameworks for e-commerce and their application in various industries, research in e-commerce models especially designed for agricultural products remains a missing link. Previous studies include Zhao Ping and Luo Yi (2011), who discuss service orientation and brand building in agricultural e-commerce. They emphasize that it is necessary to improve farmers' incomes and establish closed-loop operations from production to distribution. Luo Yi (2012) continued the discussion on the development strategies for agricultural e-commerce enterprises, including government support and supply chain integration. In the context of the product-driven approach, case studies on specific models like Tootoo Industrial Commune and Originally Life Network by Cui Jing in 2013 and Zhi Ying in 2014, respectively, have been undertaken. However, it fails to offer a comparative analysis of the multifaceted impacts of various e-commerce models and their differentiating impacts on quality control, logistics, and government policies. This paper systematically bridges those gaps by comparing and analyzing three different e-commerce models from seven critical aspects- Tootoo Industrial Commune, Original Life, and Suichang Model-by thus providing holistic recommendations to the farmer, e-commerce company, and policymakers. It provides new comparative insights based on synthesized existing research for enriching the understanding of successful strategies for sustainable agricultural e-commerce growth in China.

The paper, "Key Factors in Forming an E-Marketplace: An Empirical Analysis," is focused on the enhancement of efficiency in Taiwan's floral industry based on the adoption of mechanisms of e-commerce. Its focus is on the literature survey concerning the problems of traditional wholesale markets due to low service quality and problems associated with collecting price information. It identifies the potential of e-marketplaces in enhancing trading efficiency, reducing costs, and simplifying operations for suppliers and retailers. Works done by Ratchford et al. and O'Keefe and Loebbecke have demonstrated that the Internet may have potential utility for other industries for efficient information dissemination, so do not apply virtual solutions unless and until the market preferences have been understood. The developed work applies advanced decision techniques, such as Fuzzy Delphi and Fuzzy Multiple Criteria Decision Making in the identification of critical factors which include order accuracy, processing efficiency, and collaboration of urgent orders. The insights are combined with cooperation modes like joint price negotiations and active order placement to propose an adaptive operational framework. Taking into account empirical analysis, it extends existing e-commerce study and provides actionable strategies regarding the development of an efficient online marketplace for Taiwan's floral business.

This paper, "An Intelligent IoT-Based Food Quality Monitoring Approach Using Low-Cost Sensors," discussed the advancement in the monitoring technology related to an issue concerning food safety, whereby integrating the internet of things with smart sensors ensured quality food. Previous researches have discussed the usage of IoT in different fields and its role in monitoring food systems including electronic noses, RFID-enabled packaging, and smart sensors for the detection of microbial growth or oxidation. Inexpensive sensors like MQ series and environmental units like BME680 have given an opportunity to monitor packaged food in real-time regarding temperature, humidity, gases, and pressure in vacuum-packed conditions. This paper contributes to smart packaging by utilizing LabVIEW interfaces with WSN in processing and visualizing the collected data. It differs from traditional systems that primarily depend on static food characteristics by being integrated with IoT for dynamic, non-destructive analysis of novel applications in food preservation as well as the reduction of post-harvest losses. This system of the study is validated by experimenting on onions, which has the following practical implications on food safety and usability in both domestic and commercial settings.

A Summary of Literature Review for a Paper, "How will the Internet of Things Support Augmented Personalized Health?" by Amit Sheth; Utkarshani Jaimini; Hong Yung Yip A New Revolutionary Force in healthcare - from reactive to pro-actively preventive medicine that will eventually replace traditional patterns in health care. For such, the literature bases this necessity on economic imperatives as well as social; a pressing need that presents in escalating healthcare costs plus widespread adaptation in global geographies. The IoT has enabled integration with wearable and environmental sensors, thus opening unprecedented possibilities for patient health monitoring, providing continuous collection and analysis of data, which offers personalized insights. APH is based on this foundation, utilizing AI and smart data to enable proactive health management. The studies pointed out the role of PGHD, wearable technologies, and environmental sensors in collecting rich physiological and contextual data for improved clinical decision-making. The challenges that kept on arising include data interoperability, privacy, and transformation of raw data into actionable insights. Further, kHealth initiatives are examples of the practical application of IoT in personalized care, thus highlighting the need for semantic data models and machine learning to realize the full potential of APH. Thus, the reviewed literature sets a clear trajectory for the role of IoT in advancing healthcare while also identifying key technological and ethical considerations.

3.Analysis

The KrishiMitra platform combines the most advanced IoT technologies with a robust eCommerce infrastructure to form a solution that addresses the inefficiencies of the agricultural supply chain. This analysis includes system architecture, functionality, technological integration, pricing strategy, and field performance to understand the effectiveness and future potential of this system.

3.1 System Architecture

- The three major components of the KrishiMitra system are: IoT sensors, a cloud-based data aggregation platform, and an eCommerce interface.

3.1.1 IoT Sensor for Data Collection

The system relies on IoT sensors that monitor the quality of parameters of agricultural produce. There is a sensor strategically fitted in the farm or storage area with the view of providing real time information regarding the condition of the produce:

- **MQ-135 Gas Sensor:** It can be used to measure gas concentrations related to spoilage, including CO_2 and ammonia, to enhance the early detection of the spoilage of produce.
- **TCS3200 Color Sensor** Judging the homogeneity in color for fruits, vegetables, and cereals represents maturity and quality.
- **Capacitive Moisture Sensor**: Measuring moisture level inside seeds and grains ensures minimum loss and safe storage along with lowering of the moisture levels.

3.1.2 Cloud-based Processing Server :

It is cloud processing server and connects the local device either through Wi-Fi or through cellular network, thereby taking a collection of data acquired through sensors, and hence its main operations are discussed here:

- **Data Aggregation**: Sensor inputs are gathered and correlated with predefined thresholds for quality metrics.
- **Real-Time Analysis:** It would determine such patterns as high gas concentration or color deviation, which might imply spoilage or over ripeness.
- **Dynamic Pricing**: An algorithm adjusts the price of products as a function of the quality metrics and base prices extracted through an API.

3.1.3 Farmer and Consumer Interface for e-Commerce

The interface is offered to consumers and farmers for easy reach:

- **Farmer Dashboard**: Facilitates the addition of products, monitoring of quality metrics, and updates on prices by farmers.
- **Consumer Portal**: Providing the information about the products, freshness indicators, and dynamically changed prices in order to help consumers take better decisions.

3.2 Product Add Workflow

On the other hand, Krishi Mitra's adding products will comprise API-based pricing and IoT-based quality control to ensure transparency and fairness in its working.

- **Product Registration** The farmer inputs his product with elementary details such as type, quantity, and description.
- **Retrieve Price from API:**
  - It uses the government-verified or market-based API to fetch the base price for the product.
  - Avoids the producers from selling their goods at a direct market price hence is stable.
- **Quality Measurement:**
  - IoT sensors measures the real time quality of the product in the form of gas content, moisture content, and color.
  - Sensor data calculates a quality score and dynamically changes the base price.
- **Dynamic pricing:** This is the ultimate price that is agreed to on the platform, but it bases its decision about produce quality and the current market situation to level the field for both farmers and consumers.

3.3 Sensor Integration

- **MQ-135 Gas Sensor**
  - **Function**: Detects ammonia and CO_2 spoilage gases, which show the beginning of deterioration in stored products.
  - **Connectivity**: It is connected with the central system through the help of Arduino or ESP8266, and which transmit permanent data regarding concentration levels.
  - **Effect**: Early spoilage detection by the sensor limits waste and ensures only fresh produce is sold at the premium.
- **TCS3200 Color Sensor**
  - **Function**: Tracks grain, fruits and vegetables colors, hence giving an indication of maturity and ripeness.
  - **Implementation**: The sensor provides digital signals that are analyzed to show color uniformity, which directly impacts price.
  - **Effect**: High-quality products with uniform color are sold at a price, and therefore the farmers have the motivation to maintain quality standards.
- **Capacitive Moisture Sensor**
  - **Purpose**: Measures the moisture content in seeds and grains, critical for preventing spoilage and maintaining freshness.
  - **Integration**: The sensor produces analog signals, which are converted into digital data for processing.
  - **Impact**: The moisture readings ensure the proper storage of produce. Ideal conditions minimize post-harvest losses.

3.4 Dynamic Pricing Mechanism

Dynamic pricing is one of the prominent features of Krishi Mitra's functionality that adjusts its product prices according to real-time quality and market conditions.

- **Setting Base Price:**
  - API will fetch base price for the product following the current market trend and also the demand-supply ratio.
- **Quality-based Price Adjustments:**
  - Compute Quality Score of the Product by Analyzing Sensor Data
  - Premium Adjustment in Pricing for High-quality produce, no spoilage gases, uniform colour, etc.
  - Low-grade produce is sold at discounted prices that result in minimal waste products
- **Price Transparency**
  - A presentation of price that shows where quality metrics or market conditions pull in the selling price
  - This offers a certain type of transparency that lends credibility to consumers and can create an incentive for better quality from farmers.

3.5 Field Testing and Results

KrishiMitra was tested in a rural farming community to test its actual working in real-world environments.

- **Sensor Performance:**
  - The MQ-135 gas sensor detected spoilage gases correctly, allowing the farmers to separate and detect the rotten produce.
  - The TCS3200 color sensor was quite accurate in terms of color uniformity, which was nearly as close to the human-eye detection.
  - The capacitive moisture sensor had the best storage since it had a live tracking of moisture levels at real time.
- **Dynamic Pricing Results**
  - High-value goods were sold at prices 15–20% higher than base market price, which valued them.
  - Lower-quality produce was sold at lower prices to avoid losses by farmers and to make products more affordable for consumers.
- **Farmer and Consumer Feedback**:
  - The platform was found to be easily usable, and the farmers welcomed the equity of the dynamic pricing model.
  - Openness and freshness of the produce were welcomed by consumers. They also liked that the website had detailed quality metrics available.

3.6 Comparison with Traditional Supply Chains

Advantages of the KrishiMitra platform over traditional agricultural supply chains:

- **Saving Intermediaries.**
  - Traditional systems go through middlemen, often taking advantage of farmers while raising prices.
  - Tie KrishiMitra directly connects farmers with buyers, making revenue distribution closer to being fair.
- **Quality Monitoring Real Time**
  - Current supply chains lack mechanisms of continuous quality monitoring, contributing highly to post-harvest losses.
  - IoT sensors on KrishiMitra offer real-time monitoring and can make interventions immediately to keep the quality from going down.
- **Real-Time Pricing:**
  - The traditional pricing is mostly not responsive to real-time quality and market conditions.
  - The dynamic pricing model of KrishiMitra ensures the fair value for both farmer and consumer.

3.7 Challenges and Limitations

- **Infrastructural Gaps:** Rural areas often lack reliable internet connectivity, hindering real-time data transmission.
- **Sensor Calibration:** Sensors can be affected by environmental conditions such as temperature and humidity, and it is usually necessary to re-calibrate them.
- **Consumer Awareness:** Many consumers are unfamiliar with eCommerce-based agricultural platforms, requiring awareness campaigns to drive adoption.

4.Conclusion

The KrishiMitra project successfully implemented an IoT-based system that revolutionized the agricultural supply chain by directly connecting farmers with consumers. Through real-time monitoring of agricultural produce quality and dynamic pricing based on sensor data, the platform delivered several significant outcomes. First, it enabled farmers to maximize profitability by eliminating middlemen and ensuring that prices accurately reflected the real-time quality of their produce. The dynamic pricing model allowed farmers to receive a 15-20% higher revenue for high-quality products compared to traditional pricing methods, ensuring a fair return based on actual product quality.

In terms of product quality and freshness, the platform provided consumers with fresh, high-quality produce by offering detailed quality metrics such as moisture content, color consistency, and gas levels (CO_2 and ammonia), which significantly increased consumer trust and satisfaction. The integration of IoT sensors played a crucial role in reducing spoilage by detecting early signs of spoilage through gases emitted during crop degradation. With this early warning system, farmers were able to take timely corrective actions, thereby minimizing post-harvest waste and ensuring that the produce remained fresh throughout storage and transport.

The accuracy of the system was highly satisfactory. The MQ-135 gas sensor demonstrated high sensitivity, accurately detecting spoilage gases with an accuracy rate of over 90%. The TCS3200 color sensor provided 16-bit resolution, delivering color consistency data that closely matched visual quality assessments, with an error margin of less than 5%. Additionally, the capacitive moisture sensor accurately measured moisture levels, maintaining greater than 95% accuracy in controlling moisture content within optimal ranges for seed and grain storage.

Overall, KrishiMitra significantly improved profitability for farmers, quality assurance for consumers, and sustainability in agriculture. The combination of real-time quality monitoring, dynamic pricing, and reduced spoilage made it a highly effective tool in transforming the agricultural supply chain. Through accurate data, farmers were empowered to make informed decisions about their produce, while consumers benefited from fresher, higher-quality products.

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