Adichunchanagiri University

Faculty of Engineering, Management &Technology

BGS Institute of Technology

Department of Computer Science & Engineering

(Approved by AICTE, New Delhi, Affiliated to ACU & Recognized by Govt. of Karnataka)
BG Nagara – 571448, Nagamangala Taluk, Mandya District, Karnataka (INDIA)

A Project Work Phase-2 Report
On
"CropSafe : Navigating Storage Space For Farmers Using AI"

Submitted in partial fulfillment for the award of degree of

Bachelor of Engineering
In
Computer Science & Engineering

Submitted by:

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ADICHUNCHANAGIRI UNIVERSITY

CERTIFICATE

This is to certify that the project work report entitle **"CropSafe : Navigating Storage Space For Farmers Using AI"** has been successfully carried out by **GURUKIRAN K L [20CSE020], HARSHITH GOWDA P [20CSE022], HEMANTH Y D [20CSE026], MANOJ V [20CSE044]** bonafide students of **BGS Institute of Technology** in partial fulfilment of the requirements **of Degree of Bachelor of Engineering in Computer Science & Engineering of Adichunchanagiri University, B G Nagara** during the academic year 2023-2024. It is certified that all corrections/suggestions indicated for the internal assessment have been incorporated in the report deposited in the Department library. The project report has been approved as it satisfies the academic requirements with respect to the project work prescribed for Bachelor of Engineering Degree.

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ABSTRACT

This study introduces a methodology that harnesses the power of Artificial Intelligence (AI) to address two critical challenges in agriculture: reducing the cost of cold storage facilities and providing farmers with real-time knowledge about the prices of their crops. The implementation of AI technologies offers innovative solutions to enhance efficiency, reduce wastage, and empower farmers with valuable market insights. The first aspect of the methodology focuses on optimizing cold storage operations. Traditional cold storage systems often incur high energy costs and operational inefficiencies. By integrating AI algorithms and predictive analytics, this study proposes a smart cold storage management system. The system dynamically adjusts temperature settings based on real-time demand forecasts, thereby minimizing energy consumption while ensuring the preservation of agricultural produce. This cost-effective approach not only reduces operational expenses for cold storage facilities but also contributes to the overall sustainability of the agricultural supply chain.

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Chapter 1

INTRODUCTION

1.1 Overview

The agricultural sector stands at the forefront of global challenges, tasked with ensuring food security, reducing post-harvest losses, and improving the livelihoods of millions of farmers worldwide. In this context, the integration of advanced technologies becomes paramount to address existing inefficiencies and bridge information gaps within the agricultural supply chain. This study explores the transformative potential of leveraging Artificial Intelligence (AI) to enhance both cold storage management and empower farmers with real- time crop price knowledge, thereby contributing to a more efficient, sustainable, and equitable agricultural ecosystem.

1. Background:

Traditional cold storage systems, essential for preserving perishable agricultural produce, often operate with fixed parameters, leading to inefficiencies and high operational costs. Concurrently, farmers face challenges in accessing timely and accurate market information, hindering their ability to make informed decisions about crop pricing and market entry points. The combination of outdated cold storage practices and limited market knowledge perpetuates post-harvest losses and economic vulnerabilities among farmers.

2. Rationale:

The advent of Artificial Intelligence presents an opportunity to revolutionize the agricultural supply chain. By integrating AI algorithms, predictive analytics, and smart data management, this study proposes a comprehensive system aimed at optimizing cold storage operations and empowering farmers with actionable market insights. The rationale behind this approach lies in the potential to enhance efficiency, reduce waste, and uplift the economic well-being of farmers, ultimately contributing to a more resilient and sustainable agricultural sector.

3. Objectives:

Optimize cold storage operations through AI-driven dynamic temperature control and predictive maintenance, thereby reducing energy consumption and operational costs. Empower farmers with real-time market information using AI-powered applications, enhancing their ability to make informed decisions about crop pricing and market engagement.

4. Significance of the Study:

The proposed system holds significant implications for the agricultural sector. By introducing intelligent cold storage management and empowering farmers with AI-drivenmarket insights, the study seeks to reduce post-harvest losses, enhance the economic viability of farming practices, and contribute to the overall sustainability of agriculture. The outcomes of this research are expected to inform policymakers, technology developers, and agricultural stakeholders, facilitating the adoption of advanced technologies to address critical challenges in the industry.

1.2 Existing System

1. **Conventional Cold Storage Systems:**

Disadvantages:

- Lack of Adaptability: Traditional cold storage facilities often operate with fixed temperature settings, leading to inefficiencies when faced with fluctuating demand or external climate variations.
- High Operational Costs: The absence of smart, adaptive systems results in higher energy consumption and operational costs, limiting the economic feasibility of cold storage for small-scale farmers.

2. Manual Market Information Gathering:

Disadvantages:

- Time Lag: Farmers rely on manual methods or delayed information sources to learn about market prices, leading to missed opportunities and suboptimal decision-making.
- Limited Accessibility: In many regions, farmers, especially those in remote areas, Face challenges accessing real-time market information due to infrastructure limitations and lack of digital connectivity.

3. Fragmented Data Ecosystem:

Disadvantages:

- Information Silos: Existing systems often lack integration, resulting in fragmented datathat is not easily accessible or usable for comprehensive decision-making.

- Limited Analytics: The absence of advanced analytics tools hampers the extraction of meaningful insights from the available data, hindering effective market analysis.

1.3 Proposed System

The proposed system incorporates cutting-edge technologies to address the existing challengesin the agricultural supply chain. The system consists of two main components: AI-optimized Cold Storage Management and AI-driven Farmer Empowerment.

1. AI-Optimized Cold Storage Management:

- **Dynamic Temperature Control:** Utilizes AI algorithms and predictive analytics to dynamically adjust temperature settings based on real-time demand forecasts, optimizing energy consumption and reducing operational costs. Adapts to external climate variations, ensuring the preservation of agricultural producewhile minimizing environmental impact.
- **Predictive Maintenance:** Implements AI-driven predictive maintenance models to anticipate equipment failures and schedule maintenance activities, preventing unexpected downtime and reducing repair costs.
- **Integration with Supply Chain:** Establishes seamless integration with the overall supply chain, allowing real-time communication and coordination to optimize the storage of perishable goods and reduce wastage.

2. AI-Driven Farmer Empowerment:

- **Real-Time Market Information:** Develops user-friendly applications powered by AI and data analytics to provide farmers with real-time market prices, trends, and demand forecasts for their crops.
- **Decision Support System:** Incorporates a decision support system that leverages machine learning to offer personalized recommendations to farmers on optimal harvest times, pricing strategies, and market entry points.
- **Training and Support:** Implements training programs to familiarize farmers with the AI-powered tools and ensurewidespread adoption. Provides ongoing support to address technical queries and challenges faced by farmers duringthe adoption process.
- **Market Access Platform:** Facilitates direct interaction between farmers and potential as

Reducing dependency onintermediaries and empowering farmers to negotiate fair prices independently.

3. Data Integration and Analytics:

- **Unified Data Platform:** Establishes a unified data platform that integrates information from various stages of the supply chain, including cold storage facilities, transportation, and market transactions.
- **Advanced Analytics:** Implements advanced analytics tools to extract meaningful insights from the integrated data, enabling stakeholders to make informed decisions and optimize overall supply chain performance.

1.4 Problem statement

The agricultural sector faces a dual challenge that requires innovative solutions to optimize resource utilization and empower farmers with critical market information. Onemajor issue is the inefficiency and high operational costs associated with traditional cold storage facilities. These facilities, essential for preserving agricultural produce, often lack adaptive and intelligent systems, resulting in excessive energy consumption and operational inefficiencies. Simultaneously, farmers frequently encounter challenges in obtaining real-time information about the market prices of their crops, leading to suboptimal selling strategies, reduced bargaining power, and economic uncertainties. The lack of smart management systems in cold storage facilities contributes to increasedenergy costs and environmental impact. Conventional storage practices often fail to adaptto fluctuating demand and market conditions, leading to wastage and financial losses. Additionally, farmers, particularly in developing regions, lack timely access to accurate market data, hindering their ability to make informed decisions regarding the timing andpricing of their harvests. This information gap perpetuates a cycle of economicvulnerability for farmers and limits their potential for sustainable agricultural practices. Addressing these challenges requires a comprehensive approach that integrates Artificial Intelligence (AI) technologies. By leveraging AI algorithms, predictive analytics, andsmart data management, it is possible to create cost-effective and energy-efficient cold storage solutions. Simultaneously, AI can be employed to develop user-friendly applications that provide farmers with real-time market insights, enabling them tonavigate the complexities of the market and improve their economic outcomes. Therefore, the problem at hand involves the need for an integrated AI-driven methodology that addresses both the inefficiencies in cold storage systems and the lack of timely market information for farmers. Developing such a solution is crucial for fostering sustainability in agriculture, reducing post-harvest losses, and empowering farmers to make informed decisions that positively impact their livelihoods.

1.5 The solution

1. AI-Driven Cold Storage Optimization:

- **Smart Sensor Integration:** Implementing sensors equipped with AI algorithms to monitor and regulate temperature, humidity, and inventory levels within cold storage units. This ensures optimal conditions for preserving produce while minimizing energy consumption.
- **Predictive Maintenance**: AI-powered predictive maintenance models can detect potential equipment issues before they occur, reducing downtime and operational inefficiencies.
- **Energy Efficiency:** Utilizing AI algorithms to optimize energy usage within cold storage facilities, identifying patterns and adjusting energy consumption during peak and off-peak hours.

2. Farmer-Centric Market Information Solutions:

- **Real-Time Market Insights:** Developing user-friendly mobile applications or platforms that leverage AI for analyzing market data, providing farmers with real-time pricing, demand forecasts, and supply chain information.
- **Localized Data Access:** Customizing these applications to cater to regional variations, languages, and specific crop-related market dynamics to ensure relevance and usabilityfor farmers in diverse areas.
- **Education and Training:** Offering training and support to farmers on utilizing these AI-powered tools effectively, ensuring they can make informed decisions based on the provided insights. crop-related market dynamics to ensure relevance and usability for farmers in diverse areas. applications to cater.

3. Integration and Collaboration:

- **Public-Private Partnerships:** Collaborations between tech companies, agricultural experts, governments, and farmer cooperatives to implement and scale these AI-driven solutions effectively,
- **Infrastructure Development:** Investing in infrastructure upgrades to facilitate internet connectivity and access to these technological solutions in remote agricultural areas.

1.6 Objectives

AgriFarm aims to transform the agricultural industry by revolutionizing the supply chain and enhancing communication and coordination among farmers, intermediaries, cold storage facilities, and consumers. With the integration of machine learning capabilities, AgriFarm can offer valuable insights to farmers, reduce wastage, and enhance product quality.

- **Enhanced Efficiency:** AgriFarm seeks to streamline the agricultural supply chain by fostering improved communication and coordination among farmers, intermediaries, cold storage facilities, and consumers.
- **Increased Profitability:** Through supply chain optimization, AgriFarm aims to reduce waste, lower transportation costs, and enhance product quality. Ultimately, these efforts are geared toward boosting the profitability of both farmers and intermediaries.
- **Enhanced Food Security:** AgriFarm plays a pivotal role in bolstering food security. It ensures a consistent supply of high-quality products to consumers, even during uncertain times, thereby contributing significantly to improved food security.

1.7 Project Scope

Agricultural Hubs and Innovation Centers:

- **Countries with Strong Agricultural Industries:** Nations like the United States, Canada, Brazil, and parts of Europe invest in advanced technology to enhance agricultural practices. AI integration in these regions aims to optimize efficiency and sustainability in both production and post-harvest management.
- **Research and Development Institutions:** Agricultural Research Centers and Universities: Many research institutions work on AI-driven projects to improve farming

techniques, enhance storage facilities, and develop applications that cater to farmers' needs.

- **Public-Private Collaborations:** Partnerships Between Governments, Tech Companies, and NGOs: These collaborations often work on pilot projects or larger initiatives to implement AI solutions in agriculture, addressing both storage issues and farmers' access to market information. Partnerships Between Governments, Tech Companies, and NGOs: These collaborations.

Chapter 2

LITERATURE SURVEY

2.1 Survey Papers

PAPER 1

TITLE: “Assessing the Readiness of Farmers towards Cold Chain Management”

YEAR: 2020

AUTHOR: Rohit Joshi, Sudhanshu Joshi

ABSTRACT:

The purpose of the paper is to gain an insight into the current status of farmers’ awareness and practices towards maintaining the postharvest cold chain. The related hypotheses are developed and tested. The major findings include- marginalized and small farms, literacy and poor awareness level are the main causes for the backwardness of Indian farmers. Also, lack of funds forces farmers to ignore the use of cold storage. Further, multi-intermediaries and fluctuating consumer prices result farmers in not getting fair share of the consumer rupee. One of the major challenges in front of fresh food industry in India is to reduce postharvest losses across the chain through increasing awareness level of famers towards cold chain, building market information systems to assist farmers in decision-making and improving food safety and quality of farm produce available in the market. The purpose of the paper is to gain an insight into the current status of farmers’ awareness and practices towards maintaining the postharvest cold chain. Also, lack of funds forces farmers to ignore the use of cold storage. into the current Also, lack of funds.

Merits:

- Cold storage helps maintain the quality of perishable goods.

Demerits:

- If the analysis reveals consistently high utilization rates, it may indicate insufficient cold storage capacity.

PAPER 2

TITLE: "Analysis of Cold Storage Capacity Utilization with Specific Reference to a Farmers Market"

YEAR: 2020

AUTHOR: S. Moghana Lavanya, K. Mahendran, S. Hemalatha

ABSTRACT: Agricultural supply chains are redundant with intermediaries and in price exploitation of farmers in marketing their produce. In order to help farmers realize better prices, direct marketing concept such as Uzahavar sandhai in Tamil Nadu, Rythu Bazar in AP etc were initiated. The study was undertaken to know the usage of cold storage units in the farmers market located in Anna Nagar, Madurai of Tamil Nadu. Thesecondary information regarding the arrivals, number of farmers and number of consumers participated, usage of cold storage facility were collected for the past five years and same was analyzed and presented. The results indicated that capacity utilization of the cold storage unit available was low and sufficient interventions are needed for promoting better usage.

Merits:

- Cold storage helps maintain the quality of perishable goods.

Demerits:

- If the analysis reveals consistently high utilization rates, it may indicate insufficient cold storage capacity**.**

PAPER 3

TITLE: "Fresh Agricultural Products Supply Chain Coordination and Volume Loss Reduction Based on Strategic Consumer"

YEAR: 2020

AUTHOR: Fang Qiu , Qifan Hu and Bing Xu

ABSTRACT: The reduction of fresh agricultural product volume loss throughout the Supply the high importance due to their perishable nature and impact on society,the economy, the reduction of fresh agricultural product volume loss throughout the supply chain system is of high importance due to their perishable nature and impact on society,the economy, and environment. In this paper, three models for two-stage pricing, coordination, and volume loss reduction of the supply chain where third-party logisticsservice providers and retailers act as a Stackelberg leader and a follower for fresh agricultural products are developed, taking into account both volume loss during transport and quality loss in retail in the presence of strategic consumers. The following results are drawn from the contract for sharing revenues and service costs: (1) The supply chain achieve coordination and the products are healthier for consumers; (2) the coordination leads to a reduction in the three types of volume losses simultaneously only if the lowest marginal costs of the supply chain occur under certain conditions; and (3) the increase in the service sensitivity coefficient, the increase in the freshness discount coefficient under certain conditions, the decrease in the consumer benefit discount coefficient under certain conditions, and the decrease in the price sensitivity coefficient lead to an increase in the profit of the supply chain and a reduction in the three types of volume losses.

Merits:

- Coordinated supply chain efforts can lead to a reduction in volume loss and waste.

Demerits:

- Consumer preferences can vary widely, making it difficult to implement a one-size-fits-all strategy.

PAPER 4

TITLE: “Automation and digitization of agriculture using artificial intelligence”

YEAR: 2020

AUTHOR: A. Subeesh ,C.R. Mehta

ABSTRACT: The growing population and effect of climate change have put a huge responsibility on the agriculture sector to increase food-grain production and productivity. In most of the countries where the expansion of cropland is merely impossible, agriculture Automation has become the only option and is the need of the hour. Internet of things and agriculture. Advancement in these digital technologies has made revolutionary changes in agriculture by providing smart systems that can monitor, control, and visualize various farm operations in real-time and with comparable intelligence of human experts. The potential applications of IoT and AI inthe development of smart farm machinery, irrigation systems, weed and pest control, fertilizer application, greenhouse cultivation, storage structures, drones for plant protection, crop health monitoring, etc. are discussed in the paper. The main objective of the paper is to provide an overview of recent research in the area of digital technology-driven agriculture and identification of the most prominent applications in the field of agriculture engineering using artificial intelligence and internet of things. The research work done in the areas during the last 10 years has been reviewed from the scientific databases including PubMed, Web of Science, and Scopus. It has been observed that the digitization of agriculture using AI and IoT has matured from their nascent conceptual stage and reached the execution phase. The technical details of artificial intelligence, IoT, and challenges related to the adoption of these digital technologies are also discussed. This will help in understanding how digital technologies can be integrated into agriculture practices and pave the way for the implementation of AI and IoT-based solutions in the farms.

Merits:

- Automation generates vast amounts of data, and AI helps analyze this data to make informed decisions.

Demerits:

- Integrating different technologies and ensuring they work seamlessly together can be complex.

PAPER 5

TITLE: "Artificial Intelligence: Implications for the Agri-Food Sector"

YEAR: 2020

AUTHOR: Akriti Taneja, Gayathri Nair, Manisha Joshi

ABSTRACT: Artificial intelligence (AI) involves the development of algorithms and the further Artificial intelligence (AI) involves the development of algorithms and computational models that enable machines to process and analyze large amounts of data, identify patterns and relationships, and make predictions or decisions based on that analysis. AI has become increasingly pervasive across a wide range of industries and sectors, with healthcare, finance, transportation, manufacturing, retail, education, and agriculture are a few examples to mention. As AI technology continues to advance, it is expected to have an even greater impact on industries in the future. For instance, AI is being increasingly used in the agri-food sector to improve productivity, efficiency, and sustainability. It has the potential to revolutionize the agri-food sector in several ways, including but not limited to precision agriculture, crop monitoring, predictive analytics, supply chain optimization, food processing, quality control, personalized nutrition, and food safety. This review emphasizes how recent developments in AI technology have transformed the agri-food sector by improving efficiency, reducing waste, and enhancing food safety and quality, providing particular examples. Furthermore, the challenges, limitations, and future prospects of AI in the field of food and agriculture are summarized.

Merits:

- AI can analyze vast amounts of data to identify early signs of crop diseases and pest infestations.

Demerits:

- The collection and sharing of sensitive agricultural data raise concerns about privacy and security.

PAPER 6

TITLE: “A review of the performance of domestic refrigerators”

YEAR: 2008

AUTHOR: S. J. James , J. Evans, C. James

ABSTRACT: This paper reviews the published data on the performance and use of the last min

This paper reviews the published data on the performance and use of domestic refrigerators throughout the world in the last 30 years. While there are considerable legislation defining maximum temperatures during the production, distribution and retailing of chilled food, as soon as the consumer purchases the food, it is outside of any of these legislative requirements. Inadequate domestic refrigeration or cooling is frequently cited as a possible factor in food poisoning incidents. It is clear from the many published surveys that many refrigerators throughout the world are running at higher than recommended temperatures. Since even these recommended temperatures are higher than the 0 to 1℃ that is usually the recommended temperature range for storing fish and seafood, meat and many chilled products the current situation is even more detrimental to maintaining the high quality life of chilled foods. Despite numerous surveys around the world, how refrigerator temperatures and cleanliness impacts on consumer health remains to be fully assessed. higher than the 0 to 1℃ that is usually the recommended temperature range the production, distribution and retailing of chilled food, as soon hat is usually the recommended temperature.

Merits:

- This information is valuable for consumers looking to minimize their energy consumption and reduce utility bills.

Demerits:

- This limitation can result in incomplete information for consumers trying tocompare a wide range of options.

PAPER 7

TITLE: "Post-harvest storage and preservation of tropical crops"

YEAR: 1993

AUTHOR: Aidoo, K. E.

ABSTRACT: On a world-wide basis, post-harvest losses of durable crops are estimated at 10%, but in Africa, Asia and Latin America, losses of 20% are frequently encountered. Attention is now being focused on improving farm-level post-harvest systems in many developing countries for all types of crops, namely staple foods, export crops, secondary food products and animal feeds. The humid tropical climate promotes microbial proliferation on food crops and feeds, often resulting in formation of my cotoxins. Improvements in the traditional post-harvest crop-handling and storage techniques would minimize or eliminate losses caused by bio deteriorative agents. The post-harvest storage of some tropical crops and traditional methods of food preservation are described. Improvements in the traditional post-harvest crop-handling and storage techniques would minimize or frequently encountered. Attention is now being focused on improving farm-level post-harvest systems feeds. The humid tropical climate promotes microbial proliferation on food crops and feeds, often resulting.

Merits:

- This is particularly important in the context of global efforts to address foodsecurity and sustainable resource use.

Demerits:

- Implementing effective post-harvest storage and preservation methods may require infrastructure investments, such as cold storage facilities and transportation systems.

PAPER 8

TITLE: "Stability of perishable goods in cold logistic chains"

YEAR: 2005

AUTHOR: Bogataj, M., Bogataj, L. & Vodopivec

ABSTRACT: We consider that production and logistics facilities in the supply chain are positioned between the origin and the supply market or in a part of it. Any changes in time-distance or temperature in the chain could cause the net present value of the activities and their added value in the supply chain to be perturbed. In reality the perturbations can be robust. The natural question arises is to what are the effects of some perturbations in a supply chain, in its production or distribution part, on the stability of perishable goods in such systems and what is the appropriate control whichkeeps the product on the required level of quality and quantity at the final delivery. These analyses are especially important to assure the stability of cold chains in the coldchains management (CCM). What conditions should be fulfilled to assure that after such robust perturbations of parameters and especially time delays (lead times and some other delays) the behavior of the logistics chain would still be within the prescribed limits. The formulation obtained in the time domain will be compared with the formulation in the frequency space introduced by Grubbström in his paper "On the Application of the Laplace Transform to Certain Economic Problems" (Manage. Sci. (7) (1967) 558) and with the later studies of his school. Their model was extended by the authors to the complete logistic chain, where location — and with it also the distance between the activity cells of logistic chain — play an important role. parameters and especially time delays (lead times and some other delays) the behavior of the logistics chain.

Merits:

- Cold logistic chains contribute to extending the shelf life of perishable goods.

Demerits:

- The operational costs associated with energy consumption and maintenance canbe high.

PAPER 9

TITLE: “Interactions among cooling, fungicide and postharvest ripening temperature“

YEAR: 2009

AUTHOR: Allais, I., & Letang, G.

ABSTRACT: Peach fruit (Prunus persica L. cv. ‘Miraflores’) harvested at the firm-ripe stage, treated or not with 2 g l−1 iprodione, were cooled or not at 1°C and ripened at 15 or 20°C and 95% RH for 10 days. During ripening, weight loss, fungal development and changes in quality parameters (firmness, soluble solids content, titratable acidity, pH and ground and flesh color), and carbon dioxide and ethylene production were monitored. Cooling alone or combined with iprodione avoided Rhizopus nigricans decay during ripening at either ripening temperatures. A skin damage not previously reported on fungicide treated peach was observed at 20°C. Cooled fruit ripened at 15°C showed an anomalous respiration rate and ethylene production after the climacteric peak, a loss of firmness and a drop in titratable acidity after 7 days of storage, and reduced endo-polygalacturonase activity in presence of continuous pectinmethylesterase activity during the first week. Cooling before ripening at 20°C ledto the best flavor without excessive total losses. These results helped in the optimization of warming cycles during cold storage used to avoid chilling injuries development on peaches.

Merits:

- The interaction between cooling, fungicide application, and postharvest ripening temperature can contribute to an extended shelf life for peaches.

Demerits:

- The use of fungicides raises environmental concerns, especially if they contain chemicals that may have adverse effects on ecosystems.

Chapter 3

SOFTWARE REQUIREMENT

3.1 Functional Requirements

- User registration and Authentication
- Crop Management
- Cold storage monitoring.
- AI powered Crop price prediction

3.2 Nonfunctional Requirements

Non-functional requirements are the requirements which are not directly concerned with the specific function delivered by the system. They specify the criteria that can be usedto judge the operation of a system rather than specific behaviors. They may relate to emergent system properties such as reliability, response time and store occupancy. Non- functional requirements arise through the user needs, because of budget constraints, organizational policies, the need for interoperability with other software and hardware systems or because of external factors such as:

- Product Requirements
- Organizational Requirements
- User Requirements
- Basic Operational Requirements.

3.3 System Requirements

Software requirement Specification is a fundamental document, which forms the foundation of the software development process. It not only lists the requirements of a system but also has a description of its major feature. An SRS is basically an organization's understanding (in writing) of a customer or potential client's system requirements and dependencies at a particular point in time (usually) prior to any actual design or development work. It's a two-way insurance policy that assures that both the client and the organization understand the other's requirements from that perspective at a given point in time. The SRS also functions as a blueprint for completing a project with as little cost growth as possible. The SRS is often referred to as the "parent" document because all subsequent project management documents, such as design specifications, statements of work, software architecture specifications, testing and validation plans, and documentation plans only; it doesn't offer design suggestions, possible solutions to technology or business issues, or any other information other than what the development team understands the customer's system requirements to be.

HARDWARE REQUIREMENTS

- System : Intel IV 2.4 GHz.
- Hard Disk : 500 GB.
- Ram : 4 GB

SOFTWARE REQUIREMENTS

- Operating system : Windows 7 / 8 / 10
- Coding Language : Python
- Software : Anaconda
- IDE : Spyder / Jupyter Notebook /Pycharm

SPYDER

Spyder, the Scientific Python Development Environment, is a free integrated development environment (IDE) that is included with Anaconda. It includes editing, interactive testing, debugging, and introspection features. After you have installed Anaconda, start Spyder on Windows, macOS, or Linux by running the command spyder. Spyder is also pre-installed in Anaconda Navigator, which is included in Anaconda. On theNavigator Home tab, click the Spyder icon. For more information about spyder, seethe spyder web page or the spyder documentation. Anaconda command prompt is just like command prompt, but it makes sure that you are able to use anaconda and conda commands from the prompt, without having to change directories or your path. These locations contain commands and scripts that you can run. Navigator Home tab, click the Spyder icon. For more information about spyder, seethe spyder.

MATLAB for plotting graphs

- MATLAB combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly. It includes the live editor for creating scripts that combine code, output, and formatted text in an executable notebook

Professionally Built

- MATLAB toolboxes are professionally developed, rigorously tested, and fully documented.

With Interactive Apps

- MATLAB apps let you see how different algorithms work with your data. Iterate until you've got the results you want, then automatically generate a MATLAB program to reproduce or automate your work.

And the Ability to Scale

- Scale your analyses to run on clusters, GPUs, and clouds with only minor code changes. There's no need to rewrite your code or learn big data programming and out-of-memory techniques

Python Programming

- Python is a widely used general-purpose, high level programming language. It was created by Guido van Rossum in 1991 and further developed by the Python Software Foundation. It was designed with an emphasis on code readability, and its syntax allows programmers to expresstheir concepts in fewer lines of code.
- Python is a programming language that lets you work quickly and integrate systems more efficiently.

Finding an Interpreter:

- Before we start Python programming, we need to have an interpreter to interpret and run our programs. There are certain online interpreters like **https://ide.geeksforgeeks.org/**, http://ideone.com/ or http://codepad.org/ that can be used to run Python programs without installing an interpreter.

Chapter 4

SYSTEM ANALYSIS AND DESIGN

4.1 System Analysis

The proposed integrated AI-driven solution aims to revolutionize the agricultural sector by addressing the dual challenges associated with inefficient cold storage facilities and the lack of timely market information for farmers. The system design encompasses two main components: AI-enhanced cold storage management and a real-time market information platform for farmers. In the cold storage domain, advanced AI algorithms and predictive analytics will be integrated to optimize resource utilization, enhance operational efficiency, and reduce energy consumption. Smart sensors and monitoring devices will enable real-time data collection on temperature, humidity, and inventory levels, facilitating adaptive control systems to respond to fluctuating demand and market conditions. Additionally, the implementation of machine learning algorithms will enable predictive maintenance, minimizing downtime and further optimizing operational costs.

4.2 High Level Design

4.2.1 System Architecture:

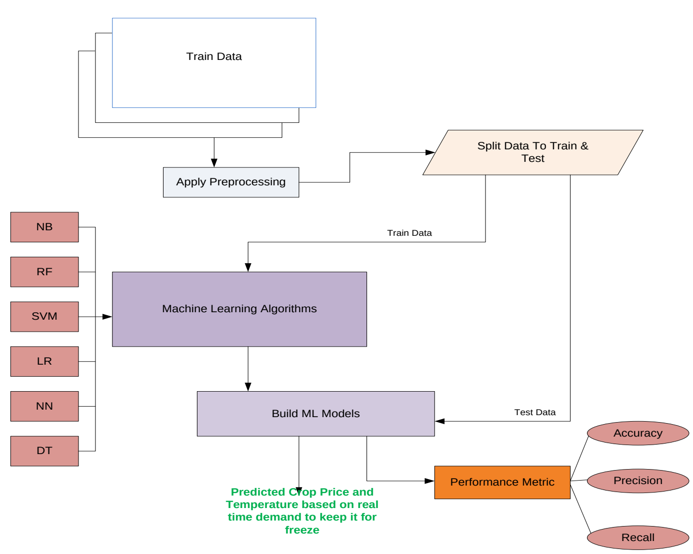


Fig 4.1 System Architecture

4.2.2 DB Design:

This DFD provides an overview of how data moves between processes and entities in the system. It showcases the flow of information from market sources to farmers and between cold storage facilities and AI systems, highlighting the integration points where AI-driven insights are generated and utilized.

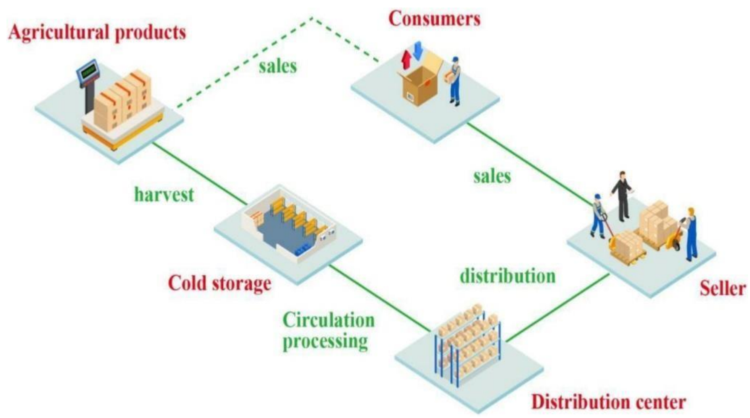


Fig 4.2 DB Design

4.2.3 ER Diagram

This ER diagram provides a visual representation of the entities involved, their relationships, and attributes, forming the foundation for understanding the data structure and interactions within the agricultural system integrating AI technologies.

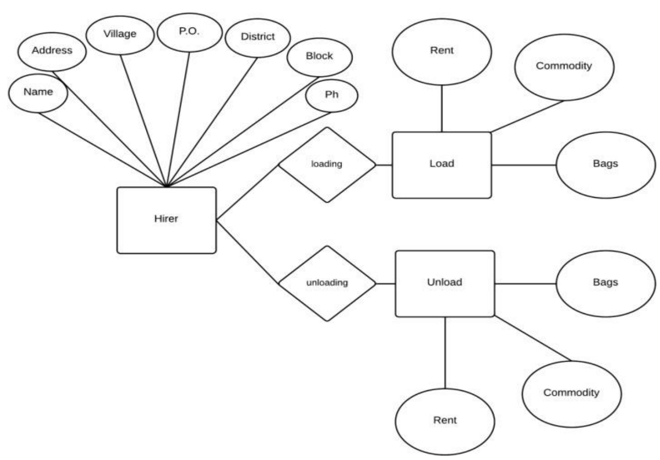


Fig 4.3 ER Diagram

4.3 Data Flow Diagram:

This data flow diagram outlines a holistic approach to addressing the challenges faced by the agricultural sector using AI technologies, emphasizing the integration of smart systems for both cold storage management and market information dissemination. The process begins with loading the dataset, which contains historical data on crop prices and temperature. The next step is to apply preprocessing techniques to clean and prepare the data for analysis. This involves handling missing values, normalizing or standardizing data, and encoding categorical variables. After preprocessing, the data is split into training and testing sets to ensure the model's performance can be evaluated. The training set is used to train and build the machine learning models, which learn patterns and relationships within the data. Finally, the trained models are used to make predictions on crop prices and temperature. The process concludes with a stop point, indicating the end of the workflow. clean and prepare the data for analysis. This involves handling missing values, normalizing or standardizing.

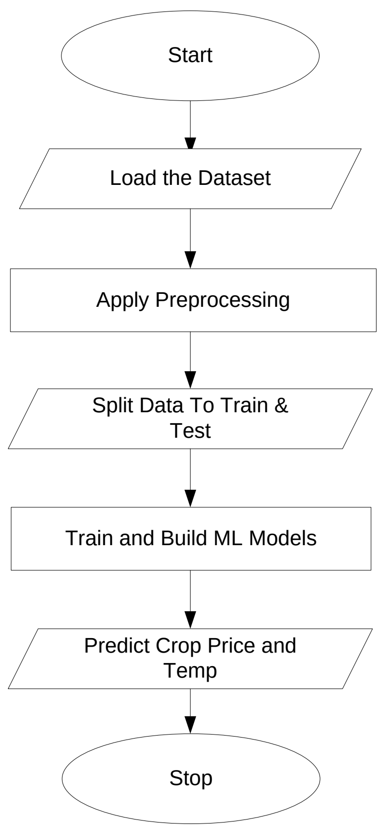


Fig 4.4 Data Flow Diagram

Chapter 5

IMPLEMENTATION

5.1 Methodology & Techniques

Step 1: Data Collection

- **Market Data**: Historical prices of various commodities from different markets.
- **Commodity Data**: Information on different types of crops.
- **Variety Data**: Specific varieties of each crop.
- **Grade Data**: Quality grades for each variety of the crops.
- **Other Relevant Data**: Weather conditions, soil data, supply and demand metrics, and seasonal factors.

Step 2: Data Preprocessing

- **Data Cleaning**: Handle missing values, remove duplicates, and correct errors.
- **Feature Engineering**: Create new features such as lagged prices, moving averages, and seasonal indicators. Encode categorical variables (market, commodity, variety, grade) using techniques like one-hot encoding.

Step 3: Exploratory Data Analysis (EDA)

- **Descriptive Statistics**: Understand the distribution and basic statistics of the data.
- **Correlation Analysis**: Check correlations between different features and the target variable (crop price).
- **Visualizations**: Use plots to visualize trends, seasonality, and relationships between features and target variable.

Step 4: Model Development

- **Data Splitting**: Split the dataset into training and test sets (e.g., 80% training, 20% testing).

Linear Regression

- **Model Training**: Fit a linear regression model to the training data.
- **Model Evaluation**: Evaluate the model using metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), and R-squared on the test set.

Lasso Regression

- **Model Training**: Fit a Lasso regression model, which includes L1 regularization, to the training data.
- **Hyper parameter Tuning**: Use techniques like cross-validation to find the best value of the regularization parameter (alpha).
- **Model Evaluation**: Evaluate the model using the same metrics as above.

Ridge Regression

- **Model Training**: Fit a Ridge regression model, which includes L2 regularization, to the training data.
- **Hyper parameter Tuning**: Use techniques like cross-validation to find the best value of the regularization parameter (alpha).

- **Model Evaluation**: Evaluate the model using the same metrics as above.

Step 5: Model Comparison

- **Compare Performance**: Compare the performance of linear, lasso, and ridge regression models based on evaluation metrics.
- **Select the Best Model**: Choose the model with the best performance for deployment.

5.2 Control Flow

5.2.1 Flow Chart

The process begins with loading raw data files, including market data, commodity data, variety data, and grade data, into a Data Frame. Once the data is loaded successfully, the next step is to handle any missing values by filling them appropriately. After addressing missing values, duplicate rows in the DataFrame are removed to ensure data quality. The flow then proceeds to correct any erroneous data within the Data Frame. Following data correction, feature engineering is conducted to create new features such as lagged prices, moving averages, and seasonal indicators, which are essential for model training. Categorical variables, such as market, commodity, variety, and grade, are then encoded using one-hot encoding to convert them into a numerical format suitable for modeling. Next, the features are normalized or scaled to standardize the data. Data Frame are removed to ensure data quality. The flow then proceeds to correct any erroneous data within the Data Frame. Following data correction, feature engineering is conducted.

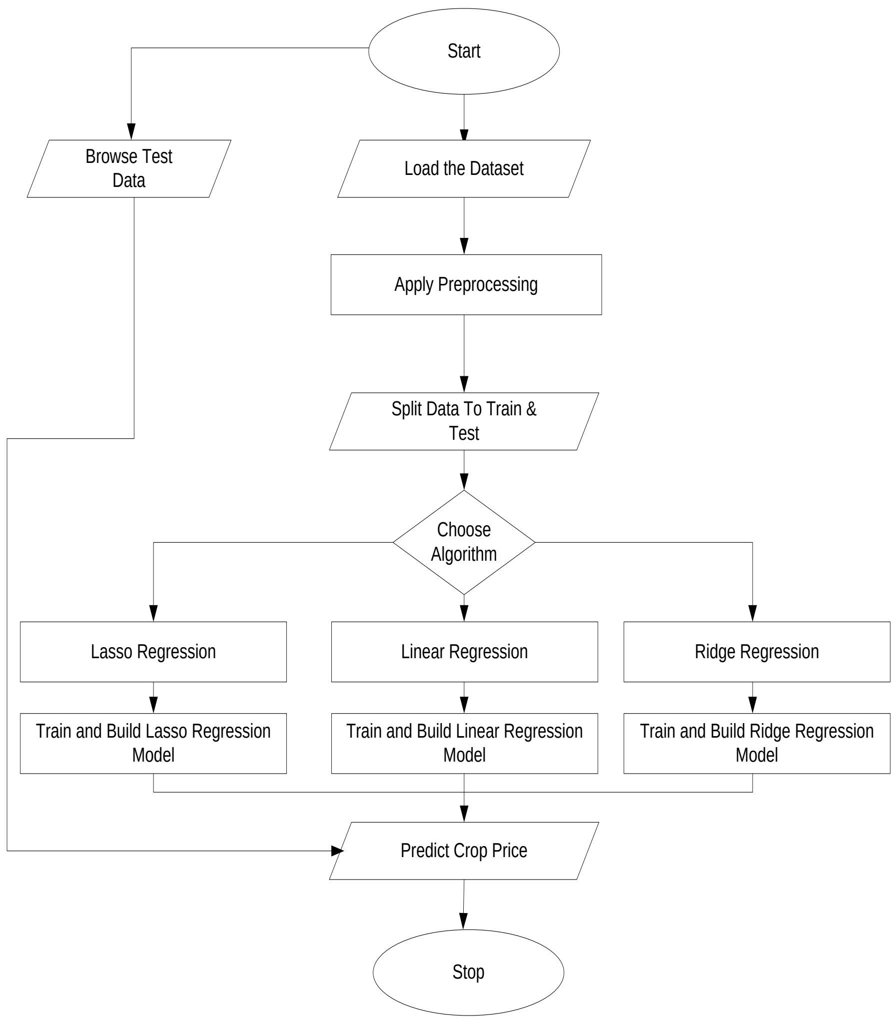


Fig 5.1 Flow Chart

5.2.2 Use case Diagram of the system

The use case diagram outlines a comprehensive workflow for developing a predictive pricing model. It starts with loading raw data files into a DataFrame, followed by handling missing values and removing duplicates to ensure data quality. The data is then corrected for any errors, and feature engineering is performed to create new predictive features. Categorical variables are one-hot encoded, and all features are normalized or scaled. The prepared data is split into training and test sets, and linear, Lasso, and Ridge regression models are trained and evaluated. The performance of these models is compared using metrics like MAE, MSE, and R-squared to identify the best model, which is then used for price prediction on new data. This methodical approach ensures accurate and reliable price predictions based on various market and commodity features. The data is then examined for errors, and necessary corrections are made to ensure accuracy. After cleaning the data, feature engineering is performed. This involves creating new features from the existing data, such as lagged prices, moving averages, and seasonal indicators.

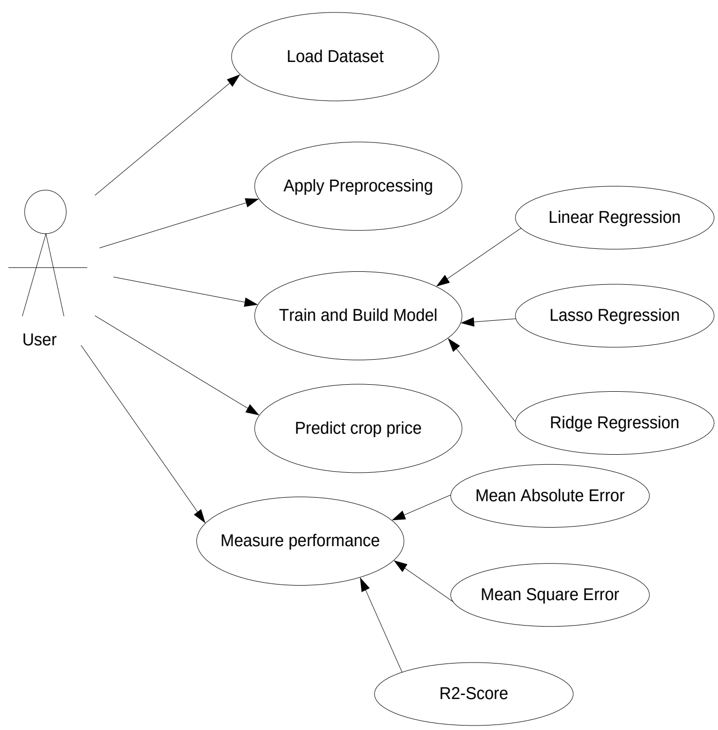


Fig 5.2 Use Case Diagram

5.3 Pseudo code or Algorithm

Step 1: Data Collection

- Input: Data from various sources
  - market_data: Historical prices from different markets
  - commodity_data: Information on different types of crops
  - variety_data: Specific varieties of each crop
  - grade_data: Quality grades for each variety

Step 2: Data Preprocessing

Pseudo code

Input: Raw data

Output: Processed data

1. Load the data
2. Clean the data:
   - Handle missing values
   - Remove duplicates
   - Correct errors
3. Feature Engineering:
   - Create lagged prices, moving averages, seasonal indicators
   - Encode categorical variables using one-hot encoding
4. Normalize/Scale the features

Step 3: Exploratory Data Analysis (EDA)

Pseudo code

Input: Processed data

Output: Insights and visualizations

1. Calculate descriptive statistics

2. Perform correlation analysis
3. Visualize trends, seasonality, and relationships

Step 4: Model Development

Data Splitting

Input: Processed data

Output: Training and test sets

1. Split data into features (X) and target (y)
2. Split X and y into training (X_train, y_train) and test sets (X_test, y_test)

Linear Regression

Input: Training data

Output: Trained linear regression model

1. Create a linear regression model
2. Train the model on X_train and y_train
3. Evaluate the model on X_test and y_test

Input: Training data

Output: Trained linear regression model

Lasso Regression

Input: Training data

Output: Trained lasso regression model

1. Create a lasso regression model
2. Use cross-validation to tune hyper parameter alpha
3. Train the model on X_train and y_train with the best alpha
4. Evaluate the model on X_test and y_test

Ridge Regression

Input: Training data

Output: Trained ridge regression model

1. Create a ridge regression model

2. Use cross-validation to tune hyperparameter alpha

3. Train the model on X_train and y_train with the best alpha

4. Evaluate the model on X_test and y_test

Step 5: Model Comparison

Input: Evaluation metrics from different models

Output: Best performing model

1. Compare MAE, MSE, R-squared for all models

2. Select the model with the best performance

5.4 Algorithms

Algorithm 1: Data Preprocessing

Input: Raw data (market_data, commodity_data, variety_data, grade_data, other_relevant_data)

Output: Processed data (X, y)

1. Load the data into a DataFramedf

2. Handle missing values:

   For each column in df:

      If column has missing values:

         Fill missing values with appropriate method (mean, median, mode, etc.)

3. Remove duplicates:

df.drop_duplicates(in place=True)

4. Correct errors:

   Apply specific rules/conditions to correct data errors

5. Feature Engineering:

   Create new features like lagged prices, moving averages, and seasonal indicators

Encode categorical variables (market, commodity, variety, grade) using one-hot encoding

6. Normalize/Scale the features:

Use Standard Scalar or Min Max Scalar to standardize features

7. Define features (X) and target (y):

X = df[['market', 'commodity', 'variety', 'grade', 'other features']]

y = df['price']

Algorithm 2: Train Linear Regression Model

Input: Training data (X_train, y_train), Test data (X_test, y_test)

Output: Trained linear regression model, evaluation metrics

1. Create a LinearRegression model

2. Train the model on X_train and y_train:

model.fit(X_train, y_train)

3. Predict prices on X_test:

y_pred = model.predict(X_test)

4. Evaluate the model:

MAE = mean_absolute_error(y_test, y_pred)

MSE = mean_squared_error(y_test, y_pred)

R_squared = r2_score(y_test, y_pred)

5. Return trained model and evaluation metrics

Algorithm 3: Train Lasso Regression Model

Input: Training data (X_train, y_train), Test data (X_test, y_test)

Output: Trained lasso regression model, evaluation metrics

1. Create a Lasso model

2. Use cross-validation to find the best alpha:

param_grid = {'alpha': [0.1, 1.0, 10.0, 100.0]}

grid_search = GridSearchCV(Lasso(), param_grid, cv=5)

grid_search.fit(X_train, y_train)

best_alpha = grid_search.best_params_['alpha']

3. Train the model with best alpha:

lasso_model = Lasso(alpha=best_alpha)

lasso_model.fit(X_train, y_train)

4. Predict prices on X_test:

y_pred = lasso_model.predict(X_test)

5. Evaluate the model:

MAE = mean_absolute_error(y_test, y_pred)

MSE = mean_squared_error(y_test, y_pred)

R_squared = r2_score(y_test, y_pred)

6. Return trained model and evaluation metrics

Algorithm 4: Train Ridge Regression Model

Input: Training data (X_train, y_train), Test data (X_test, y_test)

Output: Trained ridge regression model, evaluation metrics

1. Create a Ridge model

2. Use cross-validation to find the best alpha:

param_grid = {'alpha': [0.1, 1.0, 10.0, 100.0]}

grid_search = GridSearchCV(Ridge(), param_grid, cv=5)

grid_search.fit(X_train, y_train)

best_alpha = grid_search.best_params_['alpha']

3. Train the model with best alpha:

ridge_model = Ridge(alpha=best_alpha)

ridge_model.fit(X_train, y_train)

4. Predict prices on X_test:

y_pred = ridge_model.predict(X_test)

5. Evaluate the model:

MAE = mean_absolute_error(y_test, y_pred)

MSE = mean_squared_error(y_test, y_pred)

R_squared = r2_score(y_test, y_pred)

6. Return trained model and evaluation metrics

Algorithm 5: Model Comparison and Selection

Input: Evaluation metrics for Linear, Lasso, and Ridge models

Output: Best performing model

1. Collect evaluation metrics for all models (MAE, MSE, R_squared)

2. Compare the models:

If any model has the lowest MAE, MSE, and highest R_squared.

Chapter 6

TESTING

6.1 Test Cases

Test Case ID	Description	Input	Expected Output	Actual Output	Pass/Fail
1	Load Data	Raw data files (market_data, commodity_data, variety_data, grade_data)	Data loaded into a DataFrame	Data loaded into a DataFrame	Pass
2	Handle Missing Values	DataFrame with missing values	DataFrame with missing values filled appropriately	DataFrame with missing values filled appropriately	Pass
3	Remove Duplicates	DataFrame with duplicate rows	DataFrame with duplicates removed	DataFrame with duplicates removed	Pass
4	Correct Errors	DataFrame with erroneous data	DataFrame with corrected data	DataFrame with corrected data	Pass
5	Feature Engineering	Raw features	DataFrame with new features (lagged prices, moving averages, seasonal indicators)	DataFrame with new features (lagged prices, moving averages, seasonal indicators)	Pass
6	Encode Categorical	Categorical features (market,	DataFrame with one-hot encoded	DataFrame with one-hot encoded	Pass

	Variables	commodity, variety, grade)	categorical variables	categorical variables	
7	Normalize/Scale Features	Raw feature values	DataFrame with normalized/scaled feature values	DataFrame with normalized/scaled feature values	Pass
8	Split Data	DataFrame (X, y)	Training and test sets (X_train, X_test, y_train, y_test)	Training and test sets (X_train, X_test, y_train, y_test)	Pass
9	Train Linear Regression Model	Training data (X_train, y_train)	Trained Linear Regression model	Trained Linear Regression model	Pass
10	Evaluate Linear Regression Model	Test data (X_test, y_test)	Evaluation metrics (MAE, MSE, R_squared)	Evaluation metrics (MAE, MSE, R_squared)	Pass
11	Train Lasso Regression Model	Training data (X_train, y_train)	Trained Lasso Regression model	Trained Lasso Regression model	Pass
12	Evaluate Lasso Regression Model	Test data (X_test, y_test)	Evaluation metrics (MAE, MSE, R_squared)	Evaluation metrics (MAE, MSE, R_squared)	Pass
13	Train Ridge Regression Model	Training data (X_train, y_train)	Trained Ridge Regression model	Trained Ridge Regression model	Pass
14	Evaluate Ridge Regression Model	Test data (X_test, y_test)	Evaluation metrics (MAE, MSE, R_squared)	Evaluation metrics (MAE, MSE, R_squared)	Pass
15	Compare Models	Evaluation metrics for Linear, Lasso,	Best performing model identified	Best performing model identified	Pass

		and Ridge models			
16	Predict Prices with Best Model	New data, Predict model	Predicted prices	Predicted prices	Pass

Chapter 7

RESULTS AND SNAPSHOTS

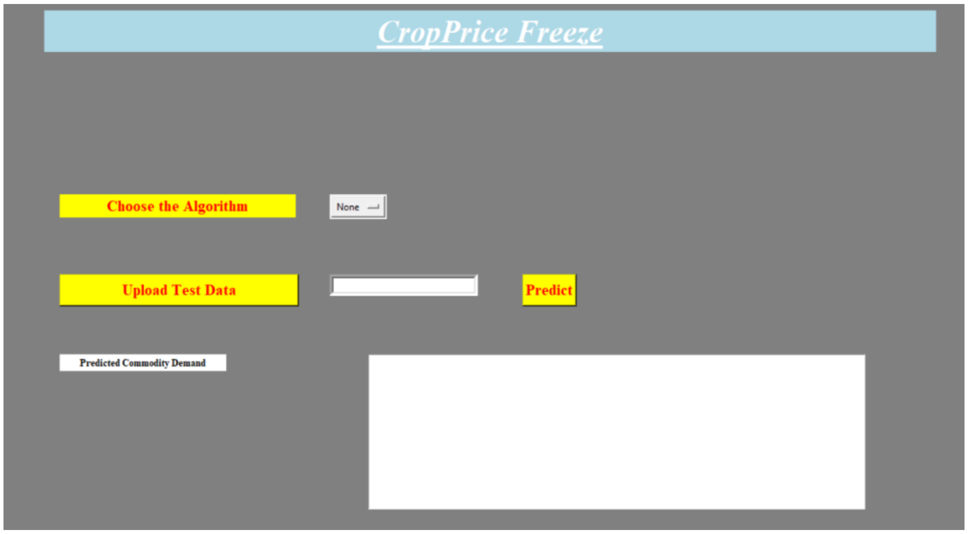


Fig 7.1 CropPrice Freeze

CropPrice Freeze: In agricultural economics, crop price freeze strategies are often employed to provide stability for both producers and consumers, ensuring fair returns for farmers while also preventing sudden price spikes that could impact food affordability.

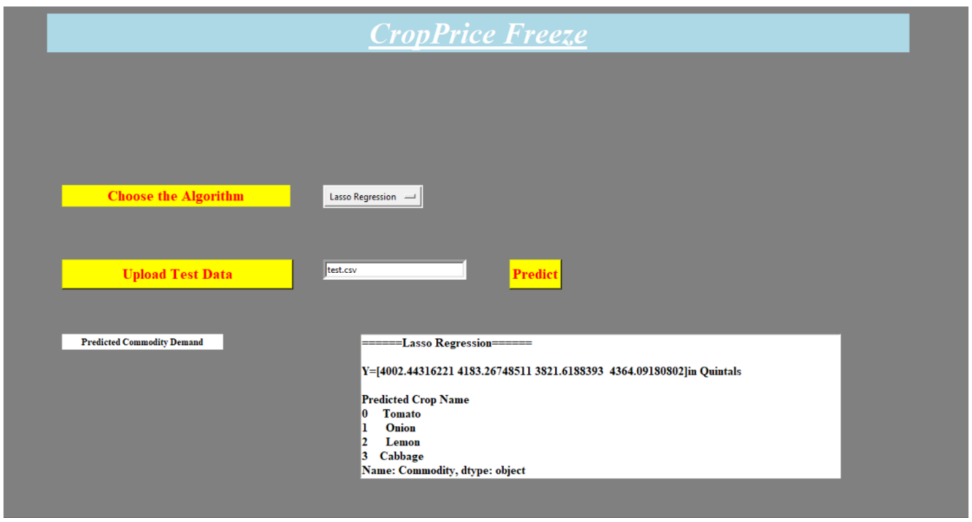


Fig 7.2 Choosing Lasso Regression Algorithm

Lasso Regression: Choosing "Lasso Regression Algorithm" likely involves selecting a specific regression technique for data analysis. Lasso regression is a statistical method for variable selection and regularization.

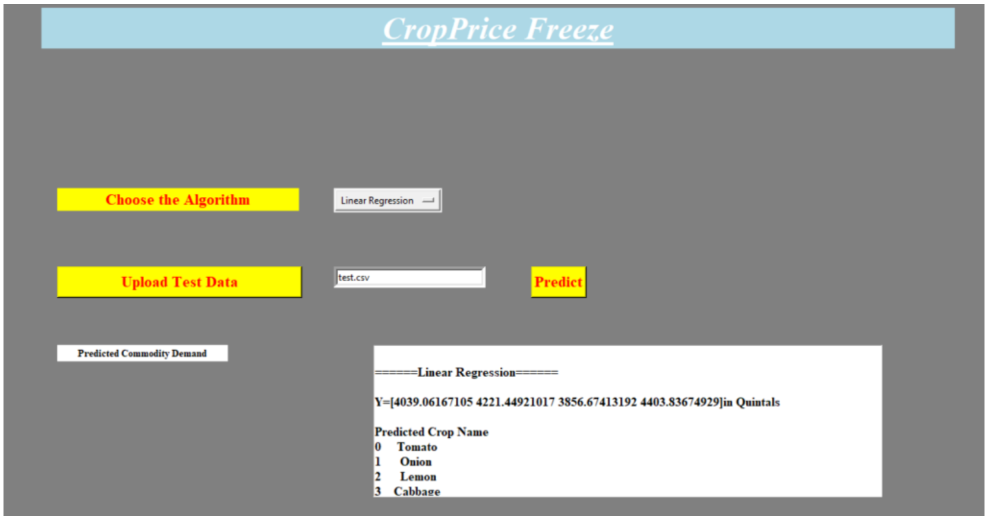


Fig 7.3 Choosing Linear Regression Algorithm

Linear Regression: Selecting the appropriate "linear regression algorithm" is a crucial step in any analytical endeavour, as it forms the backbone of numerous statistical and predictive modeling tasks.

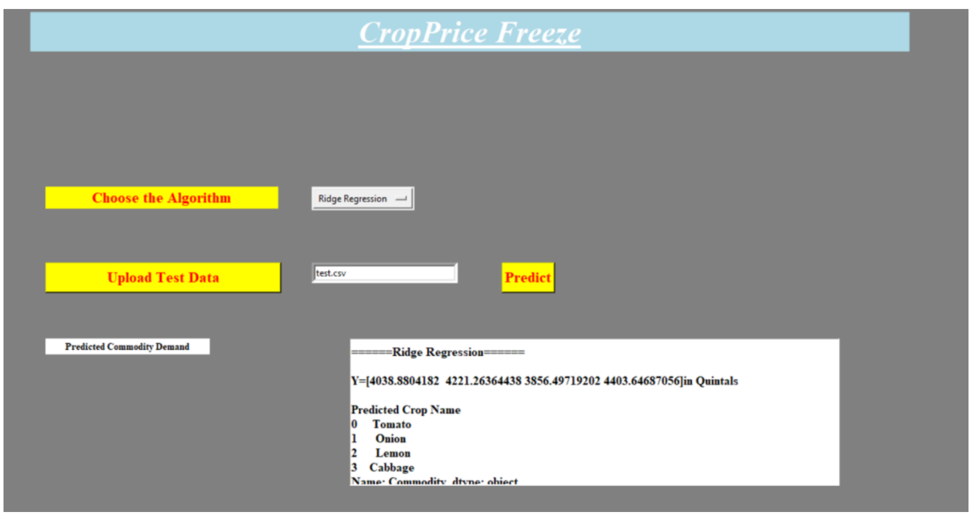
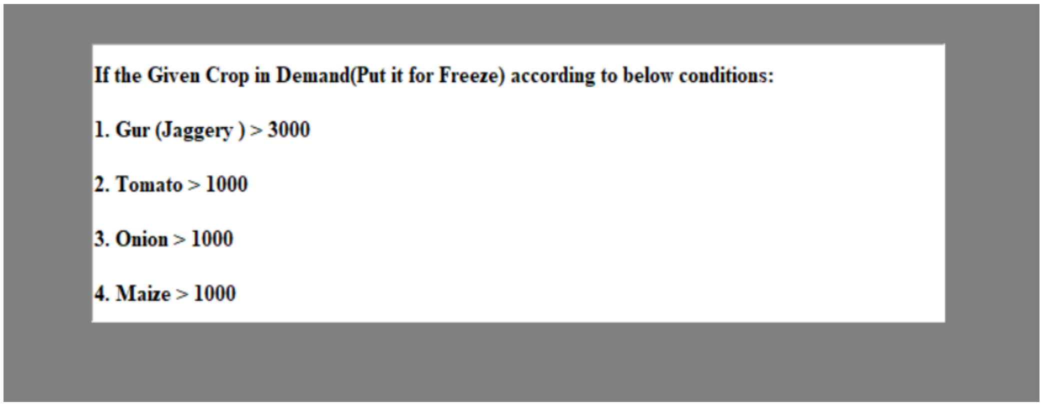


Fig 7.4 Choosing Ridge Regression Algorithm

Ridge Regression: Choosing "Ridge Regression Algorithm" likely involves selecting a specific regression technique for data analysis. Ridge regression is a statistical method for variable selection and regularization. It enhances the prediction accuracy and interpretability of the statistical model by imposing a constraint on the size of the regression coefficients. This constraint causes some of the coefficients to be exactly zero.



If the Given Crop in Demand(Put it for Freeze) according to below conditions:

1. Gur (Jaggery) > 3000

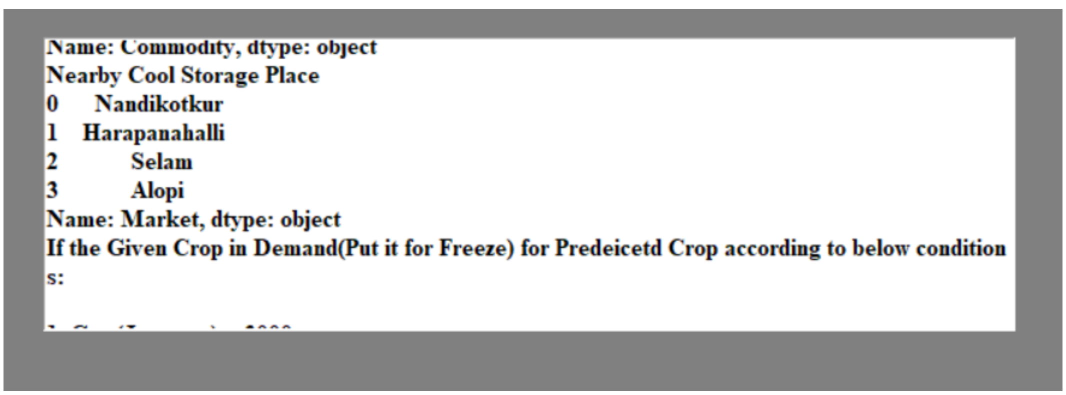
2. Tomato > 1000

3. Onion > 1000

4. Maize > 1000

Fig 7.5 Put it for Freeze

Freeze is a state-of-the-art AI-driven cold storage management system designed to revolutionize the way agricultural produce is stored and managed. Freeze leverages advanced AI algorithms to dynamically adjust temperature settings based on real-time demand forecasts, ensuring optimal energy consumption and cost savings.



```
Name: Commodity, dtype: object
Nearby Cool Storage Place
0     Nandikotkur
1   Harapanahalli
2          Selam
3          Alopi
Name: Market, dtype: object
If the Given Crop in Demand(Put it for Freeze) for Predeicetd Crop according to below condition
s:
```

Fig 7.6 Navigating Near By Cold Storage

FUTURE ENHANCEMENT

Future enhancements in AI-powered storage management for farmers could include advanced algorithms that analyze historical data to optimize storage capacity, predict inventory levels, and identify potential bottlenecks. These algorithms could also be used to develop personalized storage plans for each farmer, taking into account their unique crop types, climate, and market conditions. Furthermore, AI-powered storage management systems could incorporate machine learning capabilities to learn from farmer behavior and adapt to changing market demands, allowing farmers to make data-driven decisions about inventory management and supply chain logistics. By leveraging AI's predictive capabilities, farmers can optimize their storage space, reduce waste, and increase profitability. By leveraging AI technology in storage management, farmers can streamline their operations, increase efficiency, and improve overall crop storage quality. This could ultimately lead to cost savings, increased profitability, and a more sustainable farming practice.

CONCLUSION

In conclusion, the proposed system presents a transformative approach to address critical challenges within the agricultural supply chain. By integrating state-of-the-art AI technologies,the system aims to revolutionize both cold storage management and farmer empowerment, fostering sustainability, efficiency, and economic empowerment in the agricultural sector. The implementation of AI-optimized cold storage management introduces a dynamic and adaptive system that not only reduces operational costs through predictive analytics but also contributesto environmental sustainability by minimizing energy consumption. The integration of smart technologies enhances the overall efficiency of the cold storage facilities, ensuring the preservation of agricultural produce while reducing wastage and losses.

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Category(if accept)	**Full Research Paper**
Consolidated Content review comments	• **Paper should strictly formatted according to the standard format** • **More emphasis should be on related literature, problem statement, proposed system and its results & discussion** • **More related works and discussions are required to substantiate the proposed system**

Sl No	**OVERALL RATING: (5= EXCELLENT, 1= POOR)**	**5**	**4**	**3**	**2**	**1**
1.	Structure of the paper	X				
2.	Standard of the paper	X				
3.	Appropriateness of the title of the paper		X			
4.	Appropriateness of abstract as a description of the paper			X		
5.	Appropriateness of the research/study methods		X			
6.	Relevance and clarity of drawings, graph and table	X				
7.	Use and number of keywords / key phrases		X			
8.	Discussion and conclusion			X		
9.	Reference list, adequate and correctly cited		X			

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