ELEVATING EFFICIENCY AND SUSTAINABILITY IN LARGE-SCALE COCONUT OIL MANUFACTURING THROUGH PROGRESSIVE STRATEGIES

R24-059

Project Proposal Report

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

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DECLARATION

We declare that this is our own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature of the Supervisor
(Mr. Nelum Chathuranga)

Date

28/02/2024

ABSTRACT

The coconut oil industry is a significant source of income in Sri Lanka, ranking as the 7th largest producer globally as of 2021. Despite its prominence, the industry faces challenges due to limited utilization of Artificial Intelligence/Machine Learning (AI/ML) technologies for marketing and decision-making, resulting in stagnation and missed opportunities for growth.

Various applications have been developed to forecast coconut oil prices and trends, but there remains a gap for a comprehensive platform that offers marketing strategies to enhance efficiency and sustainability within Sri Lanka's coconut oil industry. Analyzing market trends requires expert knowledge and significant time investment.

This proposed system aims to address this gap by providing valuable insights for organizations such as the Coconut Development Authority (CDA), Coconut Research Institute Sri Lanka (CRISL), and Coconut Cultivation Board (CCB). Leveraging past analyses, the platform will facilitate informed decisions on what countries are the best to export, which industries are best to export, in which amount of quantity the coconut oil should be distributed, and the price to overcome the efficiency and sustainability of coconut oil industry in Sri Lanka.

The system analyzes previous export statistics, country-specific inflation rates, and conducts forecast analysis. Results are generated using multiclass classifier models such as One-Vs-Rest and One-Vs-One Classification Models, along with logistic regression algorithms. Additionally, Explainable AI and What-if analysis techniques are employed to manipulate expected profits and observe resulting changes in exporting countries, prices, and yield amounts.

Keywords: Artificial Intelligence/Machine Learning (AI/ML), Coconut Development Authority (CDA), Coconut Research Institute Sri Lanka (CRISL), and Coconut Cultivation Board (CCB)

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LIST OF ABBREVIATIONS

Abbreviation	Description
ISO	International Organization for Standardization
VCO	Virgin Coconut Oil
HACCP	Hazard Analysis and Critical Control Points
AI	Artificial Intelligence
ML	Machine Learning
CDA	Coconut Development Authority
CRISL	Coconut Research Institute Sri Lanka
CRI	Coconut Research Institute
CCB	Coconut Cultivation Board
MT	Metric Tons
US$ Mln	US Dollar Million
EDA	Exploratory Data Analysis
MAE	Mean Absolute Error
MSE	Mean Squared Error
RMSE	Root Mean Squared Error
OvR	One-vs-Rest
OvO	One-vs-One

1 INTRODUCTION

As Table I shows, Sri Lanka is the fourth-largest coconut producer in the world by 2021 [1], and as Table II shows, the 7th largest coconut oil producer in the world by 2019 [2]. The coconut oil industry in Sri Lanka is significant due to the country's abundant coconut resources and long-standing tradition of coconut cultivation. Sri Lanka is one of the world's leading producers of coconuts, and coconut-related products contribute significantly to the country's economy.

Coconut cultivation is widespread across Sri Lanka, with coconut palms covering a considerable portion of the country's land. The coconut tree is often referred to as the "tree of life" in Sri Lanka due to its versatility and the multitude of products derived from it. Sri Lanka exports a significant amount of coconut oil to various countries around the world. The country is known for producing high-quality, virgin coconut oil (VCO), which is extracted from fresh coconut meat without undergoing chemical refining. Sri Lanka has numerous coconut oil processing facilities scattered across the country. These facilities process coconuts into oil through methods such as cold-pressing or expeller pressing to retain the oil's natural flavor and nutrients. Some larger facilities may also engage in refining processes to produce refined coconut oil. Sri Lankan coconut oil manufacturers adhere to strict quality standards to ensure that their products meet international requirements. This includes compliance with food safety regulations and certifications such as ISO (International Organization for Standardization) and HACCP (Hazard Analysis and Critical Control Points).

MOST COCONUT OIL PRODUCED COUNTRIES AS OF 2021.

Adapted from [Source: worldpopulationreview website]

Rank	Country	2021 Production (Million Metric Tons)
1	Indonesia	17,159,938
2	Philippines	14,717,294
3	India	14,301,000
4	Sri Lanka	2,496,000
5	Brazil	2,457,860
6	Vietnam	1,866,181
7	Papua New Guinea	1,813,553
8	Myanmar	1,238,307
9	Mexico	1,120,093
10	Thailand	797,700

Table 1 Most Coconut Oil Produced Countries as of 2021

MOST COCONUT OIL PRODUCED COUNTRIES AS OF 2019.

Adapted from [Source: nationmaster website]

Rank	Country	2019 Production (Metric Tons)
1	Philippines	1,302,991
2	Indonesia	835,267
3	India	297,031
4	Vietnam	170,879
5	Mexico	130,484
6	Bangladesh	63,936
7	Sri Lanka	55,797
8	Malaysia	40,396
9	Mozambique	30,539
10	Thailand	27,256

Table 2 Most Coconut Oil Produced Countries as of 2019

The agricultural sector has seen a surge in smart solutions driven by technological advancements and the abundance of data. These elements are now crucial for decision-making in modern agriculture, transforming the industry from relying on statistics to embracing quantitative approaches and paving the way for sustainable practices.

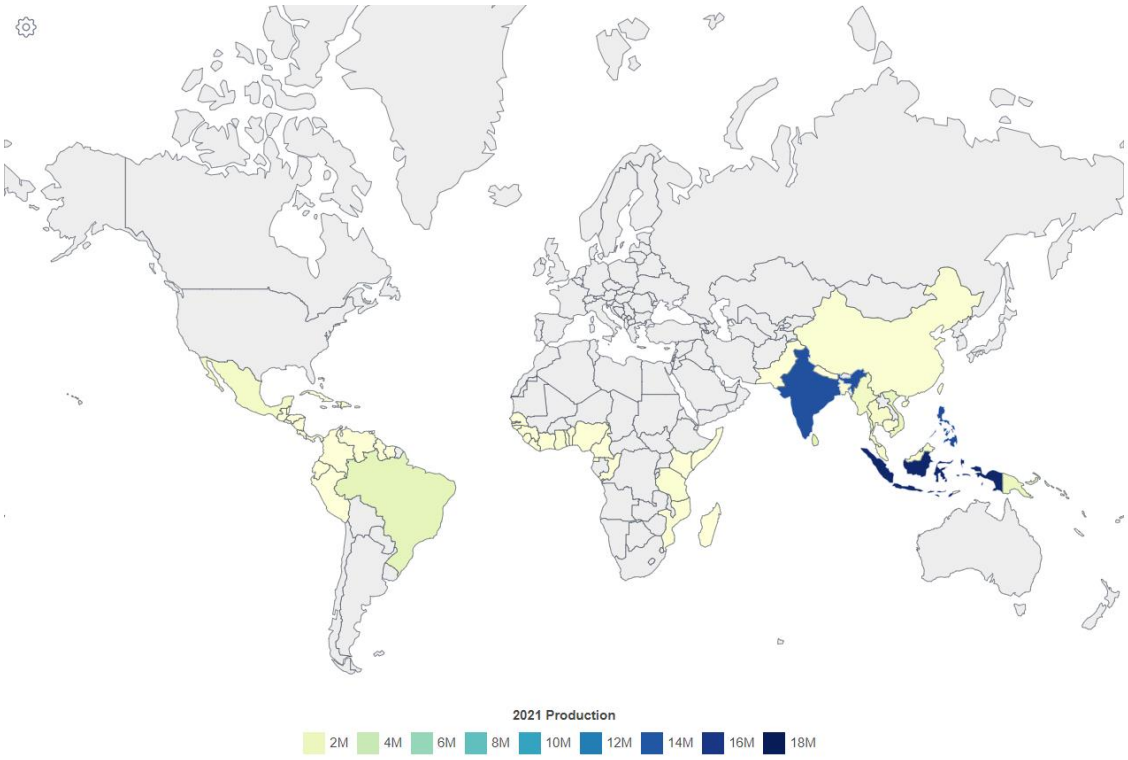

Figure 1 Coconut Production Globally.
Adapted from [Source: worldpopulationreview]

1.1 Background and Literature Survey

Sri Lanka satisfies approximately 1.33% of the worldwide demand for coconut oil, totaling an export value of USD 62.7 million. The primary importers of coconut oil from Sri Lanka include the United States, Australia, Germany, Saudi Arabia, the United Kingdom, and the Netherlands [5].

As Table III shows, Sri Lanka produced 537,986 metric tons of coconut oil during the 2010-2020 period, which is considerably less than the production during the 1960-1970 period. Specifically, Sri Lanka produced 1,195,452 metric tons of coconut oil during the 1960-1970 period. This comparison highlights a noticeable decrease in coconut oil production over the decades.

COCONUT OIL PRODUCTION IN SRI LANKA.

Adapted from [Source: nationmaster website]

Range(Years)	**Metric Tons**
2010-2020	537,986.00
2000-2010	427,672.00
1990-2000	434,410.00
1980- 1990	814,305.00
1970-1980	948,955.00
1960-1970	1,195,452.00

Table 3 Coconut Oil Production in Sri Lanka

Coconut oil generates the highest revenue among coconut industry products, second only to molded coir products for use in horticulture and coconut milk products. As Table IV illustrates, a total of 14,055 metric tons were exported during the 2021-2023 period, representing approximately 9% of the total coconut oil production for that timeframe.

COCONUT OIL EXPORT VOLUME IN SRI LANKA.

Adapted from [Source: coconut development authroity]

Product	2021 (MT)	2022 (MT)	2023 (MT)
Coconut Oil	3,825	4,712	5,518
Virgin Coconut Oil	14,960	14,965	14,728
Desiccated Coconut	36,116	43,791	37,988
Copra	828	2,080	979

Table 4 Coconut Oil Export Volume in Sri Lanka

The coconut industry stands as a vital cornerstone of Sri Lanka's economy, serving as a significant source of foreign exchange and employment while deeply ingrained in the nation's culinary traditions, nutritional sustenance, and rural livelihoods. As Table V illustrates, the value of coconut oil in 2023 is below 4000 million US dollars, indicating a slowly gradual increase over time.

COCONUT OIL EXPORT VALUE IN SRI LANKA.

Adapted from [Source: coconut development authority]

Product	2021 (US$ Mln)	2022 (US$ Mln)	2023 (US$ Mln)
Coconut Oil	2,319.74	4,051.01	3,877.58
Virgin Coconut Oil	14,744.20	20,318.86	17,974.24
Desiccated Coconut	21,501.06	30,848.45	24,062.23
Copra	270.52	924.52	414.18

Table 5 Coconut Oil Export Value in Sri Lanka

With coconut cultivation sprawling over 20 percent of Sri Lanka's arable land, predominantly managed at small-scale operations, the sector sustains a crucial role in the country's agricultural framework. Yet, amidst the backdrop of stable but variably yielding coconut harvests and the looming specter of climate change-induced uncertainties, the industry faces a spectrum of challenges and opportunities. Notably, the interplay of domestic consumption patterns, market dynamics, and governmental policies shapes the industry's course, while climate adaptation emerges as a pressing concern for stakeholders along the coconut value chain. As such, this study endeavors to shed light on the nuanced interdependencies within the Sri Lankan coconut industry and explore avenues for resilient adaptation in the face of evolving environmental and market forces [4].

In Sri Lanka, the coconut industry holds significant importance, serving as a cornerstone in cuisine, foreign trade, and job creation. Data from a survey underscores the vital role coconuts play in people's everyday lives.

1.2 Research Gap

Research Gap 1: Lack of forecast percentages that should be distributed to different countries in future

Research “A" [6] focus on analyzing past global coconut oil prices and forecasting future prices based on a single variable highlights a significant limitation in current methodologies. By

neglecting to incorporate various critical parameters such as production levels, market demand, climatic variables, peak seasons, and the economic status of coconut-producing countries, the forecasting model fails to capture the comprehensive array of factors influencing coconut oil prices. This narrow approach overlooks the intricate interplay between these variables, potentially leading to less accurate predictions and a limited understanding of the underlying drivers shaping coconut oil market dynamics. Consequently, there exists a notable research gap in the failure to integrate multiple parameters into the forecasting framework, which could significantly enhance the predictive capabilities and robustness of coconut oil price forecasts.

Research “B” [4] attempts to address part of the research gap by analyzing historical coconut oil supply and forecasting future demand, taking into account climate variables. However, its emphasis on climate overlooks the multitude of factors influencing demand. While climate undoubtedly affects coconut oil demand, other critical factors like market trends, economic conditions, consumer preferences, and geopolitical events also play significant roles. By focusing solely on climate-related variables, Research B fails to consider the broader range of factors influencing demand dynamics. Therefore, there remains a substantial gap in understanding the comprehensive determinants of coconut oil demand. Future research should adopt a more holistic approach that considers various influencing factors beyond climate alone.

A significant gap in Research “C” [3] is the lack of studies that predict the best amount of coconut oil to produce to help with inflation in Sri Lanka. Even though coconut oil is very important in Sri Lanka and inflation can be a problem, there haven't been many studies looking at how coconut oil production levels can help control inflation. Figuring out the right amount of coconut oil to produce could be really helpful for Sri Lanka's government and businesses. If we know how much coconut oil to make to meet demand without making prices go up too much, it could help policymakers make better decisions to deal with inflation. So, it's really important for researchers to study how coconut oil production levels and inflation are connected in Sri Lanka. This kind of research would fill a big gap in what we know about coconut oil and inflation in Sri Lanka.

Another noticeable gap in current research is the absence of studies predicting the optimal distribution of coconut oil to each country to maximize profits. Despite the global demand for coconut oil and its importance as a commodity in various countries, there is a lack of research specifically focusing on determining the most profitable distribution levels for different

markets. Understanding how much coconut oil should be distributed to each country to achieve the desired profits could offer valuable insights for producers, exporters, and policymakers alike. By identifying the distribution strategies that yield the highest returns, such research could inform more effective decision-making processes and resource allocation strategies in the coconut oil industry. Therefore, there is a clear research need to investigate the optimal distribution of coconut oil among different countries to maximize profitability, addressing a significant gap in the current scholarly discourse.

	RESEARCH A	RESEARCH B	RESEARCH 3	PROPOSED SOLUTION
Forecast coconut oil demand based on single parameter	NO	YES	YES	YES
Forecast coconut oil demand based on multiple parameters	NO	NO	NO	YES
Forecast coconut oil price based on countries economy status	YES	NO	NO	YES
Forecast how much of coconut oil should be produced to overcome inflation issues in Sri Lanka	NO	NO	NO	YES
Forecast percentages that should be distributed to different countries' sectors as the economy changes	NO	NO	NO	YES
Manipulate expected profit and observe the resulting changes in predicted coconut oil prices and distribution percentages	NO	NO	NO	YES

Table 6 Research Gap

1.3 Research Problem

Figure 3 displays the difference between coconut oil imports and exports across various countries. Despite Sri Lanka's achievement as one of the top 10 coconut oil producers globally [2], the data reveals a concerning trend: Sri Lanka imports more coconut oil than it exports. To address this issue and boost export rates, there's a need for substantial changes in the current export process. We must move away from manual methods towards automated and faster processes. This transformation is essential for improving efficiency and sustainability in Sri Lanka's coconut oil industry.

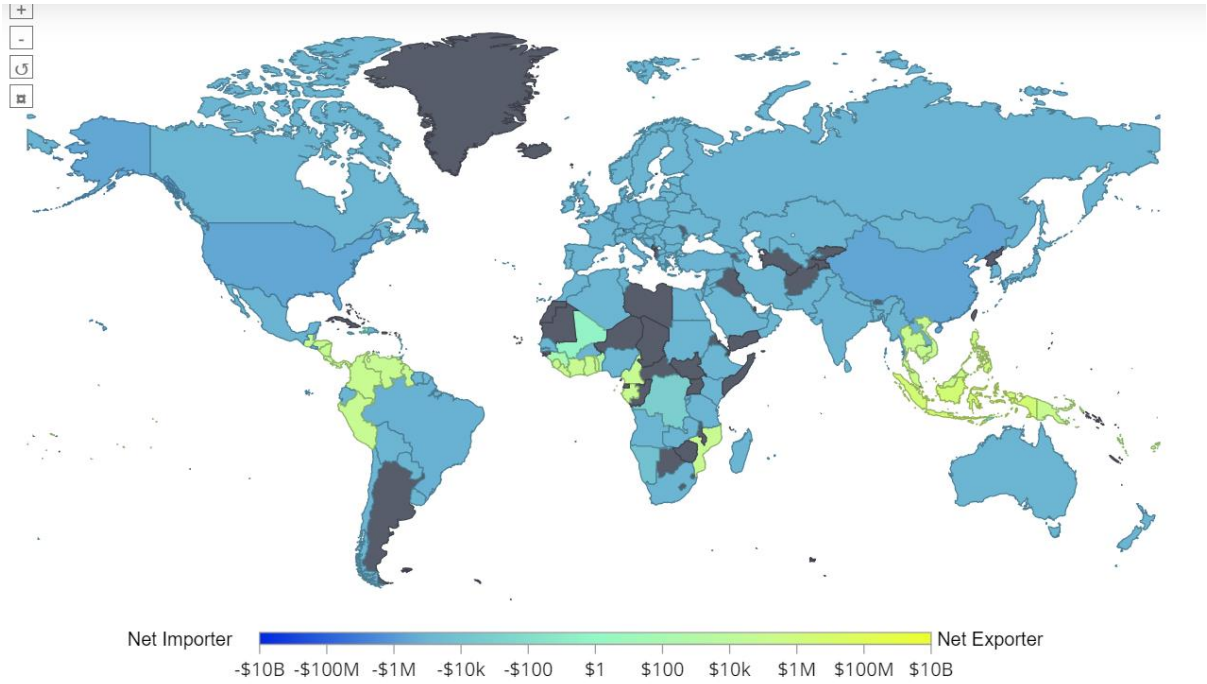

Figure 2 The net of coconut oil importing and exporting. Adapted from [Source: OEC website]

There is currently a lack of comprehensive systems for predicting country-specific demand, hindering effective planning and resource allocation in export-oriented industries.

Additionally, there exists a gap in forecasting the profitability of potential export destinations, limiting strategic decision-making for future market expansions. Furthermore, the absence of predictive models for industry distribution percentages poses challenges in optimizing supply chains and distribution networks. Addressing these shortcomings through the development of advanced predictive analytics systems could significantly enhance the efficiency and competitiveness of international trade sectors.

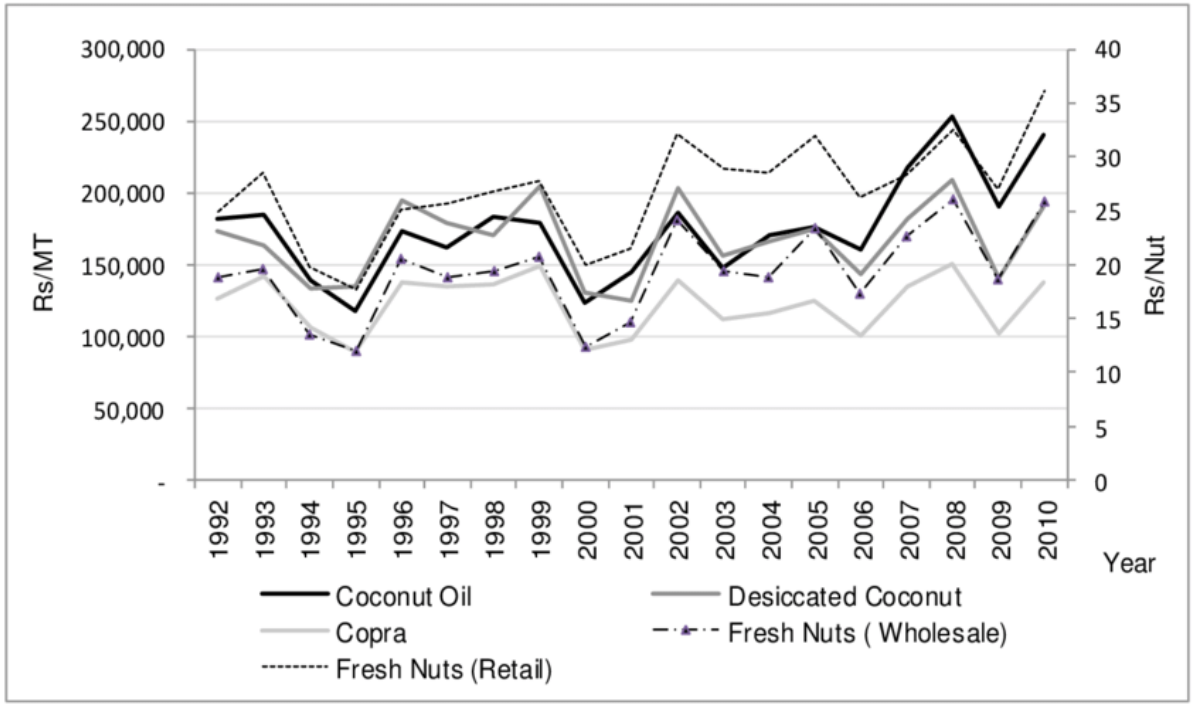

Figure 3 Local market prices of coconut kernel products (in 2012 real terms) (I USD = 130 RS). Adapted from [Source: (Coconut Development Authority, 1970-2013)]

Predicting future coconut oil prices based solely on past price data may not provide accurate forecasts, as it overlooks crucial factors such as the economic status. While historical price analysis is valuable, it fails to capture the complexity of price determinants influenced by various economic indicators, market trends, geopolitical factors, and consumer behavior. Therefore, there is a need to explore how incorporating economic indicators and other relevant factors can improve the accuracy and reliability of coconut oil price predictions. This approach can lead to more informed decision-making and better market strategies for stakeholders in the coconut oil industry.

Figure 3 shows the net between the coconut oil import and export by countries. As you can see even though Sri Lanka became one of the 10th largest coconut oil producer in the world [2], the coconut oil import rate is higher than the coconut oil export rate. In order to fix this and increase

the export rate the current exporting mechanism should be changed. It should need a huge development. Go beyond from Manual processes we need an automatic and fast process to enhance the efficiency and sustainability in coconut oil industry in Sri Lanka.

2 OBJECTIVES

2.1 Main Objectives

The objectives are to determine the appropriate quantity of coconut oil needed by individual countries, as well as the overall production volume required to meet global demand. Additionally, the aim is to establish the optimal distribution percentage of coconut oil across various industries and countries. These objectives seek to provide clarity on the specific quantity of coconut oil required by each nation, ensure efficient production planning to meet demand, and optimize distribution strategies to maximize industry effectiveness and international trade partnerships. Achieving these objectives will contribute to the effective management of coconut oil resources, fostering sustainable production practices and supporting economic growth in both local and global markets.

2.2 Specific Objectives

- Determine the precise quantity of coconut oil needed by individual countries.
- Estimate the overall production volume required to fulfill global demand for coconut oil.
- Establish the optimal distribution percentage of coconut oil across various industries within each country.
- Identify specific quantities of coconut oil required by each nation to ensure efficient production planning.
- Optimize distribution strategies to maximize industry effectiveness and foster international trade partnerships.
- Ensure clarity on the amount of coconut oil needed by each country to support sustainable production practices.
- Support economic growth by facilitating effective management of coconut oil resources in local and global markets.

- Enhance planning and decision-making processes related to coconut oil production and distribution.
- Foster collaboration between industries and countries to streamline coconut oil supply chains and minimize wastage.
- Improve transparency and accountability in the management of coconut oil resources to promote trust and stability in the market.

3 METHDOLOGY

3.1 Overall System Diagram

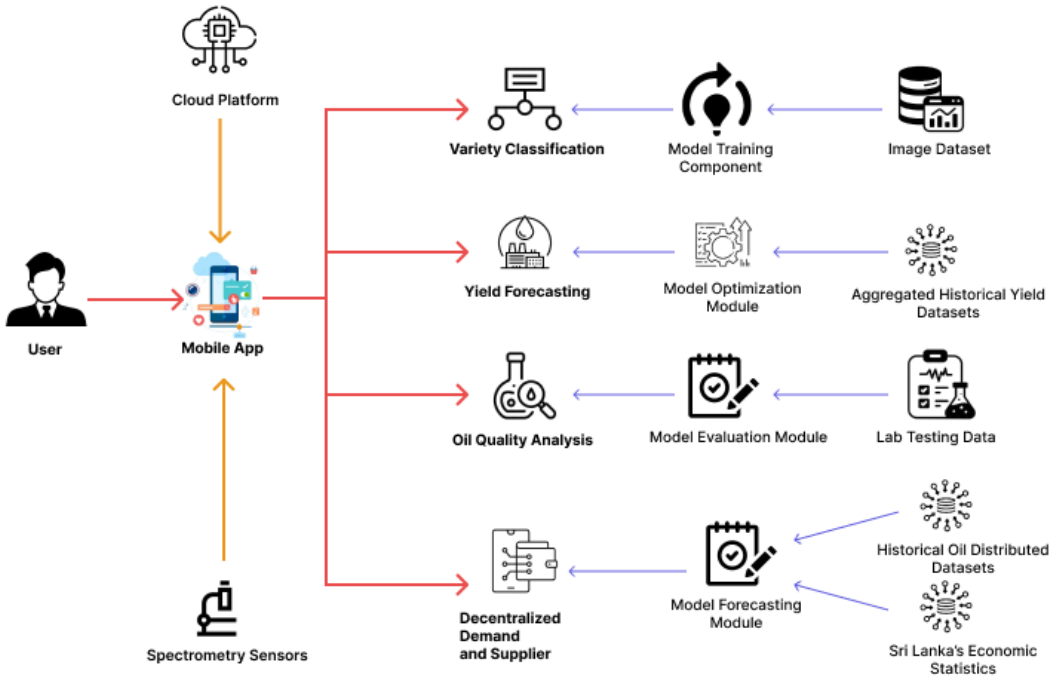

Figure 4 Overall System Diagram

3.2 Individual System Diagram

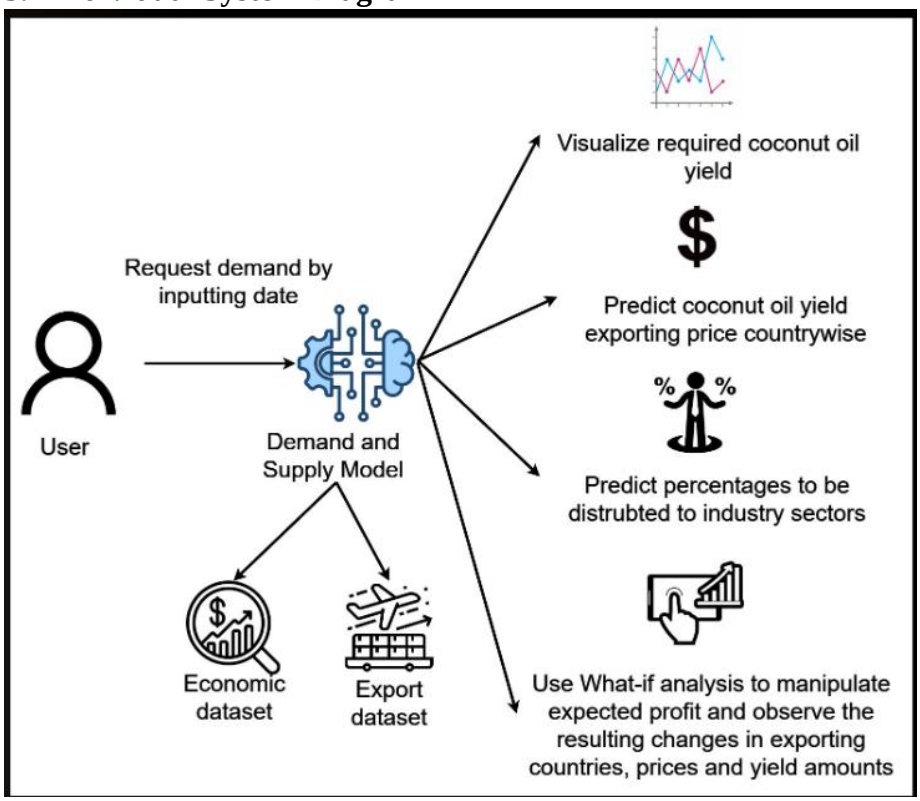

Figure 5 Individual System Diagram

3.3 Use Case Diagram

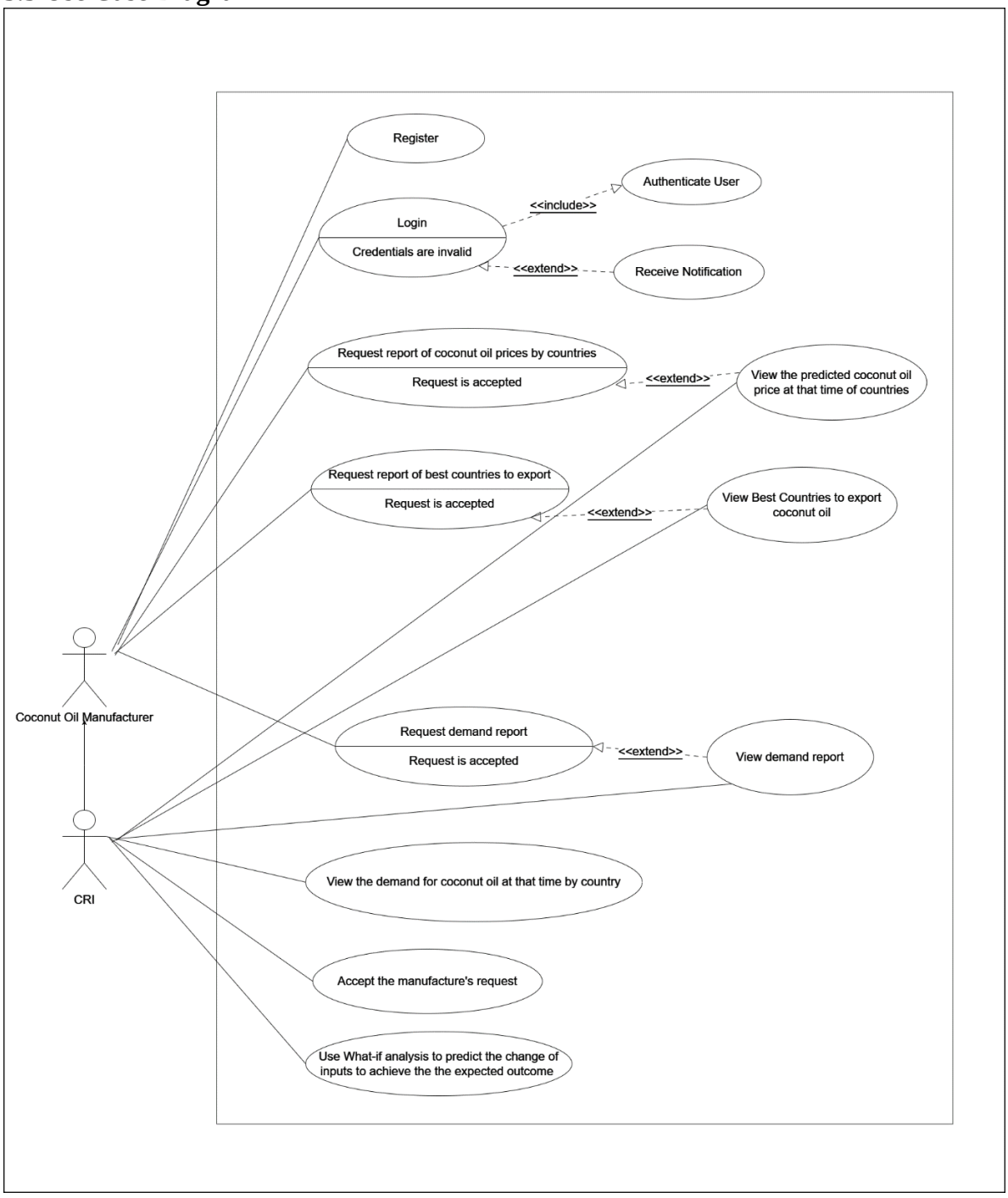

Figure 6 Use Case Diagram

3.4 Wireframes

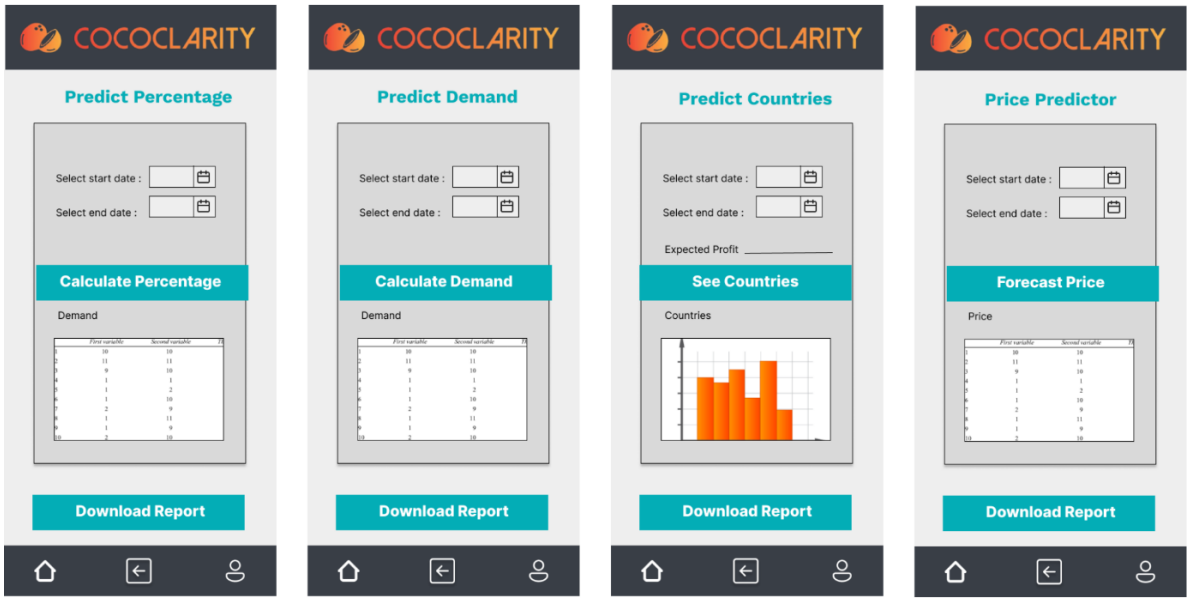

Figure 7 Wireframes

3.5 Tasks

- Visualize required coconut oil yield.
- Predict coconut oil yield exporting price country-wise.
- Predict percentages to be distributed to industries.
- Use What-if analysis to manipulate expected profit and observe the resulting changes in exporting countries, prices and yield amounts.

3.6 Data Preprocessing

3.6.1 Data Collection

- Gather historical data on coconut oil distribution to different industries.
- Collect relevant features such as industry type, market demand, seasonality, economic factors, etc.
- Obtain data on coconut oil prices and relevant factors influencing price fluctuations.
- Gather data on countries and their characteristics for multiclass predictions.

3.6.2 Data Cleaning

- Handle missing values and outliers appropriately.
- Ensure consistency and accuracy in data formats.

3.6.3 Feature Engineering

- Extract meaningful features from the data.
- Convert categorical variables into numerical representations using techniques like one-hot encoding for industry type, country, etc.
- Scale numerical features if necessary to ensure they have a similar range.

3.6.4 Train-Test Split

- Split the data into training and testing sets to evaluate model performance.

3.7 Data Analysis

3.7.1 Exploratory Data Analysis (EDA)

- Visualize distributions of features and target variables.
- Analyze correlations between features and target variables.
- Identify patterns and insights that may inform model development.

3.7.2 Feature Importance

- Use techniques like correlation analysis or tree-based methods to determine the importance of features for predicting coconut oil distribution.

3.8 Model Implementation

3.8.1 Logistic Regression for Price Forecasting

- Train logistic regression models to forecast coconut oil prices.
- Evaluate model performance using metrics like Mean Absolute Error (MAE) or Root Mean Squared Error (RMSE).

3.8.2 Multiclass Logistic Regression for Country Predictions

- Implement multiclass logistic regression to predict the countries to which coconut oil should be distributed.
- Utilize techniques like one-vs-rest (OvR) and one-vs-one (OvO) strategies for multiclass classification.
- Assess model accuracy using metrics like accuracy, precision, recall, and F1-score.

3.8.3 Decision Trees and Random Forests for Distribution Prediction

- Train decision tree and random forest models to predict the amount of coconut oil to distribute to each industry.
- Tune hyper parameters such as maximum tree depth, minimum samples per leaf, and number of trees in the forest to optimize model performance.
- Evaluate models using appropriate regression metrics like Mean Absolute Error (MAE) or Mean Squared Error (MSE).

3.9 Model Evaluation and Optimization

- Perform cross-validation to ensure the generalization of the models.
- Tune hyper parameters using techniques like grid search or random search to improve model performance.
- Validate models on the testing set to assess their performance on unseen data.

3.10 Deployment

- Once satisfied with the model performance, deploy the models into a production environment.
- Continuously monitor and update the models as new data becomes available to maintain their accuracy and relevance.

3.11 Project Requirements

3.12 Tools/Materials

A computer and a network connection to connect with the system are required.

3.13 Data Requirements

Data requirements such as previous coconut oil export statistics in Sri Lanka, previous coconut oil import statistics in countries, previous and future inflation statistics of countries are required.

3.14 Functional Requirements

- Predicting demand based on country.
- Predicting how much amount of coconut oil is required to fulfil the expected outcome.
- Predicting the percentages to be distributed to each country, industry.
- Visualizing Data.
- Integrate What-if analysis.

3.15 Non-Functional Requirements

- Accuracy of predicting data
- Timeliness of information
- Maintainability

3.16 Software Requirements

- Python
- Tenserflow
- ML
- React Native
- MERN
- MongoDB
- VS Code

3.17 Personnel Requirements

To improve the caliber, depth, continuity, and reliability of the research, the following personnel are necessary.

- Coconut Development Authority (CDA)
- Coconut Research Institute Sri Lanka (CRISL)
- Coconut Cultivation Board (CCB)
- Dr. Chandi Yalegama (Head, Coconut Processing Research Division)

4 GANTT CHART AND WORK BREAKDOWN CHART

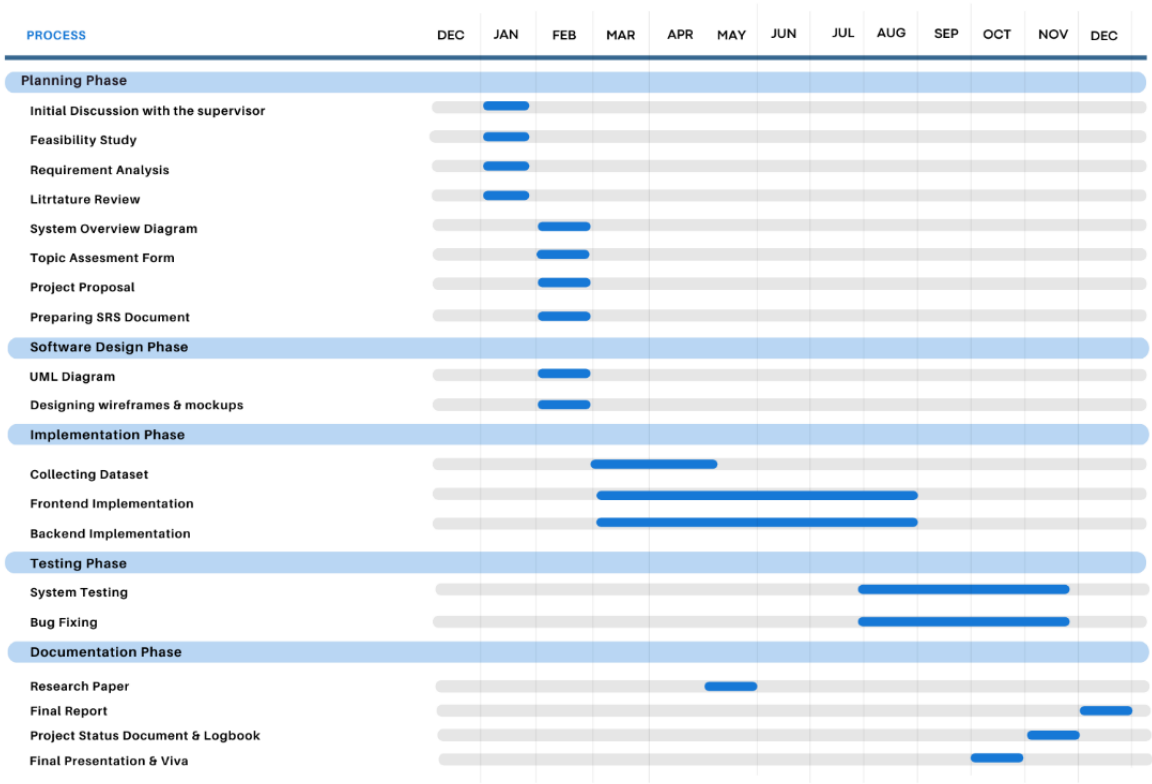

Figure 8 Gant Chart

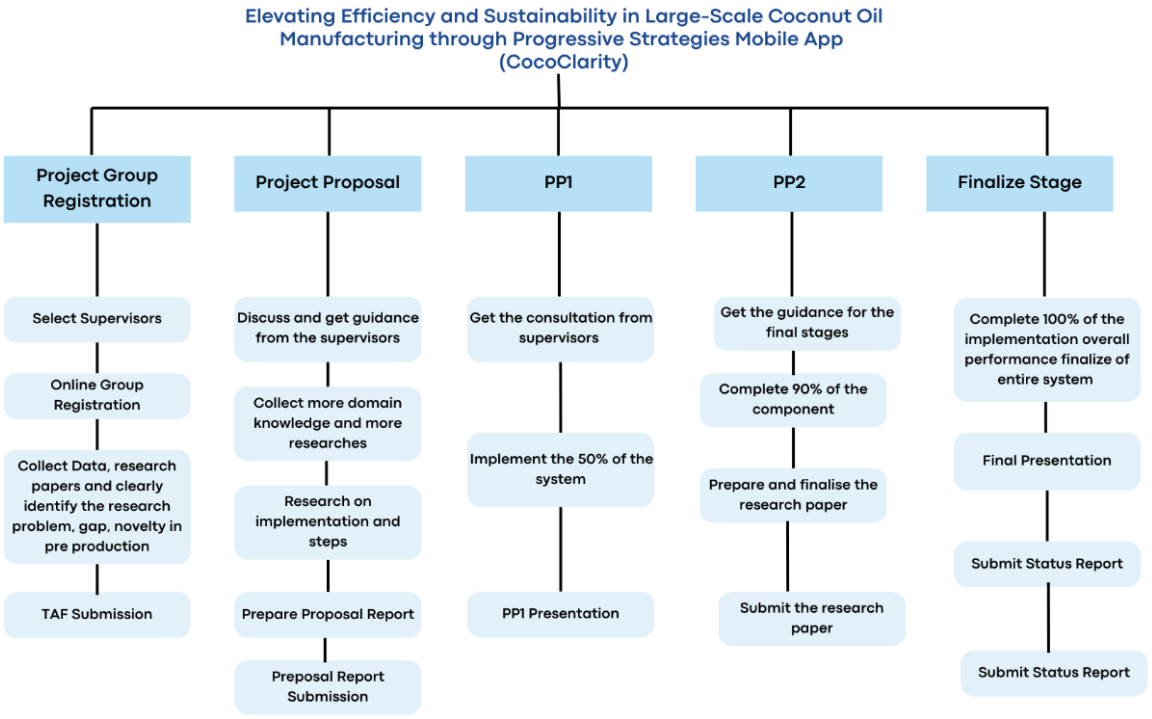

Figure 9 Work Breakdown Chart

5 COMERCIALIZATION

Figure 10 Our Logo

5.1 Target Audience

- CRISL – Researchers
- Coconut Oil Manufactures
- Coconut Farmers
- Coconut Research Institute of Sri Lanka
- University Students
- Agricultural Technology Companies
- Sri Lankan Government
- Foreign Governments

5.2 Business Potential

- Revenue Streams: Generate revenue through subscription-based models, licensing fees for premium features, and consulting services for implementation and customization.
- Cost Savings: Help businesses reduce operational costs associated with inefficient production planning, excess inventory, and suboptimal distribution strategies.
- Market Expansion: Enable businesses to expand their market reach by identifying untapped opportunities and optimizing distribution channels.
- Sustainability Impact: Address the growing consumer demand for sustainable products by promoting eco-friendly practices and transparent supply chains.
- Competitive Advantage: Provide businesses with a competitive edge through data-driven decision-making, agile supply chain management, and enhanced collaboration with partners.

5.3 Key Features

- Demand Forecasting: Utilize historical data and predictive analytics to forecast the demand for coconut oil in different countries and industries accurately.
- Production Planning: Optimize production schedules based on demand forecasts, market trends, and production capacities to ensure efficient utilization of resources.
- Distribution Strategy Optimization: Develop algorithms to determine the optimal distribution percentage of coconut oil across various industries and countries, considering factors such as transportation costs, market demand, and regulatory constraints.
- Inventory Management: Implement inventory optimization techniques to minimize stock outs and excess inventory, thereby reducing carrying costs and maximizing profitability.
- Market Intelligence: Provide real-time insights into market dynamics, competitor analysis, and emerging trends to enable informed decision-making by stakeholders.
- Sustainability Assessment: Integrate sustainability metrics into the platform to evaluate the environmental impact of coconut oil production and distribution, promoting eco-friendly practices.
- Collaborative Platform: Facilitate collaboration and communication among stakeholders, including producers, distributors, retailers, and government agencies, to streamline the supply chain and enhance transparency.
- Customizable Dashboards: Offer customizable dashboards and reports tailored to the specific needs of each user, providing actionable insights for strategic planning and performance monitoring.

5.4 Budget and Budget Justification

Feature	Cost
Deployment Cost	Rs. 6,200
Play Store	Rs. 5,000
App Store	Rs. 19,500 / annual
Firebase Database	Rs. 30 / GB / Month
Total Budget	**Rs. 30,730**

Table 7 Budget and Budget Justification

Table VII shows the estimated budget for the component. As with any project, the estimated costs for our initiative to deploy machine learning (ML) models may vary due to economic factors and the introduction of new features. Economic fluctuations, such as changes in market conditions, currency exchange rates, and regulatory policies, can influence the overall project expenses, impacting resource procurement, personnel costs, and data acquisition expenses. Furthermore, as we aim to enhance the capabilities and effectiveness of our ML models, the incorporation of new features and technologies may require additional investments in research and development, infrastructure upgrades, and training. These new features could include advancements in model accuracy, scalability, and interpretability, as well as the integration of novel techniques like reinforcement learning or natural language processing. While these investments may contribute to the project's overall cost, they are essential for maintaining competitiveness, meeting evolving market demands, and achieving our long-term objectives. Therefore, it's imperative to regularly reassess and adjust our cost projections to align with changing economic conditions and evolving project requirements, ensuring the successful realization of our goals.

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