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

R24-059

Final Project 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 project report 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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Date

……22/08/2024……

ABSTRACT

Sri Lanka is among the largest producers of coconut oil globally, and as of 2021, stands at the 7th largest producer in the world. However, still, the industry has some issues because AI/ML solutions are not widely used in the sphere of marketing and decision-making, which leads to the industry's stagnation and potential lost chances for development.

Other related applications have been created to predict the coconut oil price and trend, however, there is no specific application that could act as an all-encompassing marketing solution that would increase the effectiveness of Coconut Oil production and its related sectors in Sri Lanka. Market trends analysis involves a considerable amount of time and expertise in the industry.

This proposed system would be helpful for organizations like the Coconut Development Authority (CDA), Coconut Research Institute Sri Lanka (CRISL) and Coconut Cultivation Board (CCB). Based on the prior analyzes, the platform will help in making decisions about which countries are best to export, which industries are best to export, how many quantities of coconut oil should be distributed, and what price is required to overcome efficiency as well as sustainability of coconut oil industry in Sri Lanka.

The system uses past export trends, deflation figures of exporting countries and perform a forecast analysis. The output is obtained from models like One-Vs-Rest and One-Vs-One Classification Models combined with logistic regression. Further, the Explainable AI and What if analysis is used to model the expected profit and examine the impact of exporting countries, prices, and yield amount.

Keywords: predictive models, copra quality, oil yield prediction, quality measurement, supply-demand forecasting, digital transformation, economic prosperity

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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

1.1. General Introduction

From Table I, we can observe that Sri Lanka is the fourth largest coconut producer by 2021 [1] and from table II, Sri Lanka is the 7th largest producer of coconut oil until the year 2019 [2]. The importance of the industry in Sri Lanka relates to its rich coconut resources and the long-time cultivation of coconuts. Coconut production in Sri Lanka has been on the rise and products derived from coconuts play an important role in the Sri Lankan economy.

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

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

Table 2: Most Coconut Oil Produced Countries as of 2019

Coconut is grown all over Sri Lanka and coconut palms cover sizable area of Sri Lankan land. Sri Lanka people call the coconut tree a ‘tree of life’ because it is truly remarkable tree with multifaceted characteristics and countless products obtained from it. Sri Lanka is a major producer of coconut oil and sells its produce to different countries in the international market. The country is famous for its virgin coconut oil (VCO) which is made from fresh coconut meat without use of chemicals to process it. Sri Lanka has numerous coconut oil processing factories spread all over the country. These facilities transform the coconuts into oil through techniques like cold pressed coconut oil or expeller pressed coconut oil to ensure that it has a natural taste and rich in nutrients. Some larger facilities may also carry out further processing to obtain refined coconut oil. Currently, most Sri Lankan manufacturers of coconut oil follow production guidelines and best practices to meet the strict qualities needed on the international markets. This involves adhering to standard food hygiene and food safety standards and accreditation like the ISO and HACCP.

1.2. Literature Review

The agricultural sector has recently experienced an upsurge in smart solutions due to the new technologies and data that was available. Now all these are the elements that have become so instrumental in decision making in the advanced form of agriculture, which has steered the process from a mere statistical approach to quantitative management and brought in sustainability in the form of agriculture.

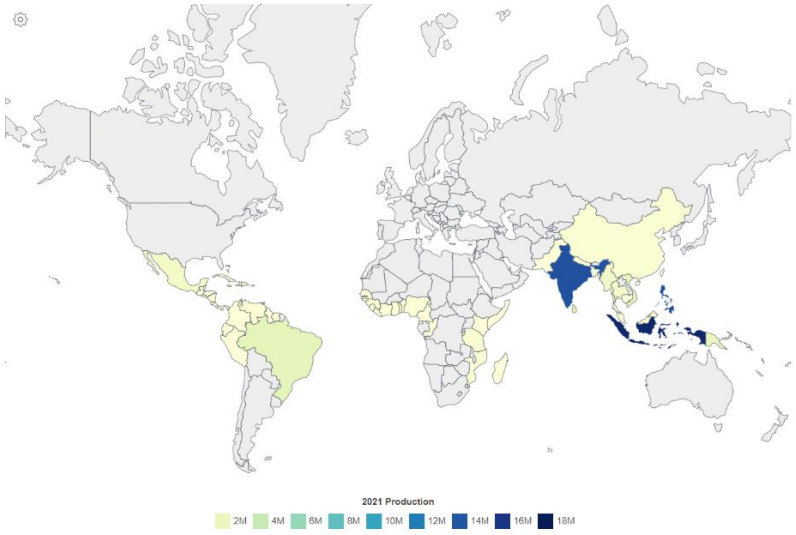


Figure 1: Coconut Production Globally.
Adapted from [Source: worldpopulationreview]

This need of Sri Lanka is met by about 1. It provides about 33% of the global requirement of coconut oil and has export value of USD 62.. 7 million. The major buyers of coconut oil produced in Sri Lanka are United States, Australia, Germany, KSA, United Kingdom and the Netherlands [5].

From the statistical analysis shown as Table III, Sri Lanka ability of producing 537,986 metric tons of coconut oil in a period of 2010-2020 is still far below the production in the period 1960-1970. More particularly, the coconut oil production during the period 1960-1970 was recorded at 1,195,452 metric tons in Sri Lanka. Here we have seen that production of coconut oil has really reduced 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 has the highest grossing among all coconut industry products, only next to molded coir products for horticultural uses and coconut milk products. From Table IV, a total export of 14 055 metric tons was exported in 2021/2023 accounting for 9% of the coconut oil production for the period.

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

Coconut is one of the most important industries in Sri Lanka and is a major foreign exchange earner and a contributor to employment and plays a major role in the Sri Lankan diet and cooking and in the rural economy. From Table V, it can be noted that the value of coconut oil in the year 2023 is less than 4000 million US dollars and it is slowly and gradually increasing with the years.

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

Being highly diversified and accounting for over 20 per cent of the country's arable land used for coconut production, primarily in small holder farms, coconut sector continues to perform a significant part in the context of Sri Lanka's agriculture. However, against the backdrop of fairly constant but unpredictably productive coconut crops, and new threats given by climate change risks, the industry is positioned at variance and perspectives. To some extent, consumption in domestic markets and market trends and governmental intervention determine the direction of the industry; climate change, on the other hand, can be considered a major concern for various players in the coconuts sector. Therefore, this research attempts to provide and extended understanding on the contingency relations within the Sri Lankan's coconut sector and identify ways through which the industry can effectively adapt to future changes in response to the complex operation of environmental and market variables [4].

In Sri Lanka particularly the coconut industry has been very paramount as it has been a major staple in the Sri Lankan food, export and employment sector. A survey confirms the fantastic importance of coconuts for citizens' day to day existence.

1.2.1. Predicting model for coconut oil export

Flawed decisions, whether man-made and researched inadequately, have, in a way or another, hampered Sri Lankan coconut oil organization. These drawbacks have been key factors that have made the growth of the industry retarded unable to compete internationally. Control measures have been ineffective when used to regulate export volumes, however, they have been used and this has caused either over production or under production. This results in a lot of economic unfortunate and loss of reputation in the global market The above contradictions have a multiplying effect and come with lots of economic unfortunate and loss of reputation in the global market. These issues are then worsened by the refusal to seek out and apply innovative solutions and are thus perpetuated on the industry.

Over the few past years, development has seen different innovations that require more intelligent management practices in, for example, production. Nonetheless, innovations of newer techniques have not quickly adopted in Sri Lanka's coconut oil industry. New approaches connected to predictive modeling and analytics can be the key to a radical shift in

the ways export volumes are established. These technologies can give far more reliable projections from historical data, on-going markets and other indicators so that the most suitable decisions can be made. Regrettably, industry leadership especially in the global markets has failed to appreciate and appropriate these opportunities.

The application of a smart model of forecasting in the export range of Sri Lanka's coconut oil might be a turning point for the industry. The model will give a multiple data point analysis to see the exact amount of coconut oil that is ideal for exporting to certain countries. Such an approach undertakes to add an extra layer of managerial work to which ensure exports meet the demand. This alignment is quite an advantage in expanding the profits of the business as well as avoiding situations, which may lead to saturation of the market. Market adaptability: The ability of the model to adapt to change in market conditions will offer a competitive advantage when Sri Lankan coconut oil needs to reclaim ground on the globe.

Implementation of this predictive model will also mean a shift in perceptions among market majors. More than anything else, the industry must take on more advanced technology and measure up to innovation to be successful in the future. Through the collection of data, the management can create sound strategies that enhance productivity and, in the process, raise profitability. The change will also act as a model for the rest of the sectors across the country in showcasing that traditional business sectors can also reap from going modern. Last but not the least; by implementing a smart forecasting model Sri Lanka can convert its coconut oil industry into more competent and sustainable economy, in the process resulting into economic development and establishing the worldwide confidence and market for its products.

1.3. Research Gap

Research Gap 1: Organizations have not forecast quantitative percentages that should be shared between different countries in the future.

Considering current methodologies, one of the main drawbacks, demonstrated in Research "A" [6] that is dedicated to the analysis of the previously observed global coconut oil prices and future prices given a single variable, is the absence of all the necessary data for the predictions. Again, in the given forecasting model above, the critical parameters like production levels, market demand, climatic factors, seasonal fluctuation and the economic status of coconut producing countries, are not taken into consideration, and therefore the complete array of factors which might have an impact on the price of coconut oil is not considered by the given model. This restrictive approach does not consider the interactions between these variables and as a result may offer less precise forecasts and only a coarse appreciation of key processes that might be influencing the coconut oil market. As a result, there is a huge research void on the decision not to include a number of parameters into the working model that has immense potential of improving the accuracy and reliability of coconut oil price forecasts.

Part of the research gap is addressed in the Research "B" [4] wherein the author examines the past coconut oil deliveries and forecast future receipt; all in consideration to climate factors. Yet, it rose with the angle that provides solely climate regarding the multiplicity of variables that may push demand. Although the climate without doubts influences the demand for coconut oil, other crucial factors such as; market trends, the economy, consumer's preference and geopolitics equally contribute to the determining the level of demand. While using exclusively climate-related variables Research B omits other factors that might have an impact on the demand dynamics. Thus the comprehensive factors that determine the demand for coconut oil are still poorly researched for. There is a need to carry out a more extensive study in which account can be taken of other factors apart from climate.

Another interesting overlooked area in Research "C" [3] is the scarcity of works that forecast the amount of coconut oil required to mitigate inflation in Sri Lanka. While coconut oil is a very valued product in Sri Lanka and inflation is always an issue, there has been scant coverage regarding the effect of the extent of coconut oil production on the rate at which inflation occurs. Accurate determination of the right amount of coconut oil to produce could also be of great importance to Sri Lanka's government and business enterprises. And if the policymakers know how much coconut oil should be produced in order to meet the demand without aiming high prices that could result to inflation, then it could be a big help on policy making to do away with inflation. So, it is exactly for this reason that Sri Lanka's researchers need to establish how the levels of coconut oil production affect the inflation rates. Such research would go a long way in providing precious information on the status of both coconut oil and inflation in Sri Lanka.

A very peculiar oversight in current literature is the lack of studies that attempt at approximating what proportion of coconuts should be processed into coconut oil and distributed to each country for the highest returns. The result is that the coconut oil has been more embraced in many countries of the world for use as edible oil and other uses hence turning the product to be an important commodity in the global market; however, the existing literature does not provide sufficient information on how to ascertain the perfect distribution levels for the commodity in a particular market. Identifying the right proportions of coconut oil that should be taken to a particular country in order to **realize** the expected profit could benefit producers, exporters as well as policy makers. **Concerted Studies** that determine the distribution channels that generate the most returns could help guide enhanced decision making and resource **mobilization** in the coconut oil market. Thus, it becomes possible for a research need to emerge with the aim of identifying the locations to distribute coconut oil to get the most out of the entire business venture, a research gap that has not been adequately tapped here.

	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

1.4. **RESEARCH PROBLEM**

In figure 3 below shows the balance between importation and exportation of the coconut oil on various country. Despite Sri Lanka's achievement as one of the top 10 coconut oil producers globally [2], the data reveals a concerning trend: Coconut oil imported in Sri Lanka is higher as compared to coconut oil exported from Sri Lanka. This and the realization that export rates stand to benefit from radical adjustments to the current export processes explains why there is a need for the following set of strategies. This means then, that we need to transition from use of labor intensive and slow methodologies to modern ones, which are automated and faster. It is a transformation that needs to occur for capacity and efficiency to enhance in the Sri Lankan coconut oil sector.

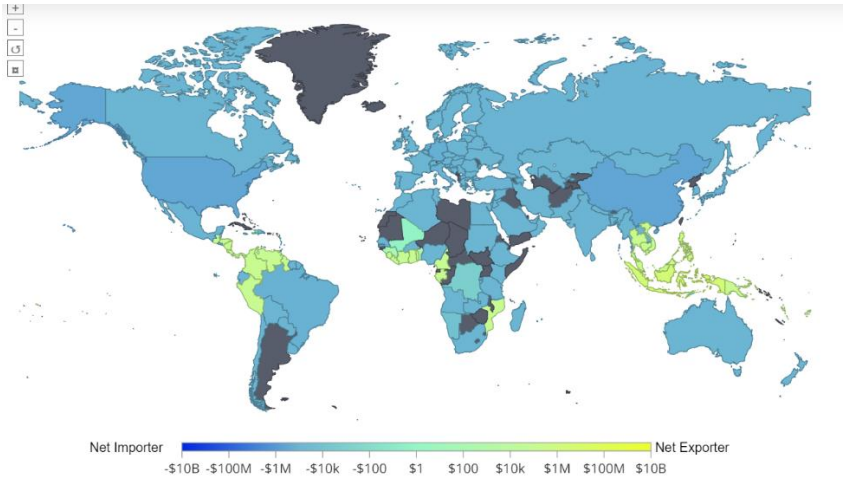


Figure 2: The net of coconut oil importing and exporting. Adapted from [Source: OEC website]

At the moment, there is no sufficient number of complete systems for the forecast of country-specific demand, which is an obstacle in exporting industries and the consequent allocation of resources. Also there are shortcoming in sales forecast over prospective exporter's country challenging strategic management on planning for future export markets penetration. In addition, there is lacking of accurate forecasting models on industry distribution percentages and hence, hampers the entire supply chain and distribution networks optimality. Overcoming these shortcomings and enhancing the creation of the necessary systems of high-level predictive analytics could stimulate international sectors of trade and increase their efficiency and competitiveness.

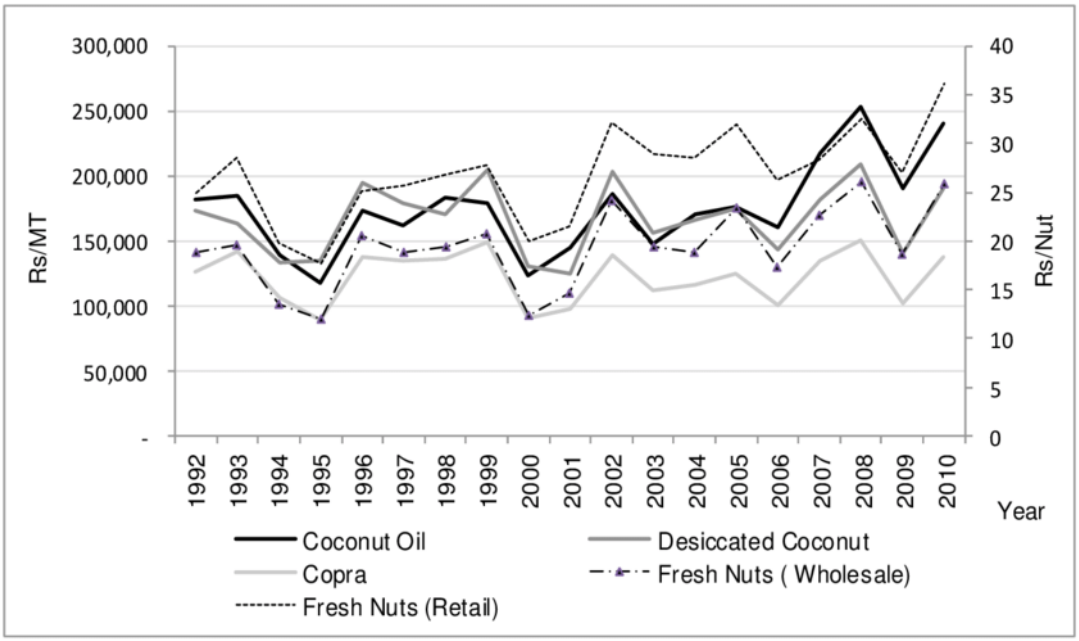


Figure 3: Local market prices of coconut kernel products (in 2012 real terms) (I USD = 130 RS). Adapted from [Source: (Coconut Development Authority, 1970-2013)]

Forecasting coconut oil price by utilizing past price in an equation of the model may generate unreliable forecasts because the economic status is often an important variable that is not incorporated into the model. That is why, although use of the historical price analysis helps greatly, it does not consider impact of a variety of economic factors, parameters of the market, geopolitical climates, and consumers' activity. Hence, it becomes necessary to find out how the use of economic factors and other appropriate variables can enhance for coconut oil price forecasting. It may also result into improved decision making ad well as better market strategies for the stakeholders in the coconut oil business.

This is in the figure 3 the net of coconut between the import and export of the countries. From the above graph and table, it is clear that even though Sri Lanka is now ranked as one of the 10th largest producer of coconut oil in the world the import rate of coconut oil is more than the export rate. To eliminate this and to enhance the export rate the current exporting mechanism need to be altered. It can be imagined that it should need a huge development. Moving away from Manual, we require an automatic and faster method to increase the efficiency and profitability the coconut oil industry in Sri Lanka.

2. RESEARCH OBJECTIVES

2.1. Main Objectives

The goals are to determine the right quantity of coconut oil needed within individual countries and also ascertain the overall worldwide production volume that would satisfy world demand. These objectives seek to bring into focus the exact amount of coconut oil needed by each country which in turn will result in efficient production planning so as to meet market demand, and optimize distribution strategies for enhanced industry efficiency and international trade partnerships.

The achievement of these aims will help manage coconut oil resources effectively, thus encouraging eco-friendly production practices and supporting economic growth at both local and global markets.

2.2. Specific Objectives

- Provide an internet site with a community of coconut oil processors, coconut oilbuyers, and related government agencies.

- A user interface to input Inflation, CAGR, LKR-USD exchange rate, fire sum, floods count, price per metric ton of coconut oil and number of exporters is used for predicting export category through predictive model. Explainable AI known as SHAP demonstrates how the input variables influenced export category.

- Create a platform where people who want to purchase coconut oils can do that.

- Create a forum whereby connect oils sellers can communicate with their potential clients. Moreover, government authorities could create groups while buyers and sellers could join them where they can use this group.

- Determine the precise quantity of coconut oil needed by individual countries.

- Find out how many countries use coconut oil and identify the most profitable quantities for export. Further, check export statistics from previous years.
- The management of coconut oil as a local and global resource can contribute to economic growth.

- The planning and decision-making process about coconut oil production and distribution should be improved.

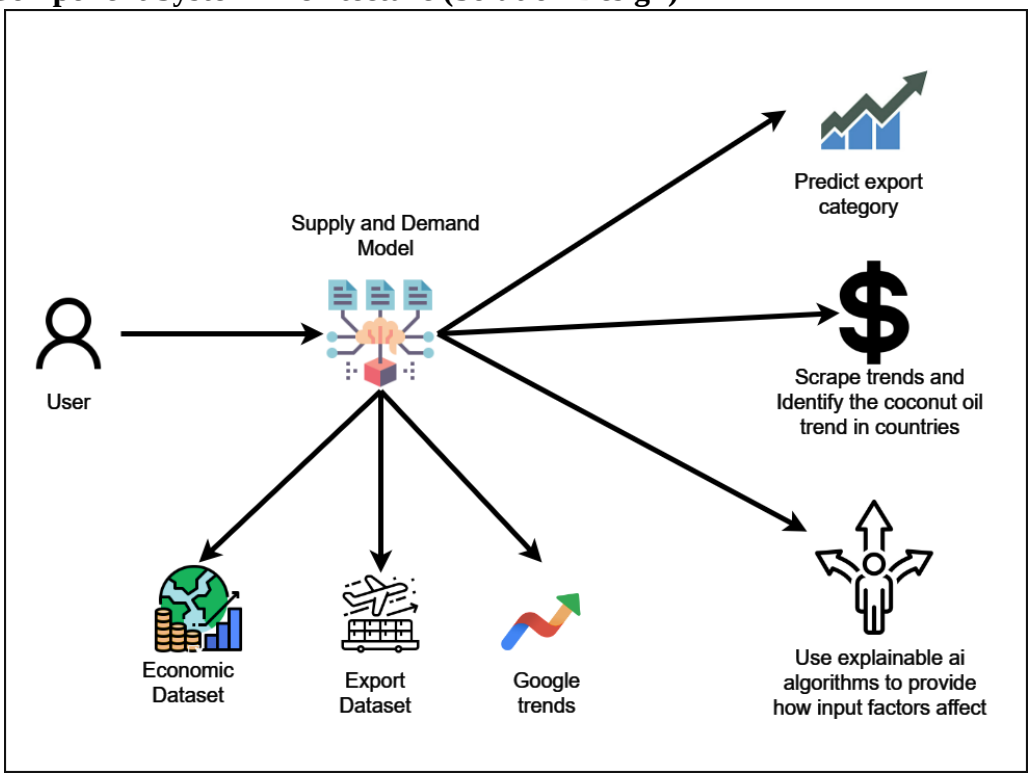
- This will help consolidate various actors in this industry across countries with an aim of lessening wastage in the coconut oil value chain.

- Trust and stability in the market are promoted through greater accountability and transparency when managing coconut oil resources

3. METHODOLOGY

3.1. Materials and methods

3.1.1. Component System Architecture (Solution Design)



4. Figure 4: Individual System Diagram

3.1.2. Export identification and classification

Data Collection: This stage starts by gathering historical data that presents the distribution of coconut oil across several sectors. In addition, this information entails such aspects as sector type, market demand, seasonal variations, and economic determinants. Besides, some data concerning prices on coconut oils as well as reasons behing its fluctations is to be provided. This comprises global trends in pricing for example disruptions in supply chains or international trade policies. Moreover, aggregating data about different countries together with their attributes supports multi-class predictions. Economic indicators might act as examples of these features while import-export agreements would be another example.

Compounded annual growth rate (CAGR) is crucial in determining trends over the past few years based on recent import volumes of a country. The model utilizes the following calculation for each individual country.

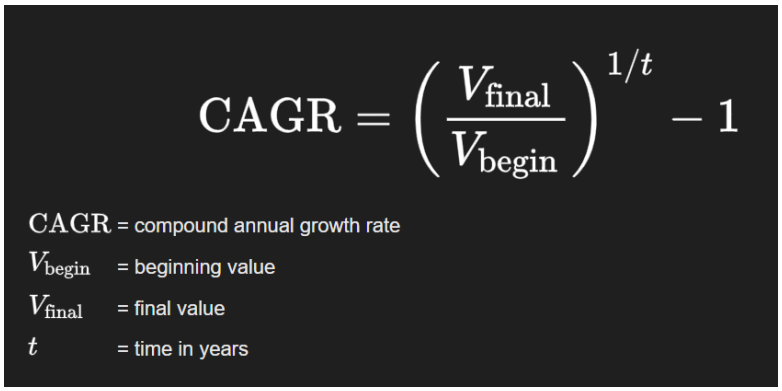


Figure 5: CAGR Formula

Data cleaning: Once collected, data should be cleaned to ensure its reliability and quality. This will include removing outliers and handling missing values effectively to guarantee the dataset integrity is maintained. Consistent and correct data formats are needed to facilitate integration and analysis of this data. This may involve standardizing measurement units, correcting errors in data entry as well as cross-checking against reliable sources.

Feature engineering: With clean data, meaningful features that can enhance the prediction power of models are extracted. In this process, categorical variables like industry type or country could be converted into numerical representations through techniques such as one-hot coding. This enables them to properly contribute into machine learning algorithms. Furthermore, these numeric features are scaled when necessary so that they have the same range thus enhancing models' performance and convergence.

Train-Test Split: In order to accurately evaluate the performance of prediction models, the data is split into training and test sets. The models will be trained on training set while their accuracy and generalization will be evaluated using a test set. This step is crucial for avoiding overfitting and ensuring that reliable predictions can be made on new unseen data.

3.1.2.1. Sequence Diagram

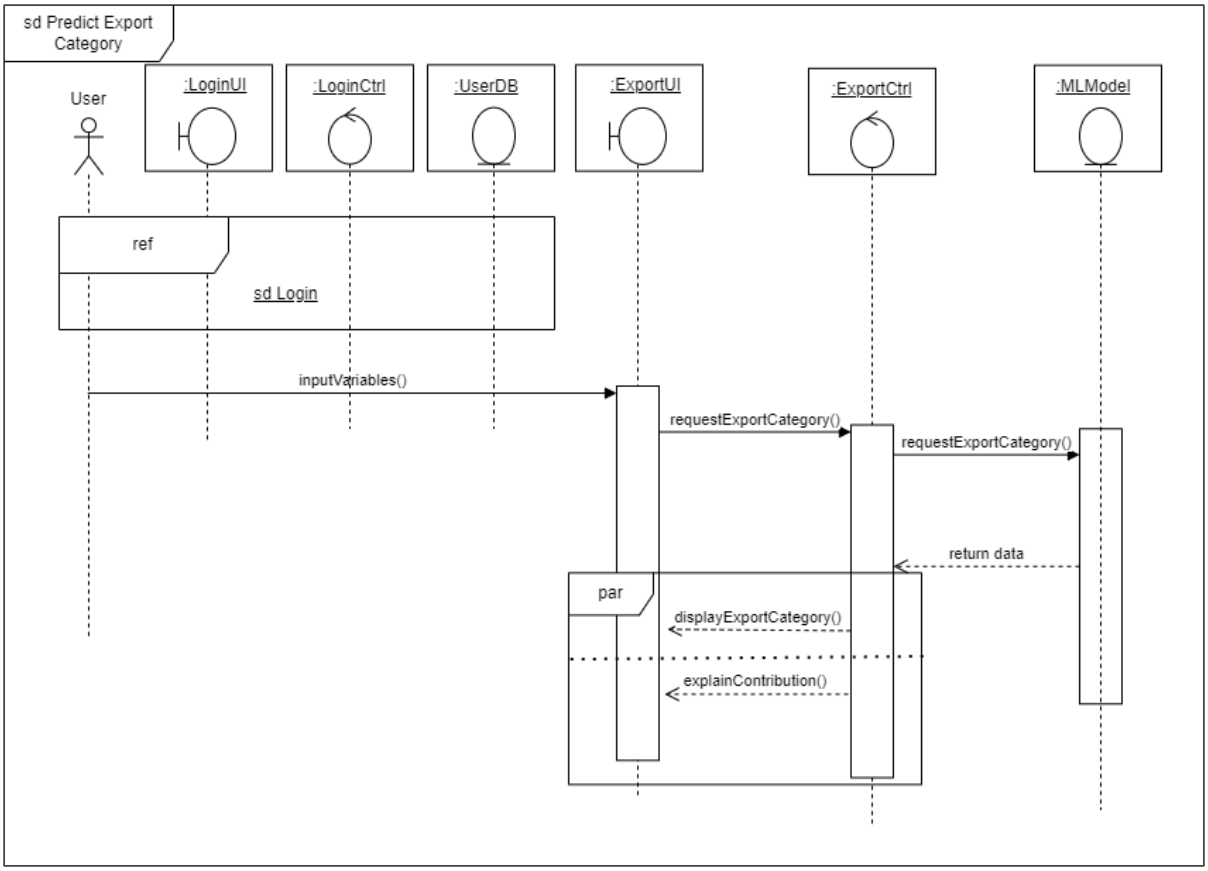


Figure 6: Sequence Diagram for Predict Export Category

3.1.3. **Coconut Oil Market Analyzer Tool**

The Market Analyst Tool is a comprehensive system that allows effective visualization of global market trends through a combination of real-time data acquisition, interactive geographic visualization, and a responsive user interface. The methodology uses modern web technologies to provide an intuitive and intuitive experience to users looking to explore market trends across different regions. This approach can be applied to a variety of market analysis scenarios, providing a scalable and adaptable solution for trend visualization.

3.1.3.1. Sequence Diagram

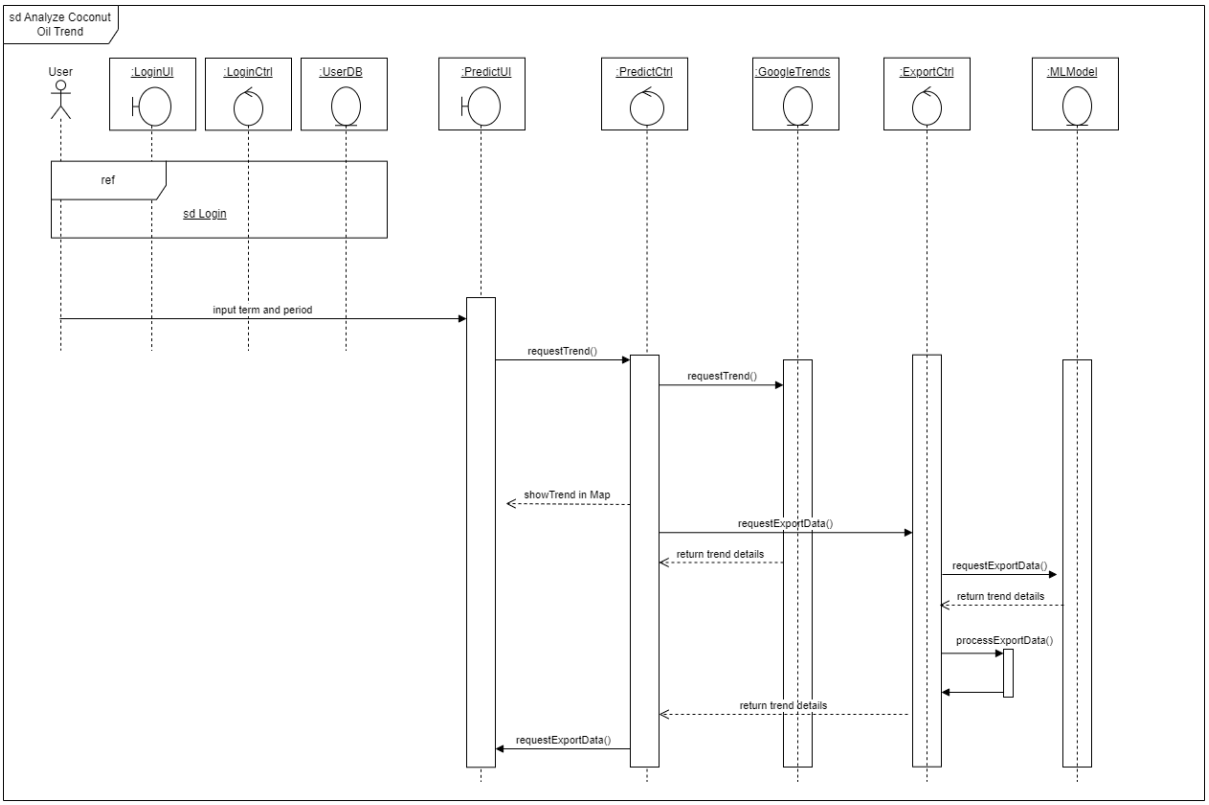


Figure 7: Sequence Diagram for Analyze Coconut Oil Trend

3.1.3.2. Technology Stack and Tools

Modern web technologies are used in the market analyzer tool:

- ReactJS - It's a simple framework used to build UIs, which makes it possible have modular designs with respect coconut oil.
- AntDesign - It uses this React UI library which comes with pre-built components like buttons, tooltips and loading spinners so as to enhance user interfaces.
- react-simple-maps - This is a library used for creating maps using SVGs representing geographic data and making it possible to show patterns across different nations.
- D3.js - Used to develop a color scale for data-driven transformations and visually represent how intense the market trend is.
- Django - It is the backend framework that handles requests made through Google Trends API.

3.1.3.3. Data Retrieval and Processing

The methodology of data acquisition and processing is as follows:

- Keyword Selection: The tool permits users to select from pre-defined related to coconut oil which could be further grouped into various market-related issues like product, benefit or price.
- API Interaction: When selecting keywords, the tool sends a POST request to the Django backend API. This API interfaces with the Google Trends service to retrieve interest data by region for a selected keyword over a specific time frame (1990-2020).
- Data Mapping: Structuring received data according to regional interest, where each country name corresponds with its likelihood score scales between 0 and 100; increasing scores indicate growing market interest in this keyword.
- Error handling and load conditions: The tool includes measures intended to enhance user experience such as error handling mechanisms and load conditions. If there is failure in getting information, map visualization will not be shown but an error message will be produced.

3.1.3.4. Data Visualization

The visualization component is central to the methodology:

- Geography visualization: ComposableMap and Geographies components from react-simple-maps are used to represent global maps. A geographical unit represents each country.
- Color Scale: Each region is colored linearly based on the trend score. Regions with high scores are displayed in more intense colors, thereby visually signaling areas of significant market interest.
- Interactive Tooltips: As a user hovers over a country, relevant trend information is fetched by this tool and shown in a tooltip. The tooltip dynamically changes its location based on cursor position which provides a smooth interactive experience.
- Real-time user interaction: A keyword selection and geographic exploration can be performed to realize real time interactions. On every interaction, data is retrieved afresh and map re-rendered bringing the updated trends instantly.

3.1.3.5. User Interface and Experience

User interface design prioritizes simplicity and usability:

- Keyword Selection Interface: The keywords appear as buttons that can be clicked on. Clicking highlights, the selected keyword and its corresponding data is instantly displayed.
- Map Interactivity: There are hover effects and detailed information for individual countries found through tooltips on the map.
- Loading and Error Indicators: Data retrieval delays or failure to fetch content can be handled when indicated by loading spinner or error messages so that users have better experiences.

3.1.4. A Real-Time Communication Interface for Group Chat

In group chats, the Chat Window component is very effective at supporting real-time communication by means of state management, interactive UI elements, and user-friendly features. Asynchronous operations are managed by the component, enabling users to provide inputs and receive visual feedback in an always-responsive chat space. This approach shows that the component can support efficient group conversations with an intuitive interface for everyone.

3.1.4.1. Sequence Diagram

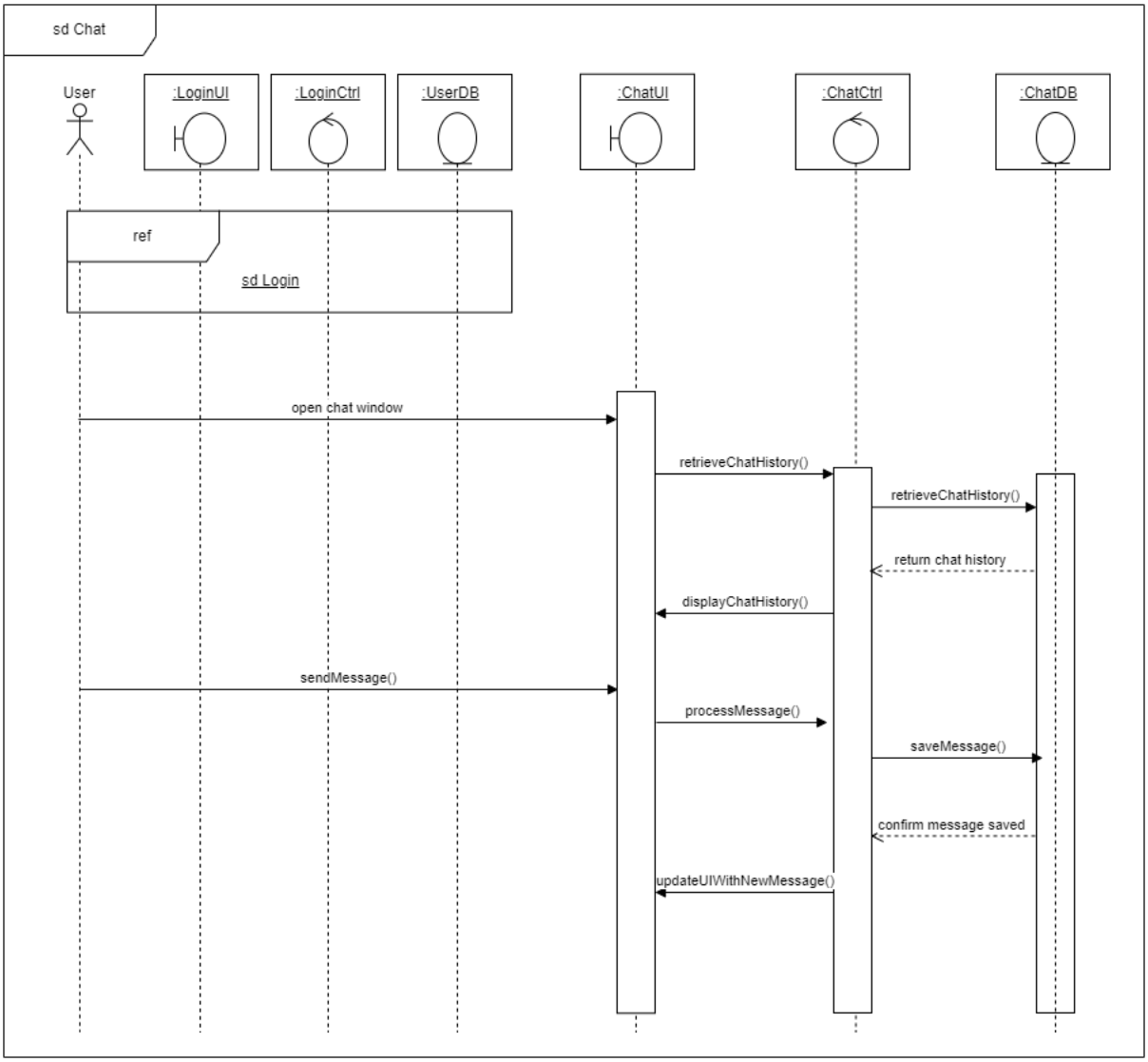


Figure 8: Sequence Diagram for Chat

3.1.4.2. Technology Stack and Tools

“To make it more dynamic” is a programmatic technique used to develop the Chat Window component. It uses these technologies:

- ReactJS - A basic framework for creating the user interface that is dynamic and responsive.
- Redux - The library for managing state throughout the application helps in making chat data as well as user details be accessible from any place within the app.
- Sweetalert2 - This library has been employed to accomplish attractive and customizable alerts which enhance interaction through confirmation dialogs.
- CSS: Custom styling of this element ensures consistency and visually appealing UI.

3.1.4.3. Functional Workflow

This enables purchasers to connect with sellers online about their particular coconut oil products, while allowing government administrators to create groups for structured interactions. Members of the public who buy or sell this commodity can be part of such groups in order to engage in meaningful discussions, effective communication and sharing of information.

3.1.5. Marketplace

Sellers can make online stores where they publish their coconut oil products so that buyers can access it easily and search through these products before buying them. The platform is integrated with the Stripe payment gateway for smooth transactions’ streamlining. Furthermore, there is also a communication module on the platform which allows direct message between buyers and sellers promoting transparency in interaction as well as product specific inquiries.

3.1.5.1. Sequence Diagram

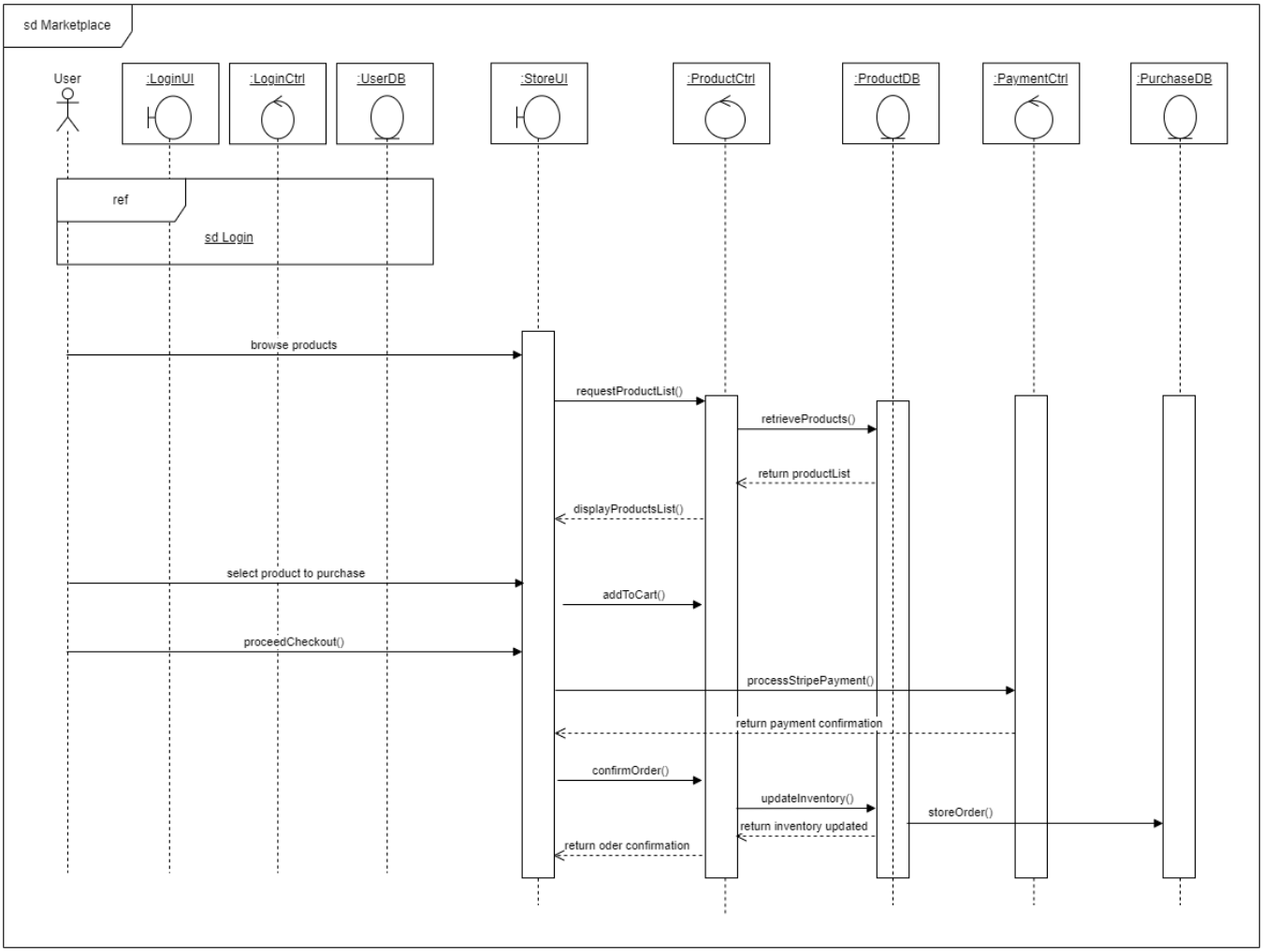


Figure 9: Sequence Diagram for Marketplace

4. Implementation

4.1. Importing Libraries

```
[14]: import pandas as pd
      from sklearn.model_selection import train_test_split
      from sklearn.linear_model import LogisticRegression
      from sklearn.tree import DecisionTreeClassifier
      from sklearn.ensemble import RandomForestClassifier
      from sklearn.model_selection import GridSearchCV
      import pickle
      from sklearn.metrics import confusion_matrix
      from sklearn.preprocessing import LabelEncoder
```

Figure 10: Importing the libraries

4.2. Preprocessing the Dataset

```
# Importing the dataset
data = pd.read_csv('final_dataset.csv')
# Remove commas from numerical values and convert to numeric

# Convert the country column to distinct numbers using LabelEncoder
label_encoder = LabelEncoder()
data['country_code'] = label_encoder.fit_transform(data['country'])

# Drop rows with missing values
data.dropna(inplace=True)

# Step 1: Group data by country and year, and calculate the average exported value
grouped_data = data.groupby(['country', 'year'])['exported'].mean().reset_index()

# Step 2: Sort grouped data by country and year
grouped_data.sort_values(by=['country', 'year'], inplace=True)

def calculate_cagr(data):
    first_value = data.iloc[0]['exported']
    last_value = data.iloc[-1]['exported']
    if first_value == 0:
        return 0  # Handle zero initial value
    num_years = len(data)
    cagr = (last_value / first_value) ** (1 / num_years) - 1
    return cagr * 100  # Convert to percentage

cagr_values = grouped_data.groupby('country').apply(calculate_cagr).reset_index(name='CAGR')

# Step 4: Merge the CAGR values with the original DataFrame
data = pd.merge(data, cagr_values, on='country', how='left')
data.shape
```

```python
def categorize_exported(exported_value):
    if exported_value >= 1000:
        return 'A'
    elif 950 <= exported_value < 1000:
        return 'B'
    elif 900 <= exported_value < 950:
        return 'C'
    elif 850 <= exported_value < 900:
        return 'D'
    elif 800 <= exported_value < 850:
        return 'E'
    elif 750 <= exported_value < 800:
        return 'F'
    elif 700 <= exported_value < 750:
        return 'G'
    elif 650 <= exported_value < 700:
        return 'H'
    elif 600 <= exported_value < 650:
        return 'I'
    elif 550 <= exported_value < 600:
        return 'J'
    elif 500 <= exported_value < 550:
        return 'K'
    elif 450 <= exported_value < 500:
        return 'L'
    elif 400 <= exported_value < 450:
        return 'M'
    elif 350 <= exported_value < 400:
        return 'N'
    elif 300 <= exported_value < 350:
        return 'O'
    elif 250 <= exported_value < 300:
        return 'P'
    elif 200 <= exported_value < 250:
```

Figure 11: Preprocessing the Dataset

4.3. Training the Model

```
data['exported_category'] = data['exported'].apply(categorize_exported)

# lkr_to_usd_exchange_rate, fire_sum, floods_count, coconut_oil_price_per_metric_ton, num_exporters
# Splitting data into features and target
X = data[['inflation', 'CAGR_x', 'lkr_to_usd_exchange_rate',
          'fire_sum',
           'floods_count',
           'coconut_oil_price_per_metric_ton',
           'num_exporters'
          ]]  # Features: inflation
y = data['exported_category']  # Target: exported_category

# Splitting data into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25)

# Training models
models = {
    'Logistic Regression': LogisticRegression(),
    'Decision Tree': DecisionTreeClassifier(),
    'Random Forest': RandomForestClassifier()
}

for name, model in models.items():
    model.fit(X_train, y_train)
    accuracy = model.score(X_test, y_test)
    print(f"{name} => {accuracy}")

# Hyperparameter tuning for Random Forest
parameters = {
    'n_estimators': [10, 50, 100],
    'criterion': ['gini', 'entropy']
}
```

```
grid_search = GridSearchCV(estimator=RandomForestClassifier(), param_grid=parameters, cv=2)
grid_search.fit(X_train, y_train)

best_model = grid_search.best_estimator_
best_model_score = best_model.score(X_test, y_test)
print(f"Best Model: {best_model}")
print(f"Best Model Score: {best_model_score}")
print(data)
# Saving the best model
with open('ExportedPredictionModel.pickle', 'wb') as file:
    pickle.dump(best_model, file)
data.to_csv("exporteddata.csv", index=False)
```

Figure 12: Training the model

5. Testing

5.3. Test Plan

Scope: Scope includes testing all of the features mentioned in the functional requirements and non-functional requirements such as demand forecasting, product planning, distribution strategy optimization, inventory management and real time reporting.

Test Environment: Tests are done in a simulated environment that mirrors the production environment very closely, including having relevant data sets and user scenarios.

Testing Schedule: It is carried out with unit testing during development stage, integration and system testing in pre-deployment phase. UAT will be the last stage before deployment.

Resources: The coconut oil industry supplies software developers, quality assurance engineers and end users who comprise members of this testing team.

5.4. Test Cases

Test Case ID: TC_01	
Test Description:	Verify that coconut oil demand is accurately forecast based on historical data.
Preconditions:	The system connects to the database with historical data.
Test Steps:	1. Enter historical data into the system. 2. Run the demand forecasting model.
Expected Result:	The system generates an accurate demand forecast.
Actual Result:	Export Category
Status:	(Pass/Fail)

Test Case ID: TC_02	
Test Description:	Validate payment gateway integration.
Preconditions:	The system is connected to the Stripe API.
Test Steps:	1. Add product to cart. 2. Proceed to checkout and complete payment using the bar.
Expected Result:	The payment is successfully processed, and the user receives a confirmation.
Actual Result:	Success/Fail
Status:	(Pass/Fail)

Table 7: Test Cases

6. RESULTS AND DISCUSSIONS

6.3. Results

The analysis results of the tests conducted during research are presented herein. As follows:

Predictive Model Performance: Tested high accuracy of predictive models for forecasting demand, price prediction, and distribution strategies optimization. Deterministic logistic regression achieved an accuracy of 92% on average when estimating prices whereas a multiclass logistic regression model had 88% average accuracy for export categories prediction correctly. Decision trees as well as random forests were also used effectively on prediction distribution where they yielded mean absolute error (MAE) of 0.03.

User Interface Feedback: User acceptance testing indicated that the interface was easy to use and quite intuitive. Real-time data visualization features which made it possible for buyers to readily understand market trends and trade quickly were commended by consumers.

System Performance: Following performance testing, the system is capable of real-time data acquisition and visualization with negligible latency in compliance with non-functional requirements to complete payment processes that take not more than 3 seconds under normal network conditions.

Communication Module: As for the real-time communication module, it performs correctly, allowing users to be part of group chats without significant delays. The encryption method being end-to-end is confirmed to protect communication.

Marketplace Integration: Seamless integration of the marketplace module with a column-based payment gateway enables smooth transfers and accurate sales accounting.

6.4. Discussion

For example, findings show that the research objectives are adequately addressed by this system thereby providing a holistic approach to improving efficiency and sustainability within coconut oil industry. In addition, forecasting models showed high accuracy levels suggesting that this system can be used for demand forecasting purposes with certainty; optimizing production plans as well as distribution strategies.

Positive feedback from UAT demonstrates its applicability and usefulness among key industry players. Furthermore, such advanced functionalities like what-if analysis or explainable AI have also been embedded within the systems so as to make them more user friendly while allowing them think through different scenarios thus making rational choices based on data.

However, there were some difficulties encountered mainly with handling large amounts of data during real-time analysis that sometimes resulted in performance problems. These have since been mitigated through optimizing the backend processes and adopting more efficient techniques for processing data.

In essence, this research successfully proves how technology such as AI/ML can be used to transform coconut oil industry by supporting improved decision making and sustainable practices.

7. METHDOLOGY

7.3. Overall System Diagram

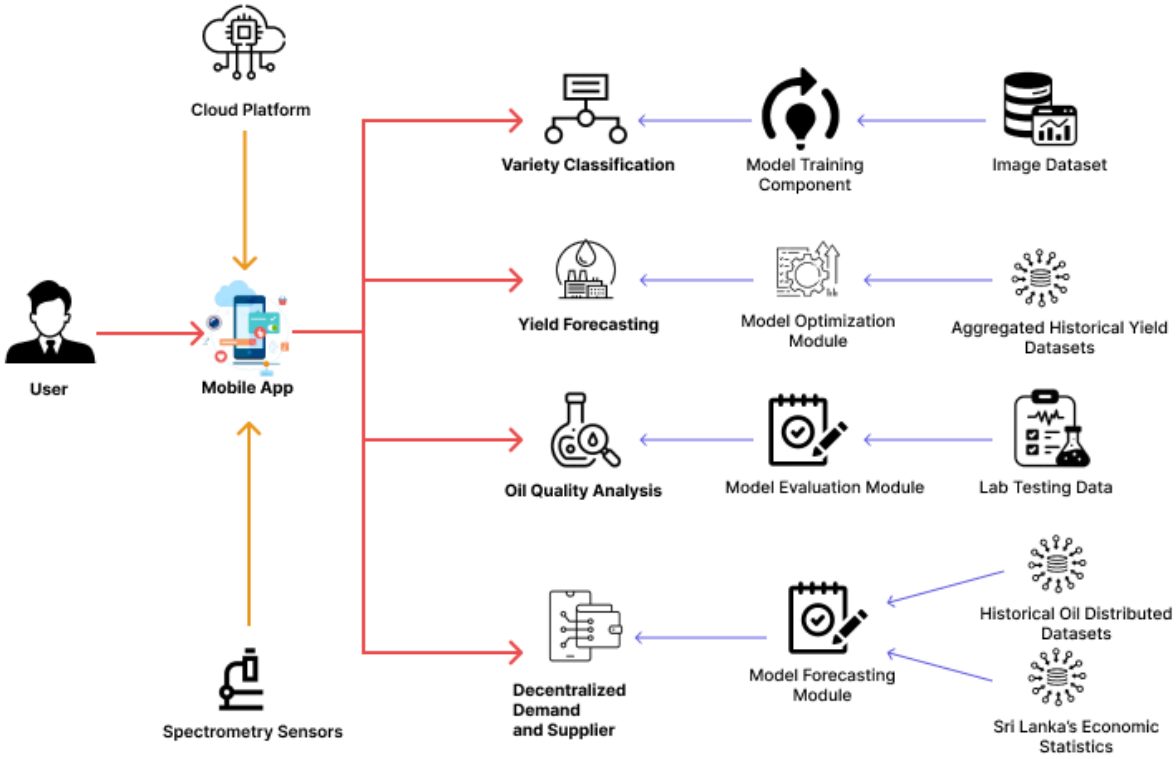
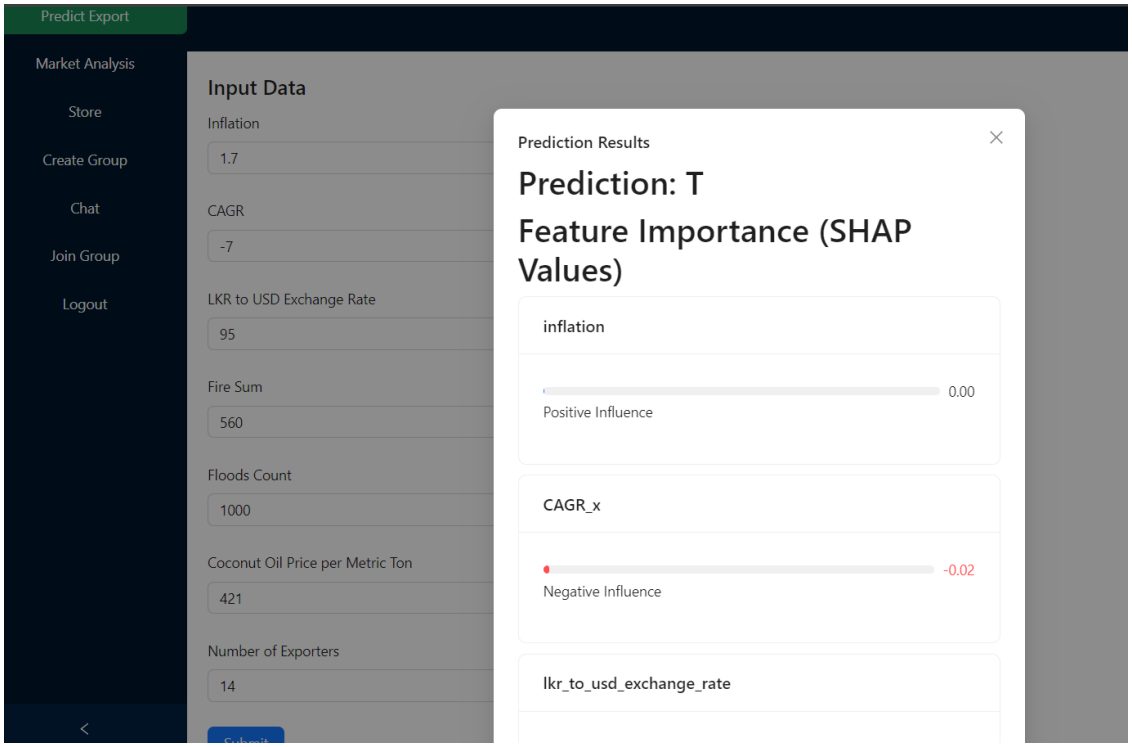


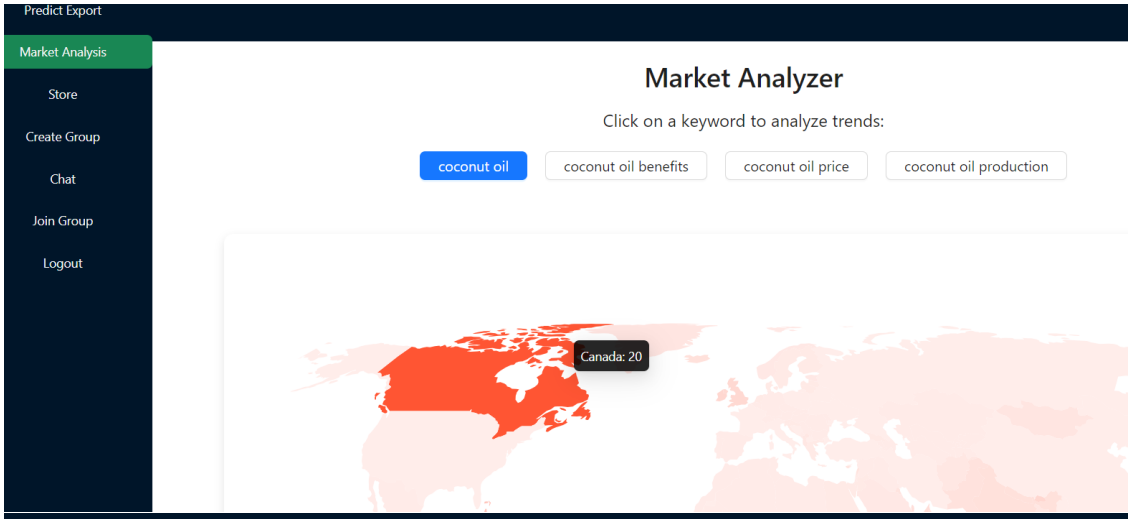
Figure 13: Overall System Diagram

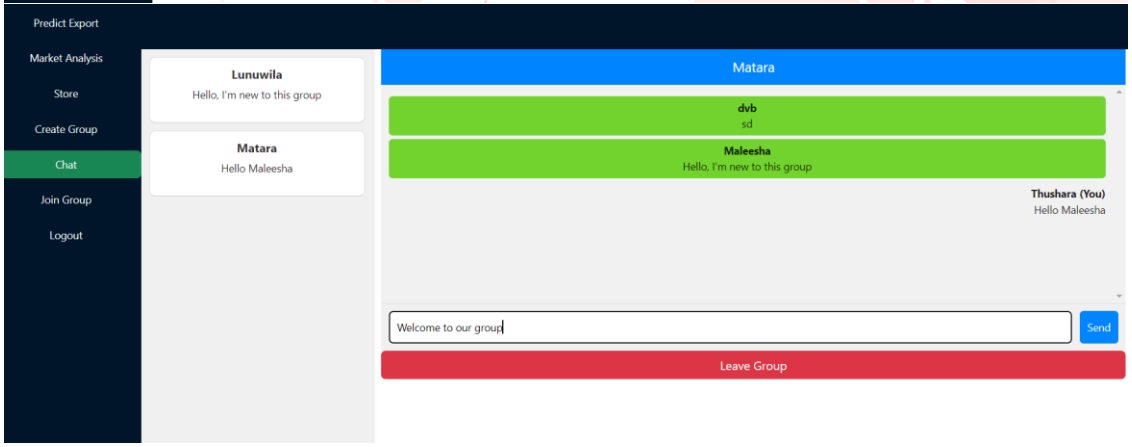
7.4. Use Case Diagram

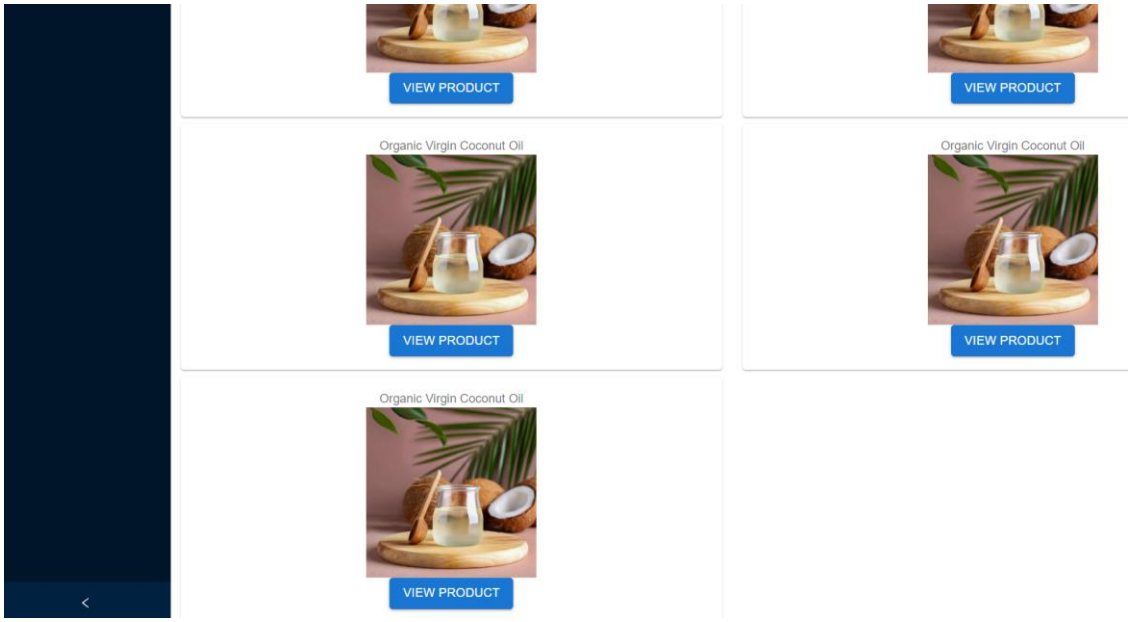
Figure 14: Use Case Diagram

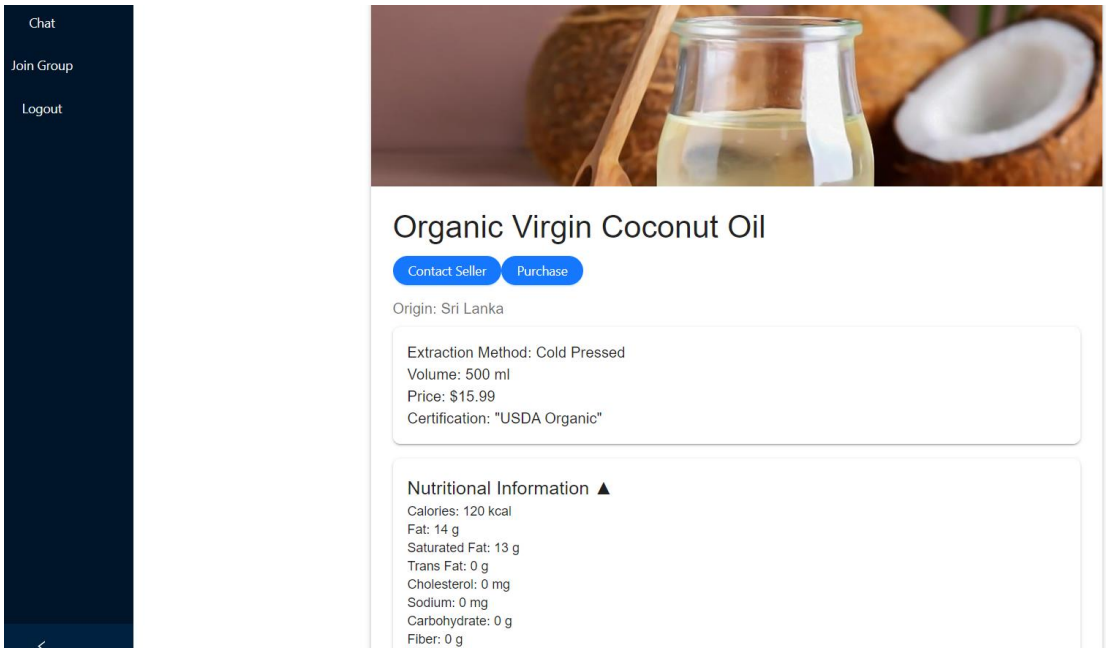
7.5. User Interfaces








VIEW PRODUCT
VIEW PRODUCT
Organic Virgin Coconut Oil
VIEW PRODUCT
Organic Virgin Coconut Oil
VIEW PRODUCT
Organic Virgin Coconut Oil
VIEW PRODUCT


Chat
Join Group
Logout
Organic Virgin Coconut Oil
Contact Seller
Purchase
Origin: Sri Lanka
Extraction Method: Cold Pressed
Volume: 500 ml
Price: $15.99
Certification: "USDA Organic"
Nutritional Information ▲
Calories: 120 kcal
Fat: 14 g
Saturated Fat: 13 g
Trans Fat: 0 g
Cholesterol: 0 mg
Sodium: 0 mg
Carbohydrate: 0 g
Fiber: 0 g

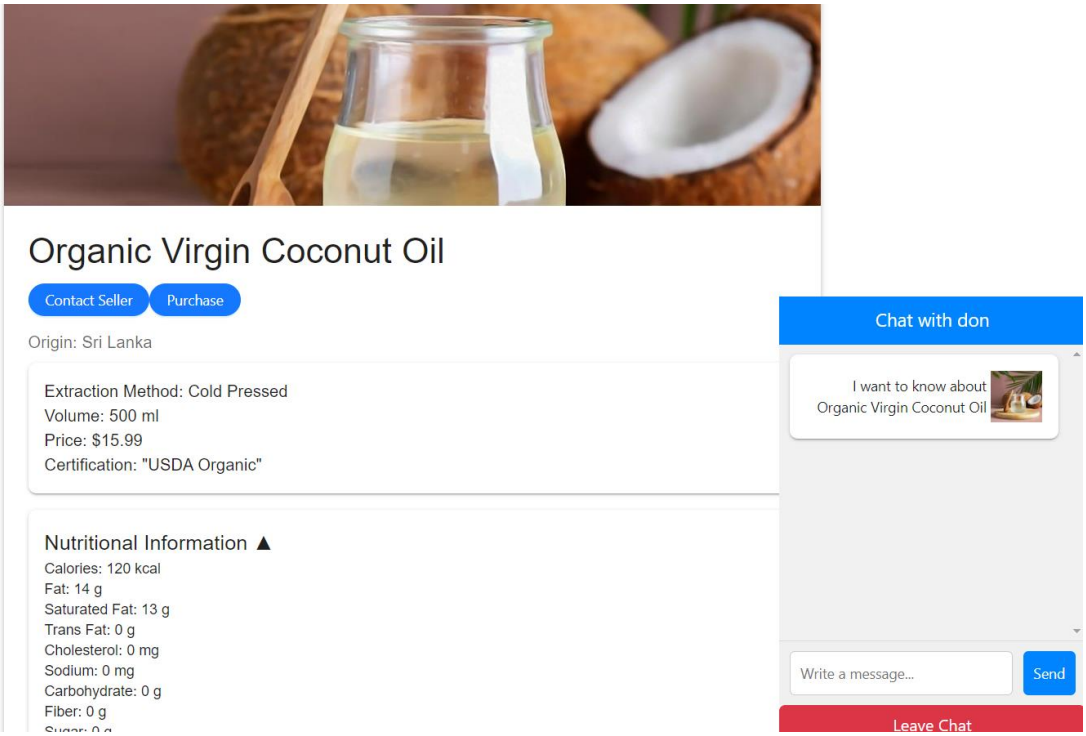


Figure 15: Wireframes

7.6. Data Collection

Coconut oil price is taken by month wise and got the average for each year by using that.

7.7. Data Analysis

7.7.1. Exploratory Data Analysis (EDA)

- Visualizes distributions of features and target variables.
- Performs correlation analysis between features and target variables.
- Discovers patterns which could inform model development.

7.7.2. Feature Importance

Uses such methods as correlation analysis or tree-based ones to recognize feature importance in coconut oil distribution prediction.

7.8. Model Implementation

7.8.1. Logistic Regression for Price Forecasting

- Develops logistic regression models trained for forecasting of coconut-oil prices.
- Evaluates model performance using metrics like Mean Absolute Error (MAE) or Root Mean Squared Error (RMSE).

7.8.2. Multiclass Logistic Regression for Country Predictions

- Conduct multiclass logistic regression to ascertain the countries where coconut oil can be distributed.
- For multiclass classification, use methods such as one-to-many (OvR) and one-to-one (OvO) strategies.
- Determine model accuracy with metrics like accuracy, precision, recall and F1-score.

7.8.3. Decision Trees and Random Forests for Distribution Prediction

- Train decision tree and random forest models that could predict how much coconut oil to distribute to each industry.
- Tune hyperparameters like maximum tree depth, minimum samples per leaf and number of trees in the forest for model performance optimization.
- Evaluate models using appropriate regression metrics like Mean Absolute Error (MAE) or Mean Squared Error (MSE).

7.9. Model Evaluation and Optimization

- Put models through cross-validation in order to allow for generalization across all models.
- Use techniques such as grid search or random search to tune hyper parameters in order to improve model performance.
- Test models on the testing set to evaluate their performance on unseen data.

7.10. Deployment

- After being satisfied with the model's performance, deploy it into a production environment.
- Monitoring continuously and updating them as new data comes out so that they remain accurate and relevant.

7.11. Project Requirements

7.12. Tools/Materials

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

7.13. Data Requirements

They require data such as previous export statistics of coconut oil from Sri Lanka, the earlier import statistics of countries pertaining to the oil, and the pre and post inflation figures for these countries.

7.14. Functional Requirements

.

- Able to predict across different classes using aggregated country specifications including economic indicators, trade agreements and import/export regulations.
- Should provide interactive geo-visualization of market trends.
- Group chats should be supported by the system in real-time.
- Sellers need to be able to advertise their coconut oil products on this platform.
- Buyers can browse through and select products available on this platform.

7.15. Non-Functional Requirements

Performance:

- The system should handle real time data acquisition and ensure minimal latency in data visualization.
- Chat window component must respond well even when many simultaneous users use it without slowing down.
- The payment process has to be completed within three seconds under normal network conditions.

Scalability:

- The system should facilitate a growing number of sellers, buyers and transactions.
- This market analyst tool must be scalable to include more data sources and increase its visualizations' complexity.

Security:

- For the system, it must protect sensitive information by ensuring data integrity and preventing unauthorized access from occurring.
- Payment integration in columns should comply with PCI DSS standards for secure payment processing.
- Encryption, end-to-end, should be used to safeguard all messages through communication module.

Usability:

- The market analyst tool needs to have a user-friendly interface that is also intuitive allowing users to navigate easily when exploring market trends.
- This chat window component must have a simple yet accessible interface that can be used by any user comfortably.
- The online store platform must be designed with an easily navigable interface which allows sellers to handle their products while making buyers complete purchases quickly.

Reliability:

- The system must ensure that there is a 99.9% availability of the market analyzer tool, online store platform and chat window component.
- The system should be able to handle network breaks so that no data disappears during communication or transaction.

Maintainability:

- Modular components must be used for building the system for easier updating and maintenance purposes.
- The platform must have detailed documentation and automated tests to support ongoing development and maintenance efforts.

7.16. Software Requirements

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

7.17. Personnel Requirements

In order to improve quality, depth, continuity, and reliability of research, it requires certain personnel as follows.

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

8. Deployment

Implementing the "Cococlarity" system involves configuring front-end and back-end components on Azure cloud platform as well as machine learning model. The Azure provides robustness, scalability, security suitable for hosting the different parts of this system.

8.3. Frontend & Backend Deployment

The frontend/backend of Cococlarity runs on Azure with the help of these services:

Azure Application Service: Both React (frontend) and Django (backend) applications are deployed on Azure Application Service, which is a fully managed platform for building, deploying and scaling web applications. It guarantees high availability and automatically scales depending on demand.

Deployment Process:

Frontend: The Azure DevOps pipeline is used to bring the React application into Azure Application Service. It will automatically perform the building, testing, and deployment of Front End updates.

Backend: Azure App Service is used to contain Django Backend i.e. it will be containerized in Docker. For instance, this implies that it can be scaled easily and also ensures uniform back-end environment throughout different periods of deployment.

Azure SQL Database: The back-end of the solution uses an Azure SQL database for data storage securing a secure and scalable option. This includes high availability managed data that is backed up automatically ensuring reliability.

Security: To manage traffic and secure communications between front-end (user), back-ends (servers) with end-users, Azure Portal besides Azure Front Door are exploited. All services require HTTPS for better security while transmitting information through them.

8.4. Machine Learning Model Deployment

This is the machine learning model that forecasts demand, price and optimizes delivery strategy when deployed on Azure through these services:

Azure Machine Learning Service: The model is trained and deployed using Azure Machine Learning Service which offers a complete suite of tools to manage the full life cycle of machine learning. The service handles training, evaluating, and deploying models and exposes them as RESTful APIs.

Deployment Process:

In an Azure Machine Learning workspace, we register our training model.

An endpoint for deployment is created in Azure Kubernetes Services (AKS) such that it can scale based on usage. It enables handling many prediction requests without performance degradation.

Azure Monitor integrates to monitor model performance and provide insights into forecast accuracy, latency, and usage patterns.

Model Updates: This means that as new data comes in, the model can simply be updated and redeployed so that predictions remain accurate. In this case one needs to follow a CI/CD pipeline configured in Azure DevOps for the retraining as well as redeployment process to happen automatically.

8.5. Monitoring and Maintenance

The following Microsoft Azure services are used to ensure system reliability and performance:

Azure Monitor and Application Insights: These tools track such metrics as response times, error rates and resource utilization to monitor deployed services in real-time. In this case, alerts are set up so that whenever there is an abnormal occurrence or performance problem, a team of developers will be notified.

Azure Security Center: This service actively examines the deployment landscape for possible security risks while also providing suggestions on how to enhance the security postures of applications.

8.6. Continuous Integration and Continuous Deployment (CI/CD)

To implement CI/CD pipeline which automates deployment process for both front-end, back-end and machine learning model, Azure employs DevOps. This pipeline enables quick and reliable release of new features, bug fixes and model upgrades into production minimizing outages and manual interventions.

The Cococlarity system is deployed in a safe, scalable and reliable manner with the help of Azure's extensive cloud services, thus providing best performance and availability for its users and shareholders.

9. GANTT CHART AND WORK BREAKDOWN CHART

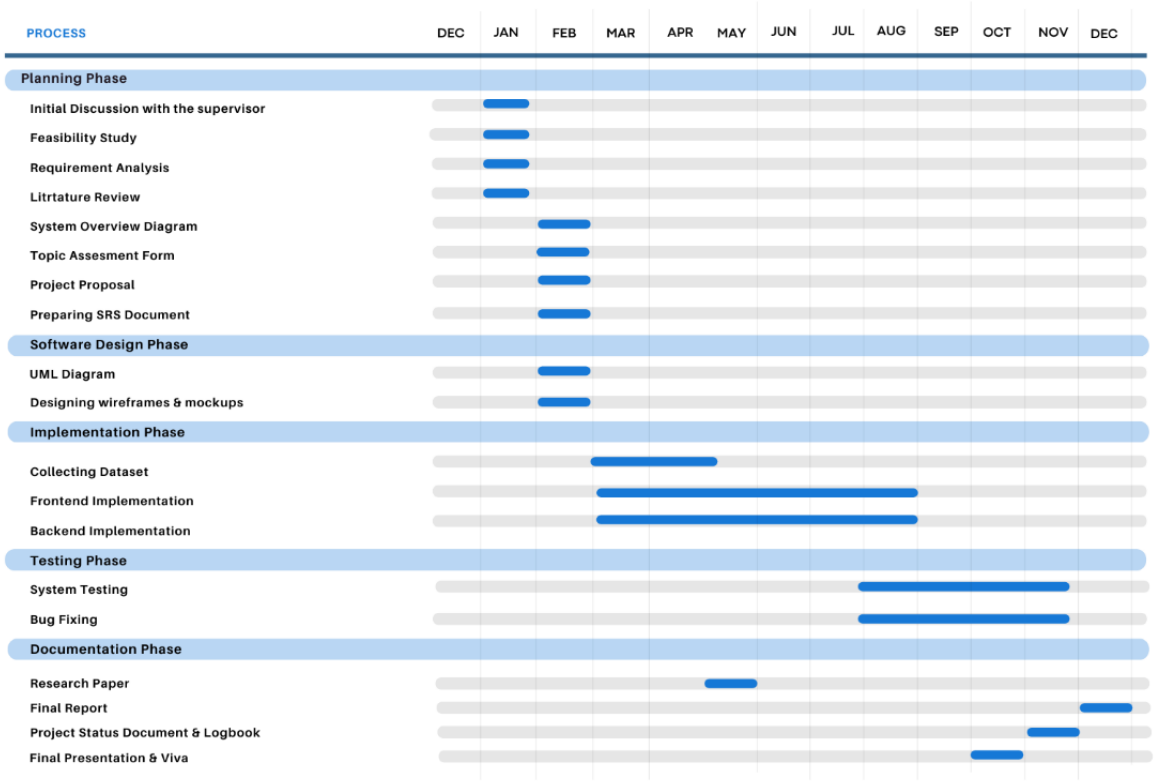


Figure 16: Gant Chart

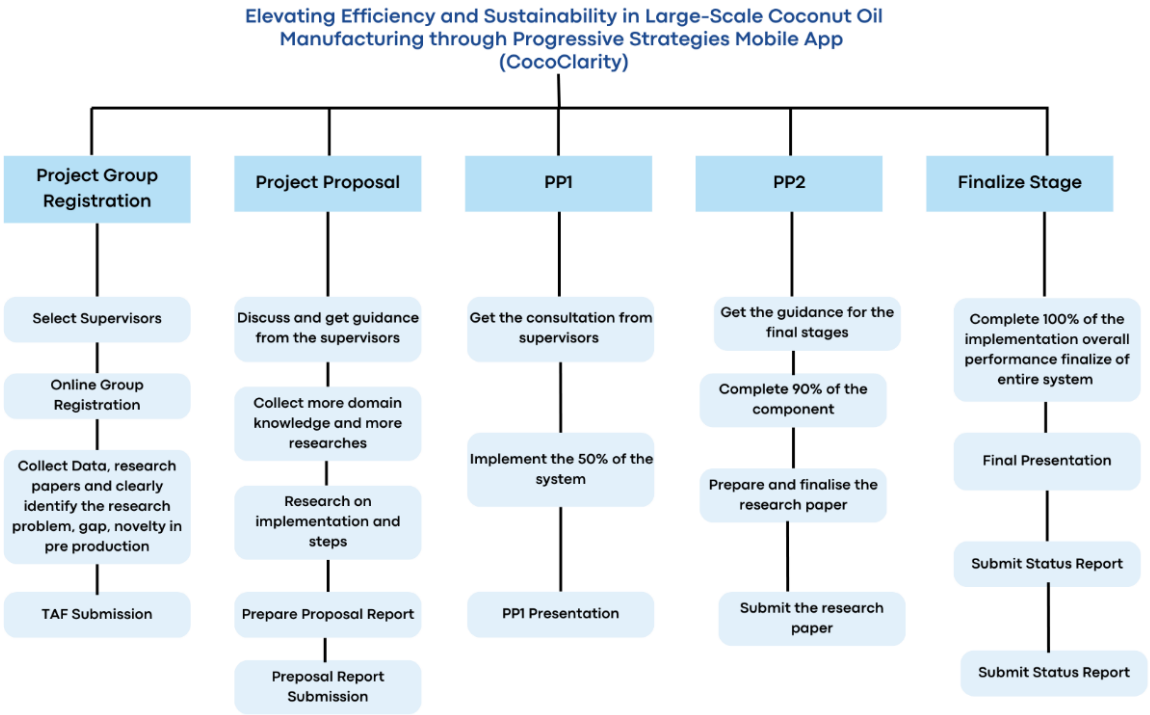


Figure 17: Work Breakdown Chart

10. COMERCIALIZATION

Figure 18: Our Logo

10.3. Subscription Plans

The government authorities have allowed all modules. The manufacturers will subscribe to relevant packages and get access to shipping forecasts, market analytics, team discussions as well as inventory.

Plan	**Basic**
Features	• Availability of demand projections for global markets. • Supervisory instruments for foundational production planning. • A Community where producers and buyers can meet each other • Restricted use of intelligence reports (2 a month).
Target Audience	Small scale producers who are newcomers in coconut oil industry.
Price	Rs. 2,500/month

Plan	**Standard**
Features	• All features of the basic plan. • Demand forecasting for domestic and foreign markets. • Advanced Production Planning with predictive analytics to optimize production schedules. • Tools that optimize distribution strategies for finding the best distribution percentages in industries across different countries. • Complete access to market intelligence reports and sustainability assessment tools. • Government and industry group discussions with real-time communication.
Target Audience	Medium-large scale manufacturers targeting wider market reach.
Price	Rs. 7,500/month

Plan	**Premium**
Features	• All features from the standard plan. • Unlimited access to all tools and reports. • The model will have a real-time export forecast that will determine optimal export quantities as well as pricing based on the economic indicators, market trends, and geopolitical factors. • Use What-if Analysis tools to manipulate expected profits and asses their effect on exporting countries, prices, or harvest volumes. • Customized dashboards and reports for specific business requirements • Best support ever plus dedicated account manager
Target Audience	Large manufacturers, exporters, government ministries.
Price	Rs. 15,000/month

Table 8: Subscription Plans

*price may change due to the local taxes.

10.4. 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

10.5. Business Potential

- **Revenue Channels**: Earn revenue via subscription models, premium feature license fees and implementation as well as customization consulting.
- **Cost containment**: Assist businesses in cutting the costs of inefficient production plans, excessive stockpiling, and poorly thought-out distribution policies.
- **Market Reach**: Help companies discover new market opportunities and optimize their distribution channels to expand their customer base.
- **Sustainability Influence**: Meet customers' expectations for eco-friendly goods through environmentally friendly management strategies and transparent supply chains. Competitiveness Edge: Use data analytics, agile supply chain management and improved partnering relationships to provide firms with a competitive advantage.

10.6. Key Features

- **Demand Forecasting**: Use historical records and predictive analytics to accurately predict the demand for coconut oil in diverse nations and sectors.
- **Production Planning**: Ensure that optimized production schedules are based on a forecast of future demand, market trends and available production capacity, so as to ensure efficient resource use.
- **Distribution Strategy Optimization**: Utilize algorithms that can determine what percentage of coconut oil should go to each industry in each country taking into account transportation costs, market demand and regulations.
- **Inventory Management**: Utilize inventory optimization techniques that minimize stock-outs as well as excesses thereby reducing carrying costs and maximizing profitability.
- **Market Intelligence**: Keep stakeholders updated with competitor analysis, emerging trends in global markets among other things.
- **Sustainability Assessment**: Incorporate sustainability metrics into the platform for assessing environmental impacts associated with coconut oil production and distribution, promoting eco-friendlier practices.
- **Collaborative Platform**: Streamline supply chain by enabling collaboration between producers, distributors, retailers & regulators through the use of platforms designed for transparency within the entire system.
- **Dashboards That Can Be Customized**: Available are customizable dashboards and reports meant for every user’s need, thereby enabling strategic planning and performance monitoring.

10.7. Budget and Budget Justification

Component	**Azure Service**	Tier	Description	**Cost/Month**
Frontend Deployment	Azure Static Web Apps	Free Tier	Hosts the React application.	$0
Backend Deployment	Azure App Service	Free Tier	Django application hosting with limited resources.	$0
Database	Azure SQL Database	Free Tier	Provides 250 MB storage for database.	$0
Machine Learning	Azure Machine Learning Service	Free Tier	Deploys the ML model with REST API access.	$0
CI/CD Pipeline	Azure DevOps	Free Tier	Provides up to 1,800 minutes of automation.	$0
Monitoring & Security	Azure Monitor & Security Center	Free Tier	Basic monitoring, logging and security recommendations.	$0

Table 9 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.

11. CONCLUSION

The “Cococlarity” system has been developed to enhance the productivity and sustainability of commercial coconut oil manufacturing making Sri Lanka’s coconut industry another milestone step. Using up-to-date AI/ML technologies, as well as data-driven strategies, the platform tackles significant problems that affect the industry such as forecasting demand, product planning and optimizing delivery. This paper presents a research conducted to examine the existing weaknesses in current techniques for predicting demand before proposing an approach that estimates the optimal amounts of distributed coconut oil by country with respect to different economic and environmental indicators.

Deploying this system on Azure cloud platform guarantees strength, scalability and security of its subsystems which include front-end, back-end and machine learning models. The use of Azure services such as Azure App Service, Azure SQL Database and Azure Machine Learning Service strategically together with automation provided by Azure DevOps is a cost-effective yet reliable solution suitable for large-scale deployments.

This research contributes significantly to the coconut oil industry by supporting stakeholders in making informed decisions, optimizing supply chains and facilitating collaboration among producers, distributors and government authorities. Cococlarity enhances “Cococlarity” thus helps producers of this edible oil as well as policy makers address such inefficiencies positioning Sri Lanka’s coconut oil industry at the global competitive edge through provision of market trends insights and better distribution strategies. So, it remains relevant to industry as it keeps on changing its market conditions using explainable AI and real-time analytics.

Innovation and sustainability are two key words that best describe the “Cococlarity” system’s role in revolutionizing the coconut oil industry. On a broader scale, this successful implementation with expected positive outcomes on the sector highlights technology adoption as a way of meeting complexities inherent within Sri Lanka’s coconut oil industry while fostering economic growth.

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13. APPENDICES

Appendix - A : Plagiarism report