Published online on the journal's webpage: **http://journal.ittelkom-pwt.ac.id/index.php/dinda**

Journal of Dinda

Data Science, Information Technology, and Data Analytics

Vol. 4 No. 2 (2024) 50 - 62 E-ISSN: 2809-8064

Development of Palm Oil Production and Sales Monitoring System Based on Android

Chikal Fachdiana[1], Rafie Novianto Sudrajat[2], Alfian Akbar Gozali[3]

[1,2,3*]Telkom University, Bandung, Indonesia

[1]chikalfch@student.telkomuniversity.ac.id, [2]rafiesudrajat@student.telkomuniversity.ac.id, [3]alfian@telkomuniversity.ac.id

Abstract

The palm oil business substantially impacts Indonesia's economic growth, specifically in reducing poverty and generating employment opportunities. This study aims to improve the monitoring and forecasting system for palm oil production and sales by creating an Android application named PalmA. This program utilizes decision tree techniques and time series analysis to predict palm oil production by leveraging weather data. The research methodologies involve gathering data from PT. Nasaktion Tumbuh Gemilang and utilizing the Open Weather API to acquire up-to-date weather data. The findings suggest that the PalmA program can precisely assess palm oil output and sales, facilitating enhanced stakeholder decision-making. Additionally, the application offers real-time updates and predictive analytics that empower farmers and business owners to make informed decisions, thereby reducing risks associated with weather variability. The installation of this application is anticipated to enhance the efficiency and sustainability of Indonesia's palm oil sector. By integrating advanced analytics and user-friendly interfaces, PalmA represents a significant step forward in the digital transformation of agricultural practices in the country, contributing to broader economic stability and growth.

Keywords: *Palm Oil, Prediction, Decision Tree, Time Series, Android*

1. Introduction

An essential part of Indonesia's economic growth, the palm oil sector greatly helps to lower poverty and generate supporting companies. Along with social tensions, it also brings environmental issues, including deforestation, land use change, and air pollution [1]. Plantations of oil palm are common in areas such as Jambi Province, which emphasizes the industry's broad influence and reach[2]. One essential component of biofuel or biodiesel, palm oil, is widely available in Indonesia. The expansion of the industry supports not only new fuel sources but also generates a lot of jobs and provides foreign exchange through exports [3].

Among the agricultural sectors with the fastest growth rates worldwide is the palm oil industry in Indonesia [4]. According to research on more than 36,000 Indonesian villages, eco-certification of palm oil lowers poverty in market-oriented villages but raises it in subsistence-oriented ones [5]. Being the biggest producer in the world, Indonesia turns roughly 43 million tons of palm oil a year. As seen by RCA values above one from 2014 to 2020 [6], its products continue to have a comparative advantage in important export markets. As per the Central Statistics Agency, there were more than 11.94 million hectares of oil palm plantations in 2016, with substantial contributions from both corporate and community plantations. With many Palm Oil Mills (POM) and a major contribution to national output, Sumatra—especially Riau Province is a major production hub [7].

Though the industry is large, mobile internet monitoring of manufacturing is not widely used. With just 33% of farmers with an internet connection using it for production, there is a significant lack of usage of digital tools to improve agricultural productivity and practices [8]. The importance of rigorous monitoring and sustainable procedures to lessen negative impacts on biodiversity, nutrition, society, and the economy is emphasized by environmental issues from Malaysian palm oil extraction [9]. Furthermore, future risks to the production of oil palm crops from diseases, pests, and climate change need for global collaboration and creative breeding and management strategies [10].

Sustaining long-term sectoral expansion, upholding good standards for palm oil, and guaranteeing stakeholder accountability all depend on effective monitoring [11], [12]. Transparency and effective industrial supervision require smallholder farmers to be

Received: 29-05-2024 | Accepted: 23-06-2024 | Published: 01-08-2024

integrated through programs such as the nucleus-plasma scheme [13]. Managing supply chain dynamics, meeting market demands, and averting consumer panic during variations all depend on precise forecasting of palm oil output and trade flows [14], [15]. The worldwide importance of palm oil and the related environmental issues make thorough monitoring and forecasting essential for guiding sustainable development policies and resolving social and economic disparities [16].

Research on precision agriculture and genetic technology to improve forecast and productivity for industry players [17]. Monitoring and forecasting are more important in understanding the economic, environmental, health, and social impact of palm oil through global news analysis [18]. This study will also provide a specific estimate of deforestation elasticity towards crude palm oil prices to inform policy and market intervention [19]. Incorporating sustainable practices in the palm oil supply chain and research is to develop a framework for sustainable supplier selection, covering environmental, economic, and social factors [20].

That's why there is a need for an application to support and track the production of Palm Oil and how essential Palm Oil is in many sectors in Indonesia for helping the Indonesian Economy. The name of the application is PalmA(Assist and Analyst). PalmA is an Android application that helps monitor, produce, and predict palm oil sales. Several essential factors drive the palm oil plantation industry.

Monitoring means it helps to see data on current production in real time. Prediction Production means using algorithms to know how much palm oil that produced in the future. It can be used for planning and growing just the right amount. Sales production means predicting how much palm oil can sell in the market, price, and demand, and making sure to sell palm oil at the right time.

2. Research Method

In this section, we will examine user requirements, the design process of the PalmA application, and the hardware and software components needed for its development.

2.1 *Literature Review*

This chapter contains information about objects and some related concepts. It's divided into five significant aspects: Palm Oil, Palm Oil in Indonesian, Research in Palm Oil Production, Research in Palm Oil Sales, and Android App Development.

2.1.1 *Palm Oil*

According to Stavila et al., palm oil is a versatile bio-renewable resource used in consumer products, oleochemicals, biofuels, etc. The use of palm oil as a bio-based polymer in polymer production is considered a promising alternative to traditional petrochemical-based polymers due to its non-toxicity, biodegradability, and wide availability[21]

2.1.2 *Palm Oil in Indonesia*

According to Nurfatriani et al., palm oil is an essential raw material that supports the Indonesian economy. Furthermore, Indonesia is the world's largest palm oil producer. In 2019, it generated a large amount of foreign exchange estimated to be worth $25.38 billion, or Rp.359.14 trillion. The palm oil sector accounts for more than 14% of the country's total foreign exchange earnings (excluding oil and gas exports) and is essential in stimulating domestic economic activity. The sector is building food security and energy sovereignty through palm oil-based biodiesel programs. This will help the country reduce its dependence on oil imports and meet its 2025 renewable energy goals. 1 Oil palm plantations and industry employ approximately 42 million direct and 12 million indirect workers, while smallholder plantations house 4.6 million. The palm oil industry has withstood the COVID-19 pandemic and continues to provide jobs. Oil palm plantations and industry are rapidly growing and span over 200 counties. These produce fresh fruit bunches (FFB), crude palm oil, palm kernel oil, and biomass, which provide economic benefits to national and local governments[22]. As stated by Yasinta et al., palm oil also plays a vital role in developing Indonesia's economy, as it is used as a raw agricultural material to produce vegetable oil. A new renewable energy development policy in Indonesia aims to promote the optimisation of the use of oil palm biofuels[23].

2.1.3 *Palm Oil Production*

Indonesia's agricultural sector has been very rapid to date, with palm oil being the most essential raw material in the plantation sector, especially in Sumatra and Kalimantan. The area of palm oil plantations in Indonesia is rapidly increasing. In 2001, the total area of palm oil plantations was 3.2 million hectares; in 2013, this number increased to 13.5 million hectares, with an average annual growth rate of 11.71%. In terms of production, in 2001, these plantations produced 4.1 million tons; in 2013, it increased to 27 million tons. Average annual production growth was 15.6%[24]. Palm oil plays a vital role in Indonesia's economy, as palm oil plantations create employment opportunities, especially in rural areas, provide raw materials for the industrial sector, and contribute to foreign exchange earnings. Additionally, palm oil is the richest source of vegetable oil for biodiesel. One hectare of palm oil can produce 35 tons of vegetable oil. This is much better than the second most productive crop, rapeseed, which can only produce 0.8 vegetable oil per hectare of land [25]. Palm oil is used for biodiesel production and is currently the most consumed edible oil worldwide. Additionally, edible oils make soaps, detergent powders, and personal care products. His two edible oils, soybean and palm oil, account for about 61% of the world's total production. Palm oil has a higher oil content than other oil crops and may have the highest yield per unit area. In terms of global palm oil supply, Indonesia became the world leader in 2015 with annual production of 33 million tons, followed by Malaysia with 20.5 million tons and Thailand with 2.4 million tons [26].

2.1.4 *Palm Oil Sales*

From a financial perspective, the share prices of palm oil companies, especially on the Indonesia Stock Exchange (IDX), have increased significantly, and an even stronger trend has been seen in recent years. Based on these trends, we can predict that the stock prices of these palm oil companies will also continue to be affected and tend to rise in the next period. This situation is supported by the fact that CPO price volatility has increased significantly over the past decade, with Malaysia's benchmark price at the end of 2019 being. Above IDR 800.00 per kg, the price will continue to increase until the end of 2021 above IDR 1,300.00 per kg. This condition is expected to increase prices by 2022 (saham.ok.net, 2021). This situation will cause a rise in palm oil stocks on the Indonesia Stock Exchange. Given this situation, investors must pay attention to palm oil companies' performance and market capitalization. CPO price fluctuations are affected by the company's internal and external factors, so it is difficult to predict them accurately [27]. According to the Directorate General of Plantation 2016, Volume (kg) and import/export value (US$) of palm oil (CPO) in Asia by destination and country of origin in 2014. India is the largest importer of CPO oil from Indonesia in Asia, with 2,888,187,557 kg CPO. The value of CPO oil exports to India was the highest at $2,101,736,375 [28].

2.1.5 *Android App Development*

New mobile technologies are bringing about fast growth in the mobile application sector. Comprising various operating systems, including Symbian OS, iOS, and Blackberry, Android OS is regarded as the most popular, frequently used, and intuitive mobile platform. The top mobile operating system is based on the open-source Linux kernel and provides great customization options. Android applications are programmed in the Java language. The Google Android SDK provides a purpose-built software stack that provides developers with a simple platform for developing Android applications. Additionally, it allows developers to leverage their existing Java IDE, giving developers flexibility. Java libraries are widely used in third-party application development processes. A cross-platform approach eliminates the need for developers to develop platform-dependent applications. These approaches allow the deployment of applications to multiple platforms without coding changes[29]. There is also Kotlin, a new programming language that replaces Java. Both target the same JVM and can safely coexist within the same application. Kotlin is touted as being able to solve some of Java's known limitations. Current research shows that Kotlin has achieved good penetration among Java developers [30]

2.2 *System Architecture*

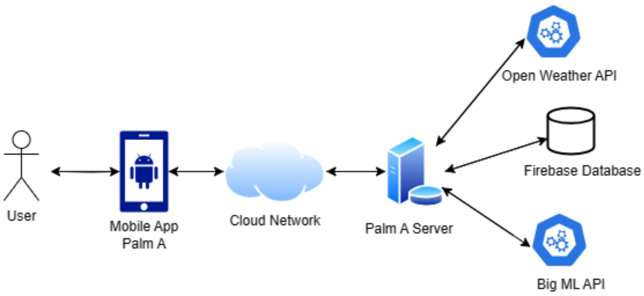


Figure 1. System Architecture

Figure 1 illustrates the application of the system architecture. Once installed on the user's smartphone, the application will use Tons or Palm Fruit Bunches data as an output to forecast palm production based on weather conditions. First, the mobile application sends a data request to the Palm A Server and uses the network to connect. This request includes details about the user's location, or the specific weather requested.

Second, the Palm A Server uses the Open Weather API to acquire data about weather information and BigML API to analyze data Palm production from data weather information with results. After that, Palm A Server processes the retrieved data about weather information. Third, the Firebase Database stores processed data or users in Firebase.

Fourth, Palm A Server sends tailored information back to the application and displays information resulting in data on tons of palm oil production or palm fruit bunches to the user.

2.3 *Data Collection*

This study focused on investigating PT. Nasaktion Tumbuh Gemilang is an oil palm management company located in Duri Riau. We conducted interviews with the company throughout the research, explicitly addressing production data from the previous year. The interview questions encompassed various aspects, including the presentation of a graphical representation depicting the production outcomes of the past year, along with other relevant production data.

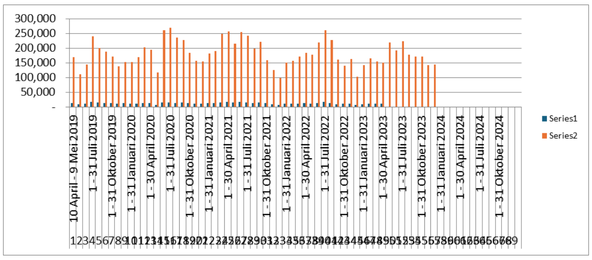
Table 1. Plantation Fund Report

	KEBUN BULUHALA		
	LAPORAN DANA KEBUN		
	PERIODE 57 (1 s/d 31 DESEMBER 2023)		
			F
	Saldo awal Dana (per 30 Nopember 2023)		(12,576,
	Hasil bersih Periode 57 (1 s/d 31 Desember 2023)		133,844
			121,267
	Saldo akhir Dana per 31 Desember 2023		4,722
			125,990
	Setoran to Holding bulan ini		(120,000,
			5,990
	Fee Mamak utk bln Desember 2023 (tgl 01/12/2023)		(5,000,
		selisih	990
	RINCIAN DANA KEBUN		
-	Saldo dana per 30 Nopember 2023		
			F
	Kas		5,214
	Kas Surti BLH		2,920
	Bank Mandiri		15,596
	Bank BRI		5,888
	Piutang pada Indra Kompi (TBS)		**19,355**
	Piutang (Panjar) pada (dari) Ramp Ajang		(7,000,
	Pinjaman dari Ajang		(84,600,
	PJS Anggota dll		30,049
			(12,576,

Table 2. Plantation Fund Report

REKAP PRODUKSI TBS KEBUN BULUHALA

Periode	Masa	Tandan	Tonase (kg)	Keterangan	Komidel
1	10 April - 9 Mei 2019	12,401	169,350		13.66
2	10 - 31 Mei 2019	9,083	109,780	Lebaran	12.09
3	1 - 30 Juni 2019	10,975	144,350		13.15
4	1 - 31 Juli 2019	17,515	239,550		13.68
5	1 - 31 Agustus 2019	14,060	201,060		14.30
6	1 - 30 September 2019	12,972	187,120		14.42
7	1 - 31 Oktober 2019	11,801	170,010		14.41
8	1 - 30 Nopember 2019	10,394	137,830		13.26
9	1 - 31 Desember 2019	11,750	153,160		13.03
10	1 - 31 Januari 2020	10,340	152,520		14.75
11	1 - 29 Pebruari 2020	11,435	168,820		14.76
12	1 - 31 Maret 2020	13,090	202,250		15.45
13	1 - 30 April 2020	11,765	194,600		16.54
14	1 - 31 Mei 2020	7,230	117,460	Lebaran	16.25
15	1 - 30 Juni 2020	15,600	259,720		16.65
16	1 - 31 Juli 2020	15,565	268,870		17.27
17	1 - 31 Agustus 2020	13,335	235,430		17.66
18	1 - 30 September 2020	13,715	226,770		16.53
19	1 - 31 Oktober 2020	12,554	183,520		14.62
20	1 - 30 Nopember 2020	10,655	155,510		14.60
21	1 - 31 Desember 2020	10,438	153,610		14.72
22	1 - 31 Januari 2021	11,645	182,330		15.66
23	1 - 28 Pebruari 2021	12,165	188,930		15.53
24	1 - 31 Maret 2021	15,516	248,140		15.99
25	1 - 30 April 2021	16,095	256,960		15.97
26	1 - 31 Mei 2021	13,970	214,530		15.36



	Tandan (bh)	Tonase (kg)	Komidel (kg)
P.1 s/d 12	145,816	2,035,800	13.96
Rata2/bulan	12,151	169,650	13.96
P.13 s/d 24	150,183	2,414,890	16.08
Rata2/bulan	12,515	201,241	16.08

After collecting the data on palm production, predicting palm production from weather needed real-time weather data from Duri, Riau, including temperature, humidity, wind speed, and more. This activity uses an API called Open Weather API.

2.4 *Open Weather API Integration*

Open Weather API is an online weather service that provides weather data, including current forecasts and analysis data, to researchers and developers of web services and mobile applications. As for data sources, it exploits meteorological broadcast services, mainly using raw data from airport weather stations and radar stations and data from other official weather stations [31].

To access Open Weather API, visit the website https://openweathermap.org/ and sign up to create a new account. After signing up, generate an API key (an API token or APPID), a unique identifier that allows the API request. The API key is usually provided in the account dashboard after registration. After that, the search API needs to use Open Call API 3.0 Weather Data for Timestamp because of the need for weather data from a particular time.

https://api.openweathermap.org/data/3.0/onecall/timemachine?lat=1.2609060678662358&lon=101.21541408089007&dt=1702598400&appid=d7c4f6a106688782301df20e1728a42f

Once get the API Key and API used, start making requests to HTTP methods like GET to retrieve data about weather according to timestamp using software for API Platform like Postman. Timestamps used are from April 2019 up to December 2023. For example, an API Call like this:

This API Call includes coordinates of latitude and longitude, dt (timestamp), applied (API key), add units, and lang(language). After making a request, receive a response from the API Platform containing requested weather data in JSON format by default. For example, with description:

```
{
  "lat": 1.2609,
  "lon": 101.2154,
  "timezone": "Asia/Jakarta",
  "timezone_offset": 25200,
  "data": [
    {
      "dt": 1702598400,
      "sunrise": 1702595314,
      "sunset": 1702638688,
      "temp": 298.08,
      "feels_like": 299.21,
      "pressure": 1011,
      "humidity": 99,
      "dew_point": 297.91,
      "clouds": 100,
      "wind_speed": 0.85,
      "wind_deg": 347,
      "weather": [
        {
          "id": 804,
          "main": "Clouds",
          "description": "overcast clouds",
          "icon": "04d"
        }
      ]
    ,
```

Table 3. Weather Data for Latitude 1.2609, Longitude 101.2154

Key	Description	Value
lat	Latitude of the location	1.2609
lon	Longitude of the location	101.2154
timezone	Timezone of the location	Asia/Jakarta
timezone_offset	Offset in seconds from UTC for the timezone	25200

Table 4. Weather Data Parameters

Key	Description	Value
dt	Timestamp for the data	1702598400
sunrise	Timestamp for sunrise	1702595314
sunset	Timestamp for sunset	1702638688
temp	Current temperature in Kelvin	298.08 K
feels_like	Feels-like temperature in Kelvin	299.21 K
pressure	Atmospheric pressure in hPa	1011
humidity	Humidity percentage	99%
dew_point	Dew point in Kelvin	297.91 K
clouds	Cloudiness percentage	100%
wind_speed	Wind speed in meters per second	0.85 m/s
wind_deg	Wind direction in degrees	347°

Table 5. Weather Conditions

Key	Description	Value
dt	Timestamp for the data	1702598400
sunrise	Timestamp for sunrise	1702595314
sunset	Timestamp for sunset	1702638688
temp	Current temperature in Kelvin	298.08 K
feels_like	Feels-like temperature in Kelvin	299.21 K
pressure	Atmospheric pressure in hPa	1011
humidity	Humidity percentage	99%
dew_point	Dew point in Kelvin	297.91 K
clouds	Cloudiness percentage	100%
wind_speed	Wind speed in meters per second	0.85 m/s
wind_deg	Wind direction in degrees	347°

After that, parse the JSON file into an Excel table like Table 3.

Table 6. Weather Data

Period	Time	Bunchs	Tonnes(kg)	Sunrise	Sunset	Temp	FeelsLike	Pressure	Humidity	Dew Points	Clouds	Wind Speed	Wind Degree	Weather
1	10 April - 9 Mei 2019	12,401	169,350	1555283453	1555327160	297.97	299.04	1011	97	297.46	99	0,42	167	Overcast Clouds
2	10 - 31 Mei 2019	9,083	109,780	1557875181	1557919007	298.28	299.41	1012	98	296.32	100	1	340	Light Rain
3	1 - 30 Juni 2019	10,975	144,350	1560553785	1560597679	296.65	297.61	1011	98	297.94	100	0,86	60	Light Rain
4	1 - 31 Juli 2019	17,515	239,550	1563146115	1563189983	296.04	296.94	1011	98	295.71	100	0.32	213	Moderate Rain
5	1 - 31 Agustus 2019	14,060	201,060	1565824510	1565868275	297.55	298.55	1013	96	296.87	100	1.13	51	Overcast Clouds

Convert this table from Excel file to a CSV format file for predicting palm production based on the weather data using the machine learning application BigML

2.5 *Decision Tree for Palm Production Forecasting*

A decision tree is a diagram-like structure where each internal node symbolizes a "test" of a feature (a decision rule, for example), each branch shows the outcome of the test, and every node in the leaf structure symbolizes a label for a class or a number (in regression). Paths that are from the root node to the leaf node are used to represent regression or classification rules.

In other words, decision trees identify or predict the desired variable by continually dividing data space into fragments according to feature values. The framework for decision-making is a tree structure in which decisions are made at each node that affects the next until a final prediction occurs at the leaf node.

The ease with which decision trees manage numerical and categorical data, automatically select features to rank them and make sense of the data makes them fascinating. However, they are vulnerable to overfitting in particular situations in which the tree is complicated and deep in depth. Forecast performance improves, and overfitting is reduced through many strategies, including pruning and combined approaches (such as random forests).

To use this algorithm, access a website application called BigML for machine learning https://bigml.com/ and sign in to create a new account. After signing up in the dashboard, upload a new local file using an Excel file in Palm production. Next, click a local file, which has already been created, and create a new dataset. In the dataset update, choose the target field and field that is not needed, then build models. For example, this is what a decision tree looks like in Figure 2.

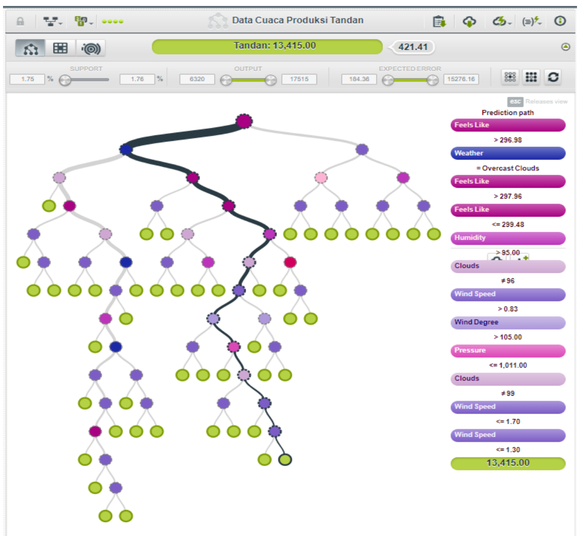


Figure 2 Example Decision Tree for Bunches

A thorough picture of how different weather-related factors help to forecast "Tandan" output is given by the combination of the decision tree and feature importance bar chart. While the bar chart measures the significance of each component, stressing "Feels Like," "Humidity," and "Wind Speed" as important elements, the decision tree illustrates the decision-making process. The summary of this decision tree is displayed in the image below.

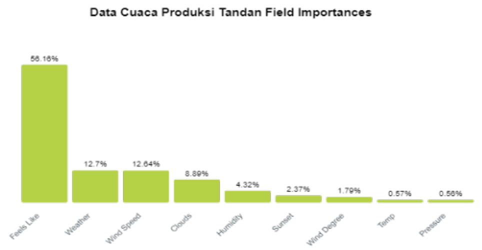


Figure 4 Summary of the Decision Tree

This image show "Feels Like" feature has the greatest impact on predicting "Tandan" production, followed by "Humidity" and "Wind Speed." Other features, such as "Cloud" and "Weather," play a role, albeit to a lesser extent. The chart highlights the predictive model's critical factors, which guide feature selection and model performance improvements.

2.6 *Timeseries Forecasting for Palm Production*

Timeseries is a sequence of data points collected over time, wherever any data point is associated with a specific timestamp or indicator before the moment. This type of data exists occasioned by observations recorded along regular interludes.

Time series analysis involves researching these series to ascertain patterns, trends, and reliance on the data. The machine learning approach applied to time series data aims to model the essential structure and dynamics and permit tasks such as predicting future values, determining oddity, and understanding temporal relationships.

To use this sequence, use the same as in https://bigml.com/ after creating an account and a dataset. Update field choosing the target field and field didn't need. Go to the gear icon on the top right and create a new time series like Figure 4.

Figure 3 Example Timeseries for Bunches

This picture shows interval line palm production from all indexes from first to last and forecast horizon to 12. The interval goes straight using 12 indexes.

2.7 *Mobile App Development*

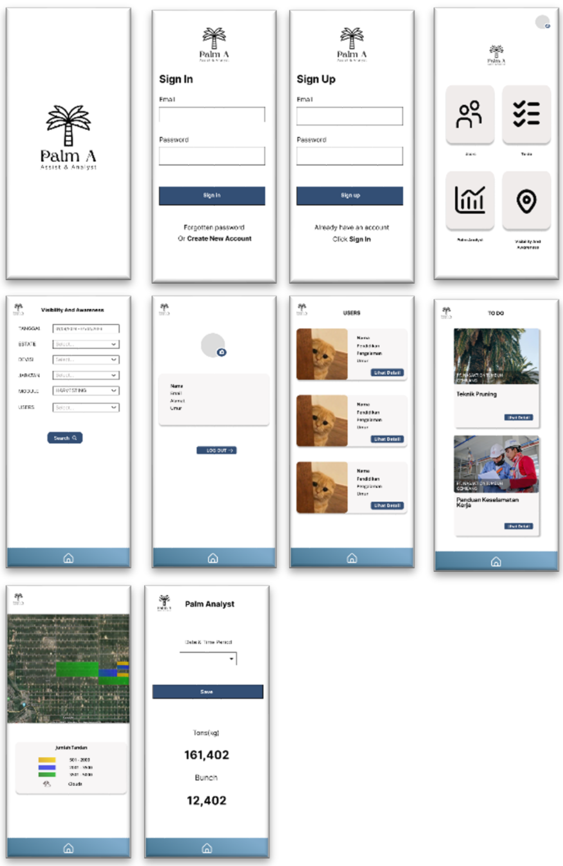


Figure 5 UI App

This Application consists of two parts: First, authentication is signing up to create a new account and signing in to access the application feature. Second, the feature to predict palm production using tons and bunch as output and date & time as input.

Moreover, the PalmA app incorporates a visibility and awareness feature that utilizes API Weather data and satellite images to predict the number of bunches expected in the upcoming year. Another noteworthy feature is the To-Do function, which facilitates productivity management by providing guidelines on correct pruning techniques and work safety.

Lastly, the Users feature serves as a comprehensive database of company employees, ensuring the prevention of any illicit work activities. These features collectively contribute to the seamless functioning of PT Nasaktion Tumbuh Gemilang, a palm oil company.

3. Results

In this paper, machine learning analysis prediction of palm production using models with algorithm decision trees and time series. What is predicted here is tons and bunches of palm production.

Through the use of weather information, a system based on machine learning was created and implemented in order to estimate palm production. This connection has proven to be a beneficial tool for making choices, monitoring, documentation, and prediction. It additionally led to greater transparency and accountability in this industry.

3.1 *Decision Tree Bunches*

This model algorithm aims to help improve forecasting, essential factor identification, early warning systems, performance monitoring, and decision support for bunches of palm production, as seen in these images.

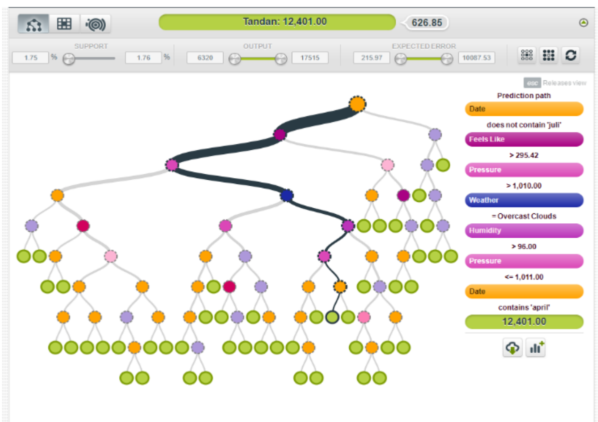


Figure 6 Decision Tree models for Bunches Palm Production

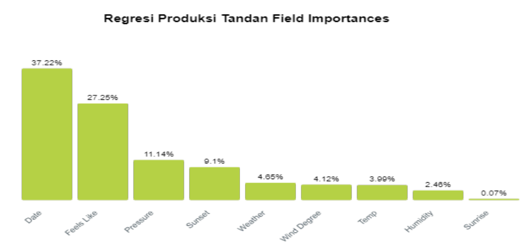


Figure 7 Summary of Decision Tree for Bunches Palm Production

Figure 6 shows date as the root and bunches as last node in bottom. Date as shown in Figure 7 is the most important data for bunches in palm production.

The next step is to use evaluation to measure the effectiveness and performance of models, as shown in the table between this model and the dataset.

Table 7. Evaluation Decision Tree models for Bunches Palm Production

	Model	Mean	Random
Mean Absolute Error	252.33	1,949.06	3,877.83
		↓ 672.41%	↓ 1000%+
Mean Squared Error	556,912.51	5,963,212.67	21,453,312.03
		↓ 970.76%	↓ 1000%+
R Squared	0.91	0.00	-2.60

Table 7 shows the evaluation result for the Model: Mean Absolute Error = 252.3, Mean Squared Error = 556,912.51, R Squared = 0.91. For the Mean: Mean Absolute Error = 1,949.06 (decrease of 672.41%), Mean Squared Error = 5,963,212.67 (decrease of 970.76%), R-squared = 0.00. For the Random: Mean Absolute Error = 3,877.83 (decrease of 1000%), Mean Squared Error = 21,453,312.03 (decrease of 1000%), R Squared = -2.60.

3.2 *Decision Tree Tons*

This model algorithm are used for tonnes of palm production with same objective with decision tree bunches as seen in these images.

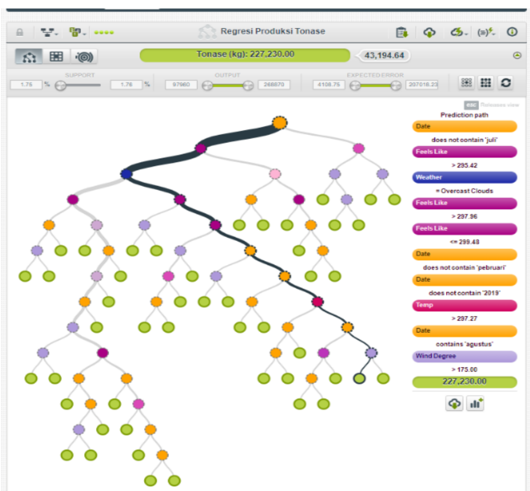


Figure 8 Decision Tree for Tons Palm Production

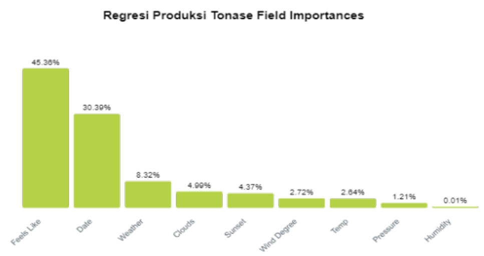


Figure 9 Summary of Decision Tree for Tons Palm Production

Figure 8 shows the date as the root and tons as the last node at the bottom. Feels like, as shown in Figure 9, is the most important data for bunches in palm production.

The next step is to use evaluation to measure the effectiveness and performance of models, as shown in the table between this model and the dataset.

Table 8. Evalution Models for Tons Palm Production

	Model	Mean	Random
Mean Absolute Error	5,383.76	34,891.96	55,392.74
		↓ 548.10%	↓ 928.89%
Mean Squared Error	232,482,743.13	1,794,092,219.76	4,596,079,691.14
		↓ 671.71%	↓ 1000%+
R Squared	0.87	0.00	-1.56

Table 8 shows the evaluation result for the Model: Mean Absolute Error = 5,383.76, Mean Squared Error =232,482,743.13, R Squared = 0.87. For the Mean: Mean Absolute Error = 34,891.96 (decrease of 548.10%), Mean Squared Error = 1,794,092,219.76 (decrease of 671.71%), R-squared = 0.00. For the Random: Mean Absolute Error = 55,392.74 (decrease of 928.89%), Mean Squared Error = 4,596,079,691.14 (decrease of 1000%), R Squared = -1.56.

3.3 *Timeseries for Bunches Palm Production*

Implementing time series analysis in the system, gaining knowledge of permits for effective tracking of palm production and sales. This technique yields insights that inform decision-making, forecasting, and optimisation techniques. Ultimately, combining this technology leads to increased efficiency and profitability in the palm industry. This can be shown in these images.

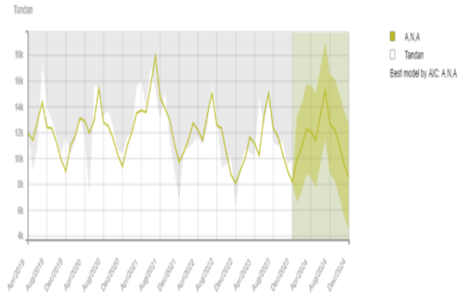


Figure 10 Timeseries Models for Bunches for Palm Production

Table 9. List Models Timeseries for Bunches Palm Production

Models Details		Performance Metrics			
Name	Description	AIC	AICc	BIC	R squared
A, N, A	Additive error, no trend, and additive seasonality model.	1104.9566	1116.6639	1135.6024	0.5437
M, N, M	Multiplicative error, no trend, and multiplicative seasonality model.	1106.9904	1118.6977	1137.6361	0.5257
M, N, A	Multiplicative error, no trend, and additive seasonality model.	1107.4484	1119.1557	1138.0942	0.5384
A, A, A	Holt-Winters additive method with additive errors. Additive error, additive trend, and additive seasonality model.	1109.5923	1125.2847	1144.3242	0.5385
M, A, A	Holt-Winters additive method with multiplicative errors. Multiplicative error, additive trend, and additive seasonality model.	1110.6887	1126.381	1145.4205	0.5335
A, Ad, A	Holt-Winters damped method with additive seasonality. Additive error, additive damped trend, and additive seasonality model.	1111.098	1129.098	1147.8729	0.5424
M, A, M	Holt-Winters method with multiplicative seasonality. Multiplicative error, additive trend, and multiplicative seasonality model.	1112.1227	1127.815	1146.8546	0.5143
M, Ad, A	Holt-Winters damped method with additive seasonality. Multiplicative error, additive damped trend, and additive seasonality model.	1112.8398	1130.8398	1149.6148	0.532
M, Ad, M	Holt-Winters damped method with multiplicative seasonality. Multiplicative error, additive damped trend, and multiplicative seasonality model.	1112.9644	1130.9644	1149.7393	0.5222
M, M, M	Multiplicative error, multiplicative trend, and multiplicative seasonality model.	1113.1368	1128.8291	1147.8687	0.5104

Figure 10 explain that prediction for bunches production best model performance method A-N-A is Additive error, no trend, and additive seasonality model compared to another model in Table 6 with AIC 1104.9566, AIC = 1116.6639, BIC = 1135.6024, R squared = 0.5437.

After that, evaluate the effectiveness and performance of prediction timeseries by comparing timeseries bunches with dataset as shown in the Figure 11 and Table 10.

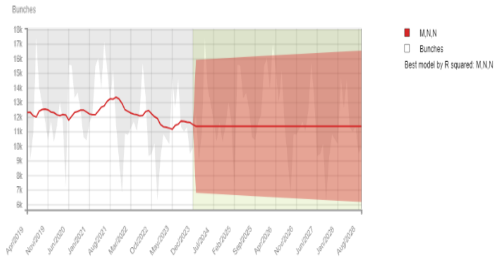


Figure 11 Models for Evaluation Timeseries Models Bunches Palm Production

Table 10. List for Evaluation Models Bunches Palm Production

Name	MAE	MSE	R squared	SMAPE	MASE	MDA
M,N,N	1922.37	6329506	-0.0614	0.1621	0.9929	0.0175
M,Md,N	1981	6898876	-0.1569	0.1672	1.0232	0.5439
M,Ad,N	2006.88	7069032	-0.1854	0.1696	1.0365	0.5439
M,M,N	2283.03	8708602	-0.4604	0.1958	1.1792	0.5439
M,Md,M	2526.36	8987031	-0.5071	0.2154	1.3048	0.4912
M,N,M	2531.83	9202722	-0.5432	0.2134	1.3077	0.5088
A,N,N	2379.18	9357267	-0.5692	0.2044	1.2288	0.0175
M,Ad,M	2524.99	9405558	-0.5773	0.2107	1.3041	0.5263
A,N,A	2575.11	9434186	-0.5821	0.218	1.33	0.5088
A,Ad,A	2546.8	9462350	-0.5868	0.213	1.3154	0.5088

After comparing with the dataset, the evaluation result in Figure 11 is that the models best performance is M,N,N Multiplicative error, no trends, no seasonality model with Mean Absolute Error = 1922.37, Mean Squared Error = 6329506, R Squared = -0614, SMAPE = 0.1621, MASE = 0,9929, MIDA = 0.0175.

3.4 *Timeseries for Tons Palm Production*

This Timeseries is used to predict Tons of Palm Production for the next 1 Year. This timeseries also hasthe same purpose as Timeseries for Bunches as seen in these figure 12.

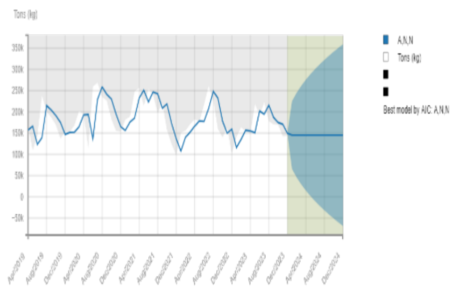


Figure 12 Timeseries Models for Tons

Table 11. List Models for Tons Palm Production

Models Details		**Performance Metrics**			
Name	Description	AIC	AICc	BIC	**R squared**
A, N, N	Simple exponential smoothing with additive errors. Additive error, no trend, and no seasonality model.	1443.666	1444.119	1449.796	**0.1207**
A, A, N	Holt's linear method with additive errors. Additive error, additive trend, and no seasonality model.	1447.682	1448.859	1457.898	**0.1202**
A, Ad, N	Damped trend linear method with additive errors. Additive error, additive damped trend, and no seasonality model.	1449.685	1451.365	1461.943	**0.1204**
M, N, N	Simple exponential smoothing with multiplicative error. Multiplicative error, no trend, and no seasonality model.	1450.425	1450.878	1456.554	**0.0815**
M, M, N	Exponential trend method. Multiplicative error, multiplicative trend, and no seasonality model.	1454.309	1455.486	1464.525	**0.0746**
M, A, N	Holt's linear method with multiplicative errors. Multiplicative error, additive trend, and no seasonality model.	1454.465	1455.641	1464.68	**0.0803**
M, Md ,N	Damped trend exponential method. Multiplicative error, multiplicative damped trend, and no seasonality model.	1455.847	1457.527	1468.106	**0.0722**
M, Ad, N	Damped trend exponential method with multiplicative errors. Multiplicative error, additive damped trend, and no seasonality model.	1456.438	1458.118	1468.697	**0.0843**

Figure 12 explain best performance for this Timeseries is A.N.N mean Simple exponential smoothing with additive errors. Additive error, no trend, and no seasonality model with value AIC = 1443.666, AICc = 1444.119, BIC = 1449.796, R squared = 0.1207.

After that, evaluate the effectiveness and performance of prediction timeseries by comparing timeseries tons with dataset as shown in the Figure 13 and Table 12.

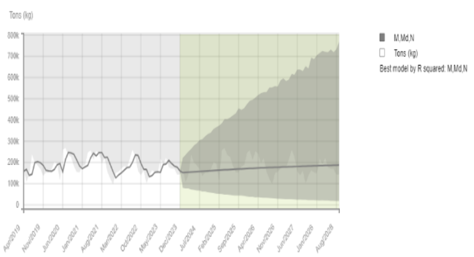


Figure 13 Models Timeseries for Evaluate Tons Palm Production

Table 12. List Models Timeseries for Evaluate Tons Palm Production

Name	**MAE**	**MSE**	**R square**	**SMAPE**	**MASE**	**MDA**
M,Md, N	36850.13	2.05E+09	-0.1452	0.2042	1.1752	0.4561
M,M, N	40511.66	2.31E+09	-0.2902	0.222	1.292	0.4561
M,N,N	39813.55	2.72E+09	-0.5163	0.2234	1.2697	0.0175
M,Ad, N	40081.66	2.75E+09	-0.5333	0.2251	1.2782	0.5614
M,A,N	40339.81	2.78E+09	-0.5491	0.2267	1.2865	0.5614
A,A, N	43527.85	3.14E+09	-0.7476	0.2477	1.3881	0.5614
A,N, N	43548.74	3.14E+09	-0.7492	0.2478	1.3888	0.0175
A,Ad, N	44445.79	3.24E+09	-0.807	0.2538	1.4174	0.5614

The evaluation result in Figure 13 is that the models best performance is M,Md,N Multiplicative error, Multiplicative damped trends, no seasonality model with Mean Absolute Error = 36850.13, Mean Squared Error = 2.05E+09, R Squared = -0.1452, SMAPE = 0.2042, MASE = 1.1752, MIDA = 0.4561.

3.5 *Functionality Test*

The functionality test conducted for the PalmA application involved a series of inquiries aimed at evaluating different aspects of the app's effectiveness and user-friendliness. The queries included:

1. What are impression of the user interface of the PalmA work application? Is it easy to comprehend?
2. To what extent does the PalmA work application align with the company's business needs and objectives?
3. How satisfied with the performance of the tested PalmA application?
4. How complex is the PalmA application to navigate and utilize?

These questions were designed to gather insights regarding the user experience, usability, information content, and technical performance of the application.

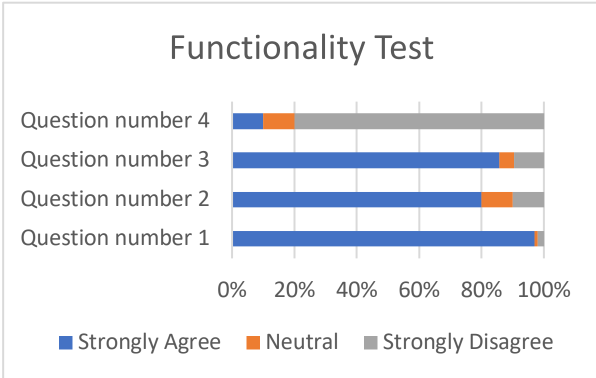


Figure 14 Functionality Test

3.6 *User Experience Test*

The usability test conducted for the PalmA application involved a set of inquiries aimed at assessing the effectiveness and user-friendliness of its features. The questions included:

1. Is the application's user interface (UI) easy to comprehend?

2. Feel comfortable utilizing the provided features?

3. Does this application meet the needs and expectations?

4. Does this application contribute to enhancing productivity and simplifying work?

These questions were designed to evaluate the PalmA application's performance, ease of accessing multimedia information, and overall user satisfaction. The survey results are depicted in Figure 15.

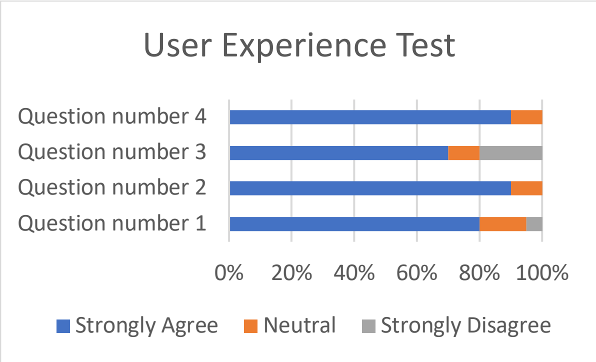


Figure 15 User Experience Test

3.7 *User Interface Test*

The UI test for the PalmA application encompasses a set of inquiries designed to evaluate the visual and interactive aspects of the application. These questions include:

1. Is the color scheme used in the PalmA application visually appealing and engaging?

2. Does the placement of buttons within each feature of the Palma application align with expectations and general usability standards?

3. Does the overall interface design of PalmA demonstrate appropriateness and user-friendliness?

4. Do the features within the PalmA application possess an attractive appearance?

These questions were formulated to assess the application's aesthetic appeal, functional layout, and ease of use, with a specific emphasis on design effectiveness.

3.8 *Survey Likert Data Analysis*

The survey results obtained from the aforementioned application testing questionnaire are reflected in the following percentages, serving as comprehensive evidence of the performance of our application.

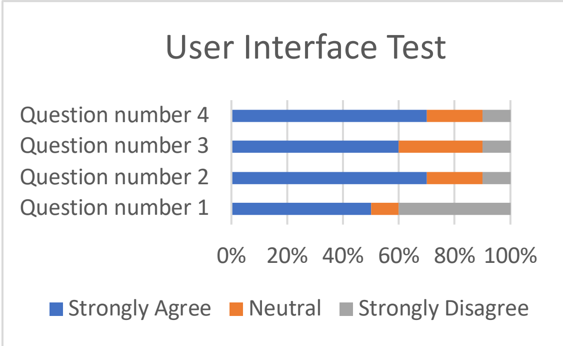


Figure 16 User Interface Test

Table 13. Survey Likert Data Analysis

Aspect Parameters	**Percentage**
Functionallity Test	90%
User Experience Test	94%
User Interface Test	83%

4. Discussion

Predicting palm production in terms of tons and bunches has been made easier with the use of machine learning models, especially decision tree algorithms and time series analysis. Outperforming baseline models, the decision tree models demonstrated high accuracy and reliability. Strong performance metrics appropriate for forecasting were demonstrated by time series models, specifically the A, N, A for bunches and the A, N, N for tons. The PalmA application's usability, functionality, and design were also rated highly by users according to their feedback.

This implies that decision-making monitoring and optimization in the palm production sector can be greatly aided by the incorporation of these predictive models into an intuitive application.

References

[1] A. I. Suroso, H. Tandra, Y. Syaukat, and M. Najib, "The issue in Indonesian palm oil stock decision making: Sustainable and risk criteria," *Decision Science Letters*, vol. 10, no. 3, pp. 241–246, 2021.

[2] D. Umayah, E. P. Purnomo, M. I. Fadhlurrohman, A. T. Fathani, and L. Salsabila, "The Implementation of Indonesian Sustainable Palm Oil (ISPO) Policy in Managing Oil Palm Plantation in Indonesia," *IOP Conf Ser Earth*

Environ Sci, vol. 943, no. 1, p. 012022, Dec. 2021.

[3] T. Yasinta and M. Karuniasa, "Palm oil-based biofuels and sustainability In Indonesia: assess social, environmental and economic aspects," *IOP Conf Ser Earth Environ Sci*, vol. 716, no. 1, p. 012113, Mar. 2021.

[4] A. I. Suroso, H. Tandra, M. Najib, and Y. Syaukat, "FIRM PERFORMANCE FACTORS AND EFFICIENCY OF INDONESIAN PALM OIL COMPANIES," *Jurnal Manajemen & Agribisnis*, vol. 17, no. 3, pp. 227–227, Nov. 2020.

[5] T. Santika *et al.*, "Impact of palm oil sustainability certification on village well-being and poverty in Indonesia," *Nature Sustainability 2020 4:2*, vol. 4, no. 2, pp. 109–119, Nov. 2020.

[6] F. R. Maulana, K. Sukiyono, Nusril, and Sriyoto, "Analysis of Indonesian Palm Oil Competitiveness in the Main Export Destination Countries," *Indonesian Journal of Agricultural Research*, vol. 6, no. 2, pp. 68–78, Oct. 2023.

[7] H. Ali, S. Karimi, R. Febriamansyah, and J. Kenedi, "Export Performance and Export Competitiveness of the Indonesian CPO (Crude Palm Oil) Industry with RSPO (Roundtable Sustainable Palm Oil) in the India and EU Markets," *Proceeding Medan International Conference on Economic and Business*, vol. 1, no. 0, pp. 1935–1949, Feb. 2023.

[8] A. I. Suroso, I. Fahmi, and H. Tandra, "Adoption of Mobile Internet and the Implication on Palm Oil Productivity: Case Study in Siak Regency," *International Journal of Sustainable Development and Planning*, vol. 18, no. 1, pp. 335–342, Jan. 2023.

[9] K. Mohd Hanafiah, A. H. Abd Mutalib, P. Miard, C. S. Goh, S. A. Mohd Sah, and N. Ruppert, "Impact of Malaysian palm oil on sustainable development goals: co-benefits and trade-offs across mitigation strategies," *Sustainability Science 2021 17:4*, vol. 17, no. 4, pp. 1639–1661, Oct. 2021.

[10] D. J. Murphy, K. Goggin, and R. R. M. Paterson, "Oil palm in the 2020s and beyond: challenges and solutions," *CABI Agriculture and Bioscience*, vol. 2, no. 1, pp. 1–22, Dec. 2021.

[11] C. S. Sundaraja, D. W. Hine, and A. Lykins, "Confronting the palm oil crisis: Identifying behaviours for targeted interventions," *Environ Sci Policy*, vol. 103, pp. 99–106, Jan. 2020.

[12] E. Apriani, Y. S. Kim, L. A. Fisher, and H. Baral, "Non-state certification of smallholders for sustainable palm oil in Sumatra, Indonesia," *Land use policy*, vol. 99, p. 105112, Dec. 2020.

[13] N. S. Rahayu, A. A. Nugroho, and R. R. Yusuf, "Exclusion of Smallholders in the Indonesia Palm Oil Industry," *KnE Social Sciences*, pp. 1158-1182–1158–1182, May 2022.

[14] V. Voora, S. Bermúdez, J. J. Farrell, C. Larrea, and E. Luna, *Palm oil prices and sustainability*. iisd.org, 2023. [Online]. Available: https://www.iisd.org/system/files/2023-06/2023-global-market-report-palm-oil.pdf

[15] Meuthia, R. P. Lita, and R. Rahmahdian, "An explanatory framework of palm oil panic buying behavior in Indonesia: Do perceived scarcity and perceived price being enablers?," *Cogent Business & Management*, vol. 10, no. 3, Dec. 2023.

[16] M. V. Chiriacò, M. Bellotta, J. Jusić, and L. Perugini, "Palm oil's contribution to the United Nations sustainable development goals: outcomes of a review of socio-economic aspects," *Environmental Research Letters*, vol. 17, no. 6, p. 063007, Jun. 2022.

[17] M. H. Zakaria, M. Z. Amin, M. F. Ahmad, and ..., "Market potential and competitiveness assessment of Malaysian coconut-based products," *Econ. Technol. Manag*, 2022, [Online]. Available: http://etmr.mardi.gov.my/Content/ETMR%20Vol.18(2022)/2.%20ETMR%20Vol.%2018%20Hafizudin.pdf

[18] M. Corciolani, G. Gistri, and S. Pace, "Legitimacy struggles in palm oil controversies: An institutional perspective," *J Clean Prod*, vol. 212, pp. 1117–1131, Mar. 2019.

[19] M. A. A. Mousa, Y. Wang, S. A. Antora, "An overview of recent advances and applications of FT-IR spectroscopy for quality, authenticity, and adulteration detection in edible oils," *Critical Reviews in*, 2022.

[20] T. C. Kuo, M. Muniroh, and K. H. Fau, "An integrated Kano model, fuzzy analytical hierarchy process, and decision matrix for sustainable supplier selection in palm oil industries Indonesia, a case study," *Processes*, 2021, [Online]. Available: https://www.mdpi.com/2227-9717/9/6/1078

[21] E. Stavila, F. Yuliati, A. Adharis, J. A. Laksmono, and M. Iqbal, "Recent advances in synthesis of polymers based on palm oil and its fatty acids," *RSC Adv*, vol. 13, no. 22, pp. 14747–14775, May 2023.

[22] F. Nurfatriani, Ramawati, G. K. Sari, W. Saputra, and H. Komarudin, "Oil Palm Economic Benefit Distribution to Regions for Environmental Sustainability: Indonesia's Revenue-Sharing Scheme," *Land 2022, Vol. 11, Page 1452*, vol. 11, no. 9, p. 1452, Sep. 2022.

[23] T. Yasinta and M. Karuniasa, "Palm oil-based biofuels and sustainability In Indonesia: assess social, environmental and economic aspects," *IOP Conf Ser Earth Environ Sci*, vol. 716, no. 1, p. 012113, Mar. 2021.

[24] A. Syahza and B. Asmit, "Development of palm oil sector and future challenge in Riau Province, Indonesia," *Journal of Science and Technology Policy*, 2020.

[25] I. Abdul, D. Wulan Sari, T. Haryanto, and T. Win, "Analysis of factors affecting the technical inefficiency on Indonesian palm oil plantation," *Scientific Reports 2022 12:1*, vol. 12, no. 1, pp. 1–9, Mar. 2022.

[26] P. Nutongkaew, J. Waewsak, W. Riansut, and ..., "The potential of palm oil production as a pathway to energy security in Thailand," *Sustainable Energy*, 2019, [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2213138819300207

[27] M. R. Hutauruk, "The potential impact of fundamental value, market value, and firm size as moderator variable on firm value at Indonesia palm oil company," *World Journal of Advanced Research and Reviews*, 2022, [Online]. Available: https://wjarr.com/content/potential-impact-fundamental-value-market-value-and-firm-size-moderator-variable-firm-value

[28] S. Hasanuddin, "Analysis of Oil Palm Marketing Efficiency in Tommo District, Mamuju, Indonesia," *Golden Ratio of Marketing and Applied Psychology of Business*, vol. 1, no. 1, pp. 01–13, Jan. 2021.

[29] A. Sarkar, A. Goyal, D. Hicks, D. Sarkar, and S. Hazra, "Android Application Development: A Brief Overview of Android Platforms and Evolution of Security Systems," *Proceedings of the 3rd International Conference on I-SMAC IoT in Social, Mobile, Analytics and Cloud, I-SMAC 2019*, pp. 73–79, Dec. 2019.

[30] L. Ardito, R. Coppola, G. Malnati, and M. Torchiano, "Effectiveness of Kotlin vs. Java in android app development tasks," *Inf Softw Technol*, vol. 127, p. 106374, Nov. 2020.

[31] A. Musah *et al.*, "An Evaluation of the OpenWeatherMap API versus INMET Using Weather Data from Two Brazilian Cities: Recife and Campina Grande," *Data 2022,* vol. 7*,* no. 8 pp. *106*, Jul. 2022.