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Commodity Intelligence Report

INDONESIA PALM OIL: HISTORICAL REVISIONS USING SATELLITE-DERIVED METHODOLOGY

Indonesia is the world's leading producer of palm oil and supplies more than half of the palm oil global market (Figures 1 and 2). High yields, low cost, and stability of palm oil makes it the most widely used vegetable oil in the world. Global production of the commodity is steadily rising in response to population growth and policies that promote the use of palm and other oils in biofuels. Due to this, palm oil production in Indonesia has increased by 400 percent over the past two decades (Figure 3). One of the main driving factors that has led to the production increase is acreage expansion, which has seen an over 300-percent increase from the year 2000.

This article desribes the methodology used to revise the historical harvested area series for palm oil in Indonesia. The palm oil production series was not revised. Indonesia palm oil production for marketing year (MY) 2022/23 is estimated at 46.0 million metric tons.

USDA estimates MY2022/23 Indonesia palm oil area at 13.5 million hectares, up from 3.0 million hectares in MY2000/01 (Figure 4). During this period of rapid expansion, areas planted to rubber and other crops were replanted to palm oil. Additionally, natural forested areas were transformed into palm oil plantations. Palm oil area expansion of this magnitude was met with global scrutiny as the ecological impacts threatened biodiversity. In response to the heightened environmental and social impacts of the palm oil industry in Indonesia, in 2018, the Indonesian government enacted a moratorium on palm oil permits to clear new land for planting. Since then, there has been modest area expansion, as large companies and small-scale farmers have opted to replant palm oil instead of expanding acreage, due to high input costs and limited permit availability. As a result, palm oil area rate of growth has slowed, increasing by 16 percent since 2018.

Palm oil in Indonesia is mostly grown on the islands of Sumatra and Borneo (Figure 5). The difference in the tree age profile is quite noticeable in the two regions, as the first palm trees were planted in Sumatra in 1911, whereas in Borneo, major developments in palm plantings occurred in the early 1980s. Replanting of palm trees is contingent on tree age and typically occurs between years 25 to 30. In some cases, replanting of trees extends past the age of 30 years, mostly on smallholder farmers. The palm oil national area percentage ratio between large scale farmers, known as plantation farmers, compared to small-scale or smallholders is about 60:40. Though new areas of

palm oil have been limited in the past 5 years and replanting of older trees has been reported, industry sources have mentioned the challenges of observing palm oil area on an annual basis due to gaps within the data collection process. One of the ways to combat the data discrepancies is using satellite-derived remote sensing methods. Resources such as the International Institute for Applied Systems Analysis have produced visual references mapping palm oil area and year of detection for Indonesia and surrounding palm oil producing countries (Figures 6 and 7). This information has been utilized as a validating source that allows palm oil stakeholders to better understand the extent of palm oil area and locations for potential replanting to occur. Satellite-derived area estimates are used to quantify planted area of palm oil. Palm oil tree age profile is an important factor. Newly planted palm oil trees are regarded as immature crops and are not harvested until their yield is commercially viable. This occurs 3 to 4 years after planting when the palm oil crop is deemed a mature crop. USDA estimates of harvested area are for the mature crop.

USDA's historical estimates for Indonesia palm oil harvested area from 2015 onward have been revised due to the incorporation of satellite imagery and remote-sensing methodologies. These methods have provided a clearer understanding of the expansion and replanting areas dedicated to palm oil. One of the industry sources USDA has used as a benchmark for Indonesia palm oil total area data is MapBiomas Indonesia developed by Auriga Nusantara. It is a land cover map for Indonesia that covers the period from 2009 through 2019, depicting characteristics that represent the agricultural and non-agricultural landscape. Total palm oil area data observed from these years provides insight into the dynamics of the palm oil sector on an annual basis. Imagery analysis indicates a higher-than-previously expected total area dedicated to palm oil. Additionally, assessing the annual change in total palm area prompted a renewed method of evaluating immature versus mature crops as USDA reports palm oil area harvested as mature only. (Figure 8)

USDA has undertaken its own satellite imagery analysis, classifying Indonesia total palm oil area for calendar year 2020. This classification process will be used to evaluate Indonesia's future total palm area on an annual basis. This first iteration of classification utilizes a supervised random forest algorithm to identify palm oil pixels, a similar methodology to the MapBiomas Indonesia Project. Additionally, the global palm oil classification dataset, Biopama (Biodiversity and Protected Areas Management), was used as reference data.

The classification study area was comprised of six primary palm producing provinces (Riau, Central Kalimantan, North Sumatra, West Kalimantan, South Sumatra, and Jambi) that account for 75 percent of total palm oil area. The date range used was January 1, 2020, to December 31, 2020. These areas have challenges of excessive clouds throughout the year, and all publicly available European Space Agency Sentinel-2 multispectral surface reflectance 10-meter resolution harmonized imagery was filtered to remove cloudy imagery.

Training samples were optically selected for six classes: palm, forest, water, mangrove, other agriculture, and non-vegetation (bare, urban). These classes were chosen in partial alignment with the MapBiomas landcover classes, which include forest (natural forest and mangrove), non-forest natural formation, agriculture (palm and other ag), non-vegetated, water, and non-observed.

To achieve a palm oil landcover, training points with reference to the MapBiomas landcover classes, in addition to Biopama palm oil classification were used to train a supervised, Random Forest algorithm. For post processing, the global dataset PALSAR forest/non-forest map was used to filter out natural forest that had incorrectly been classified as palm oil. This occurred largely as a result of cloudy imagery in forested areas, which was not fully masked out by Sentinel-2 cloud masking.

Preliminary total palm oil area data achieved from the first iteration of classification was evaluated compared to Indonesia's statistical agency (Badan Pusat Statistik Indonesia) 2020 data (Figure 9). Visualization of similar methodologies from MapBiomas and USDA show similarities in results. The palm oil area data output reflects the usefulness of using satellite imagery and remote sensing methodologies (Figures 10, 11, and12)

With the revisions to palm oil harvested area, the revised estimates indicate a more mature palm oil crop. Mature palm oil increases its yield potential from year 3 to 4 and tends to peak at year 10 before plateuing. At year 19 palm oil yield potential starts to rapidly decreasing. (Figure 13) As a result, the palm oil yield series from 2015 was adjusted downward to reflect a higher crop maturity. Indonesia palm oil yield for 2022/23 is estimated at 3.41 tons per hectare, down 6 percent from the previous estimate of 3.64 tons per hectare. (Figure 14)

Contributions from Arif Rahmanulloh at USDA-FAS' Office in Jakarta and Brooke Laird, ASRC Federal contractor, are gratefully acknowledged.

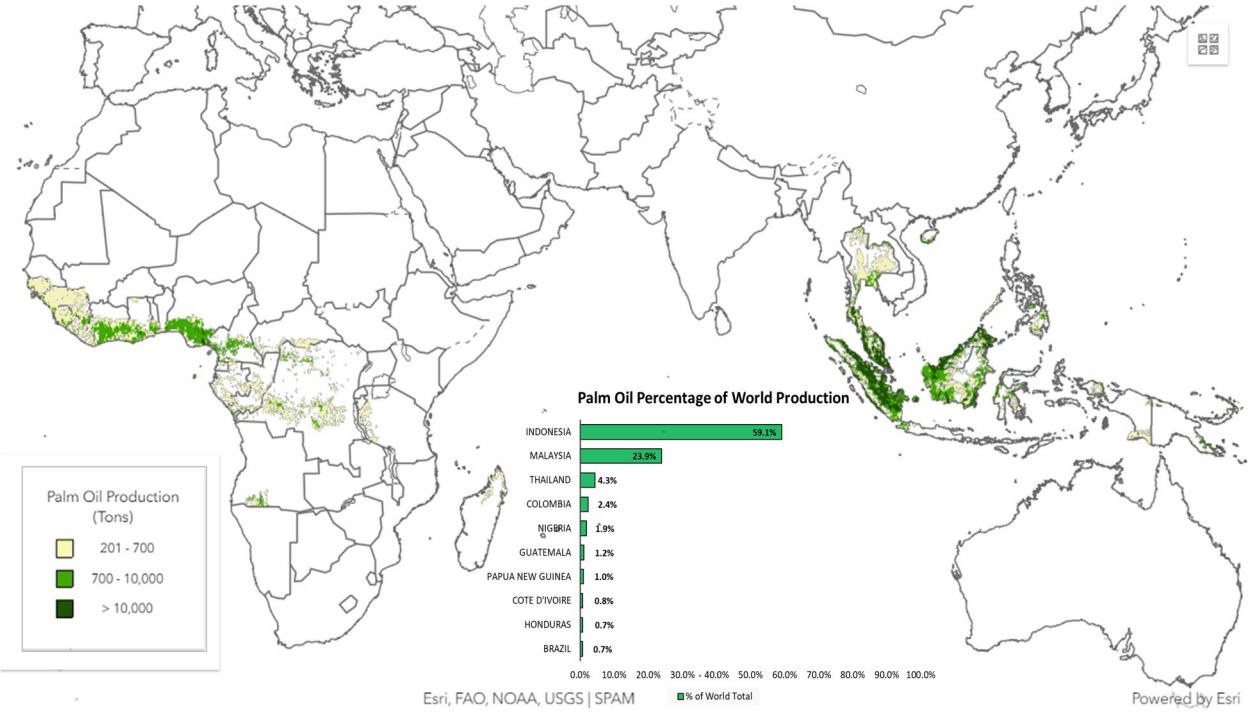

Figure 1. Indonesia produces more than half of the world's palm oil. Source: United States Department of Agriculture PSD online, Global Crop Dataset: Spatial Production Allocation Model 2010

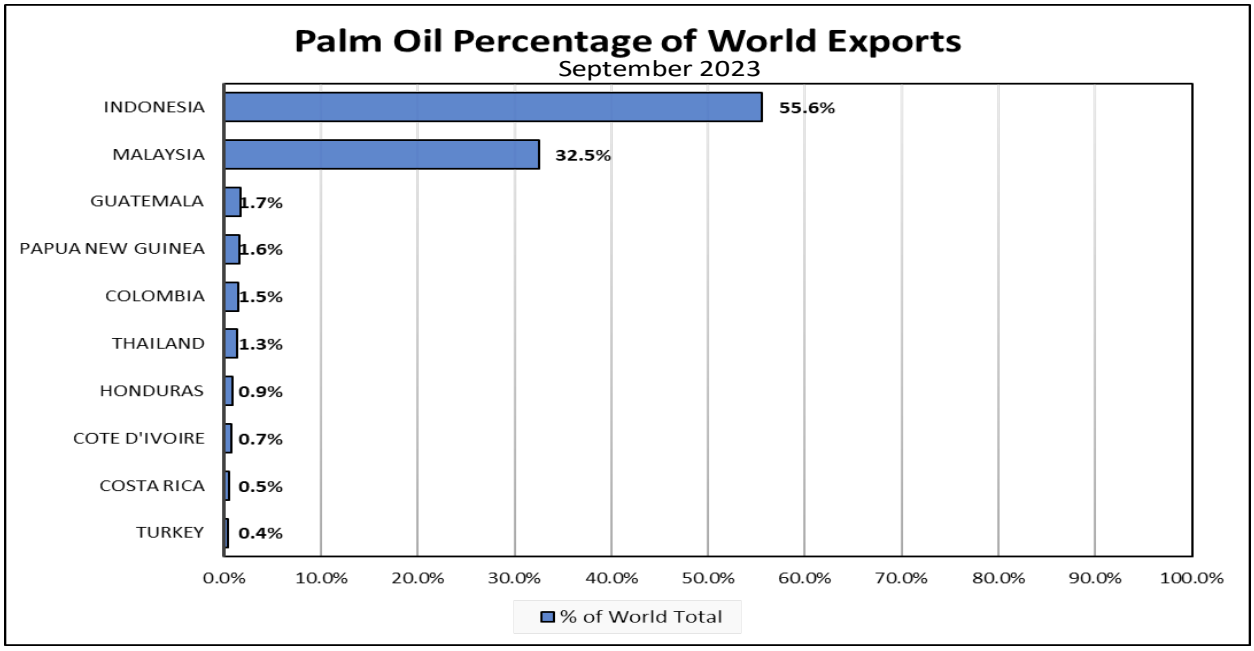

Figure 2. Indonesia palm oil export percentage on a global scale, supplies over half of the palm oil market. Source: United States Department of Agriculture PSD online.

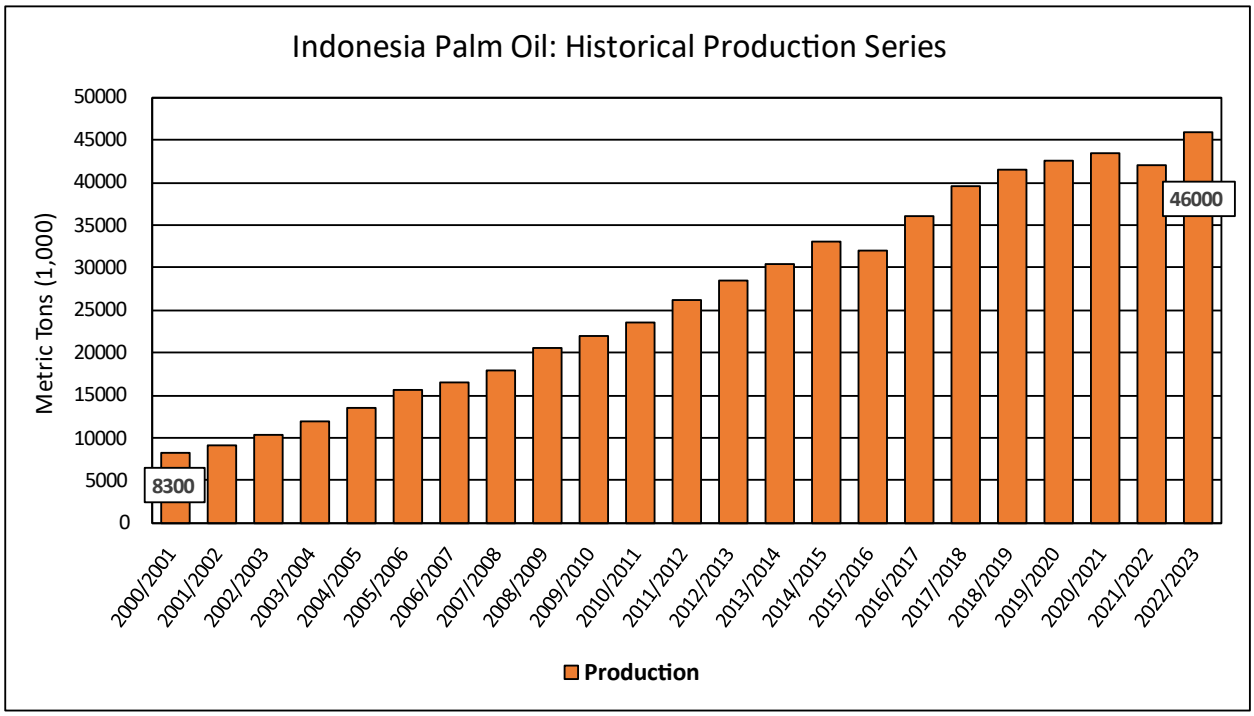

Figure 3. Indonesia palm oil historical production time series, highlighting the vast increase of 400 percent over a span of 2 decades. Source: United States Department of Agriculture PSD online.

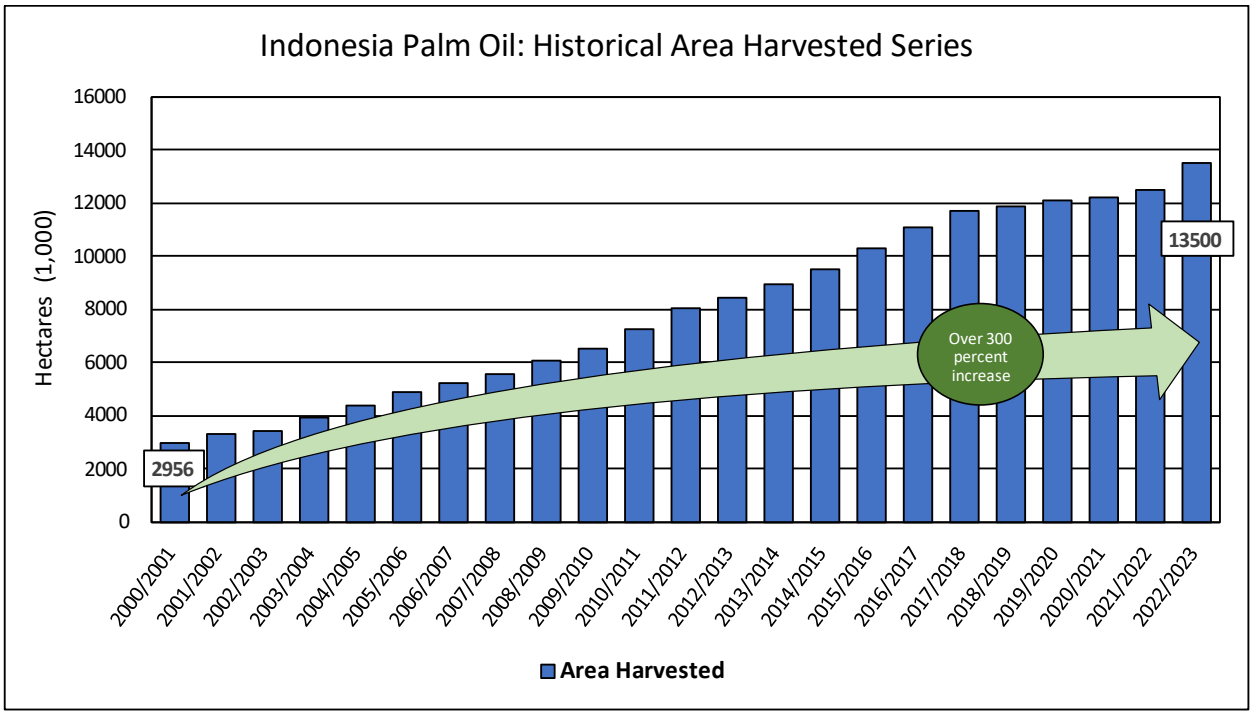

Figure 4. Indonesia palm oil historical area harvested time series, highlighting the vast increase of over 450percent over a span of two decades. Source: United States Department of Agriculture PSD online.

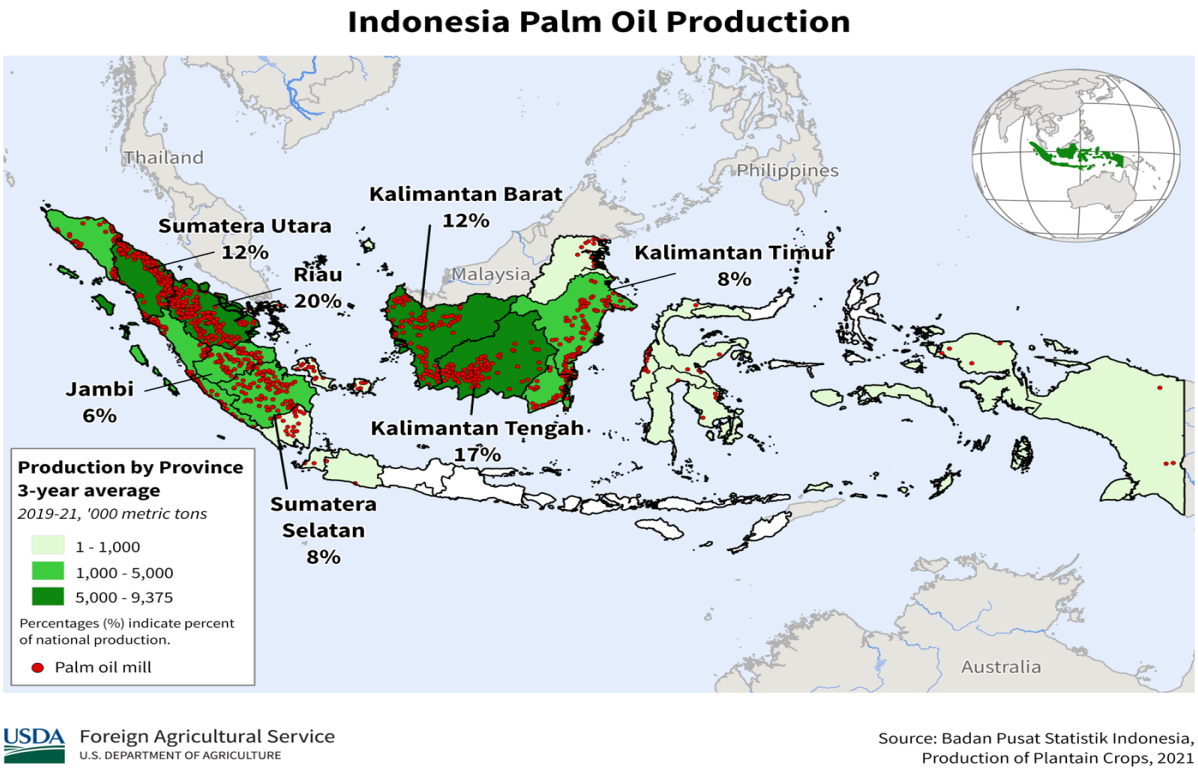

Figure 5. Indonesia palm oil production by province. Source: Badan Pursat Statistik Indonesia

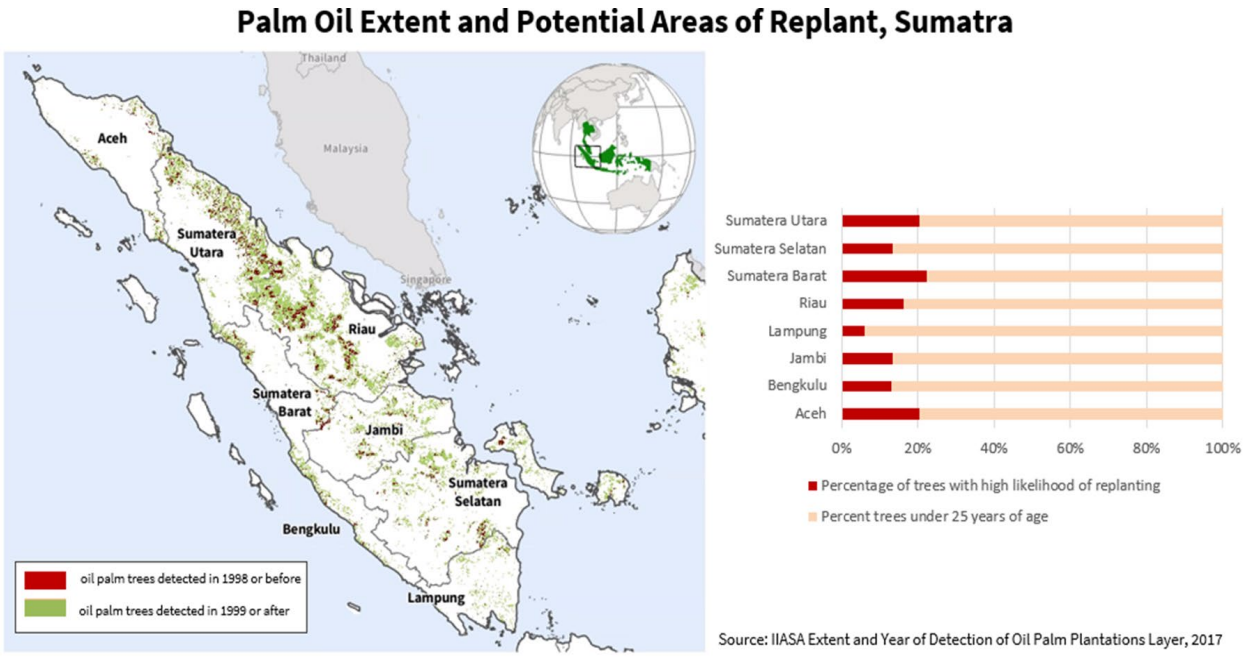

Figure 6. Sumatra palm oil area and year of detection. Additionally, this data highlights areas most likely to be replanted due to the palm oil tree age profile. Source: IIASA Extent and Year of Detection of Oil Palm Plantations Layer, 2017

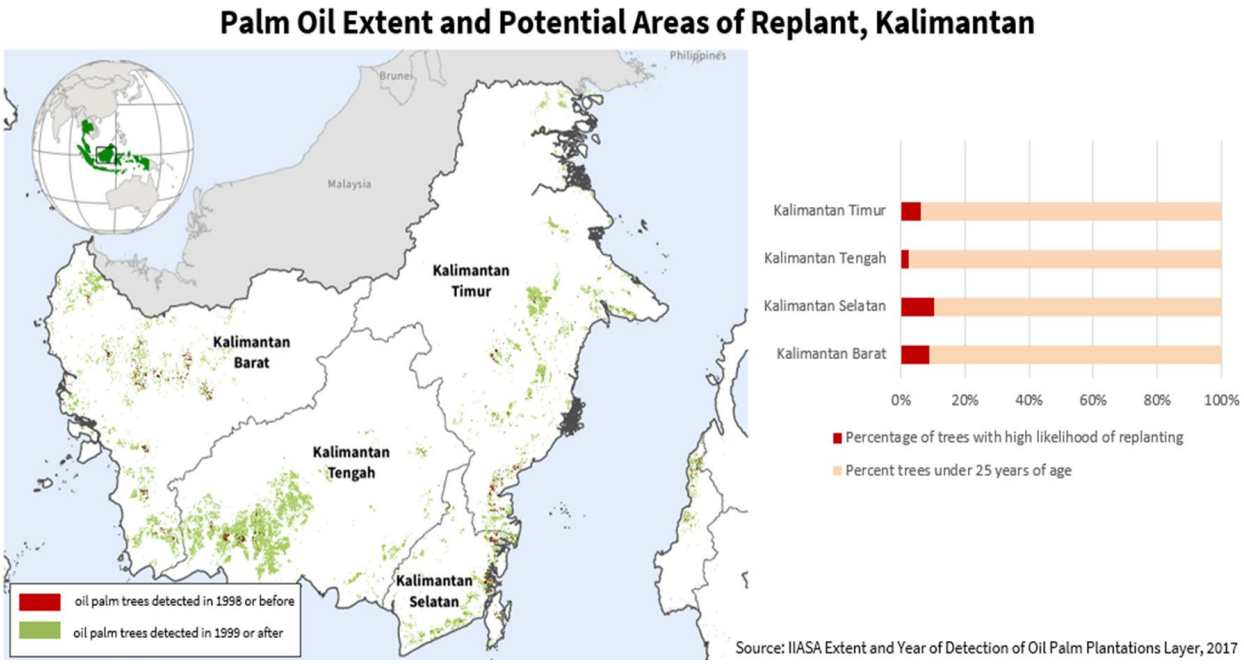

Figure 7. Kalimantan palm oil area and year of detection. Additionally, this data highlights areas most likely to be replanted due to the palm oil tree age profile. Source: IIASA Extent and Year of Detection of Oil Palm Plantations Layer, 2017

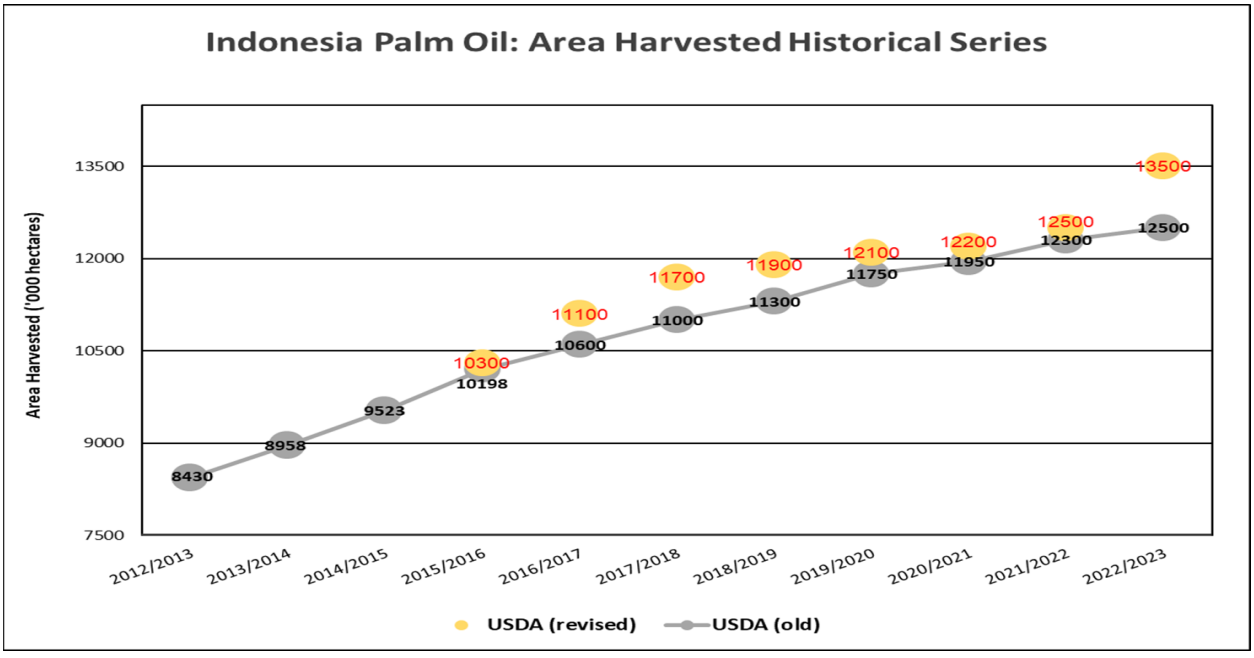

Figure 8. Indonesia palm oil area harvested series, highlighting the annual revisions made from 2015-2022. Source: United States Department of Agriculture PSD online.

Based on the initial classifier of 6 provinces with 75% of total palm area

Results for Test Palm Oil Area:

Province	Statistik Indonesia (2020)	USDA Classification (2020)	Mapbiomas (2019)
Riau	27%	33%	26%
Kalimantan Tengah (Central)	19%	13%	20%
Sumatera Utara (North)	13%	16%	21%
Kalimantan Barat (West)	19%	10%	20%
Sumatera Selatan (South)	11%	16%	7%
Jambi	10%	12%	6%

Table percentages (above) indicate percent of palm plantation area for the 6 current test classification provinces, not the entirety of Indonesia.

Figure 9. Comparing data sources of Indonesia provincial percentage of palm oil area with USDA's first iterative results from the data collected using satellite-derived methodology. Source: Badan Pusat Statistik Indonesia, MapBiomas Indonesia Project, USDA classification

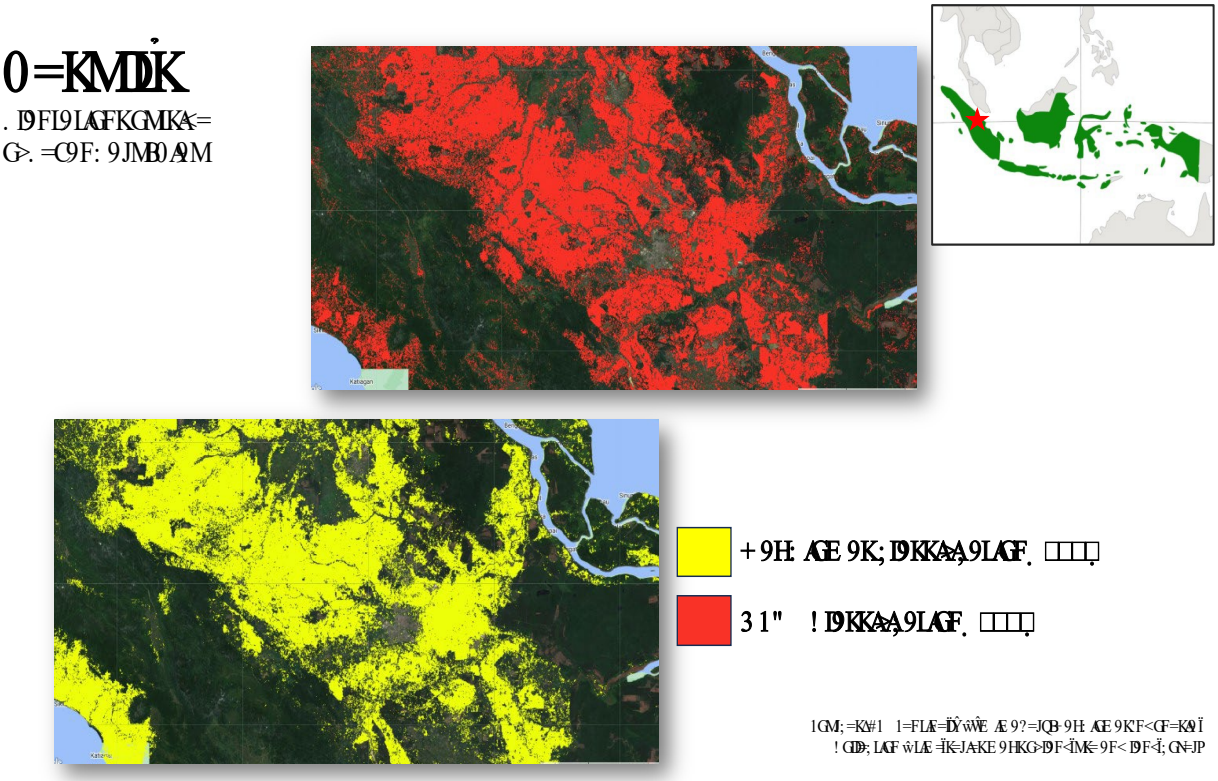

Figure 10. Visual observation of palm oil classification from (MapBiomas data collection) and USDA (2020 data collection) in the Riau province. Sources: ESA Sentinel-2 10m imagery, MapBiomas Indonesia - Collection 1 time-series maps of land-use and land-cover

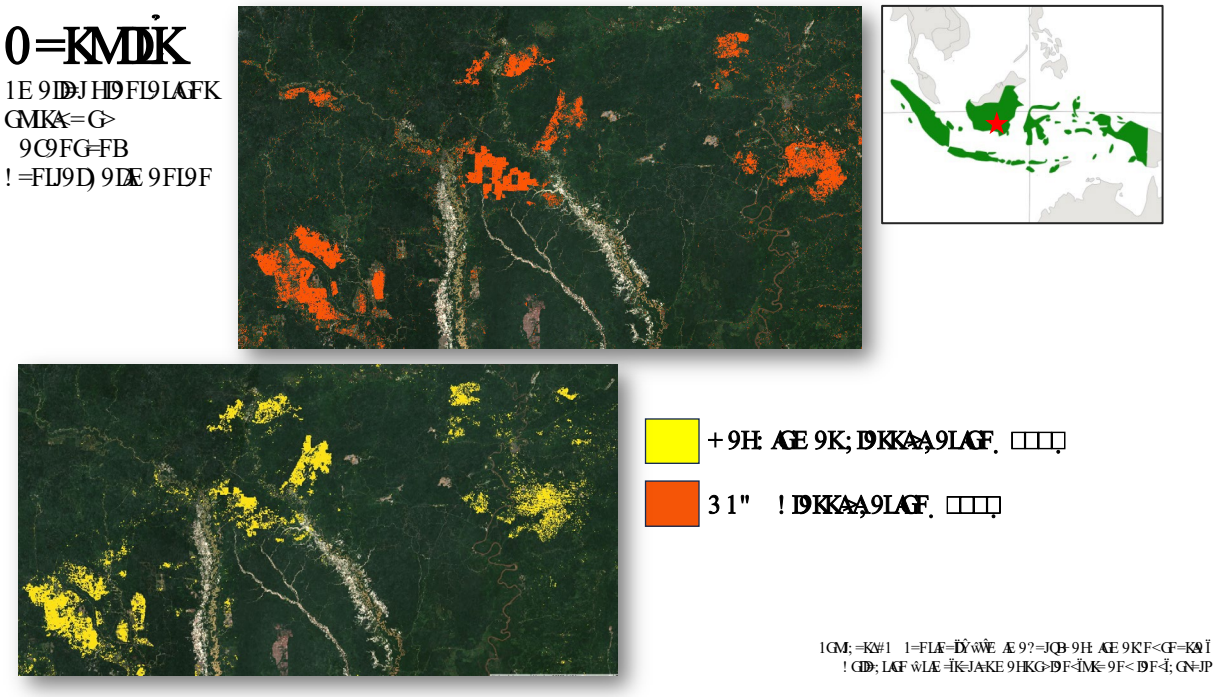

Figure 11. Visual observation of palm oil classification from MapBiomas (2019 data collection) and USDA (2020 data collection) in the Central Kalimantan province. Sources: ESA Sentinel-2 10m imagery, MapBiomas Indonesia - Collection 1 time-series maps of land-use and land-cover

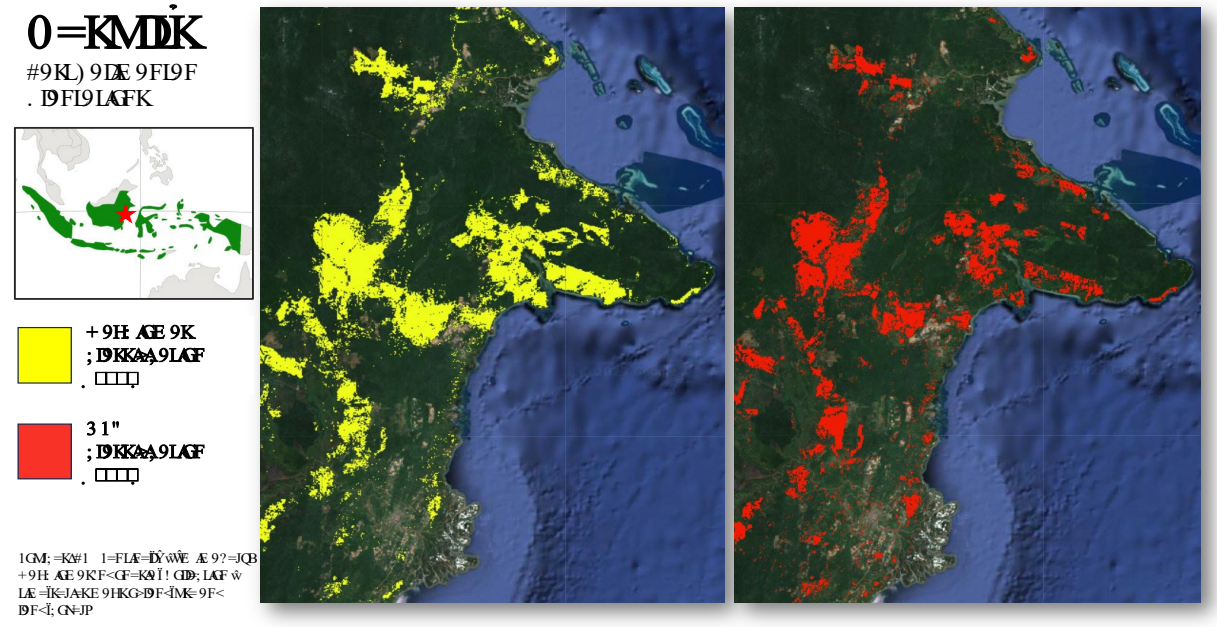

Figure 12. Visual observation of palm oil classification from MapBiomas (2019 data collection) and USDA (2020 data collection) in the East Kalimantan province. Sources: ESA Sentinel-2 10m imagery, MapBiomas Indonesia - Collection 1 time-series maps of land-use and land-cover

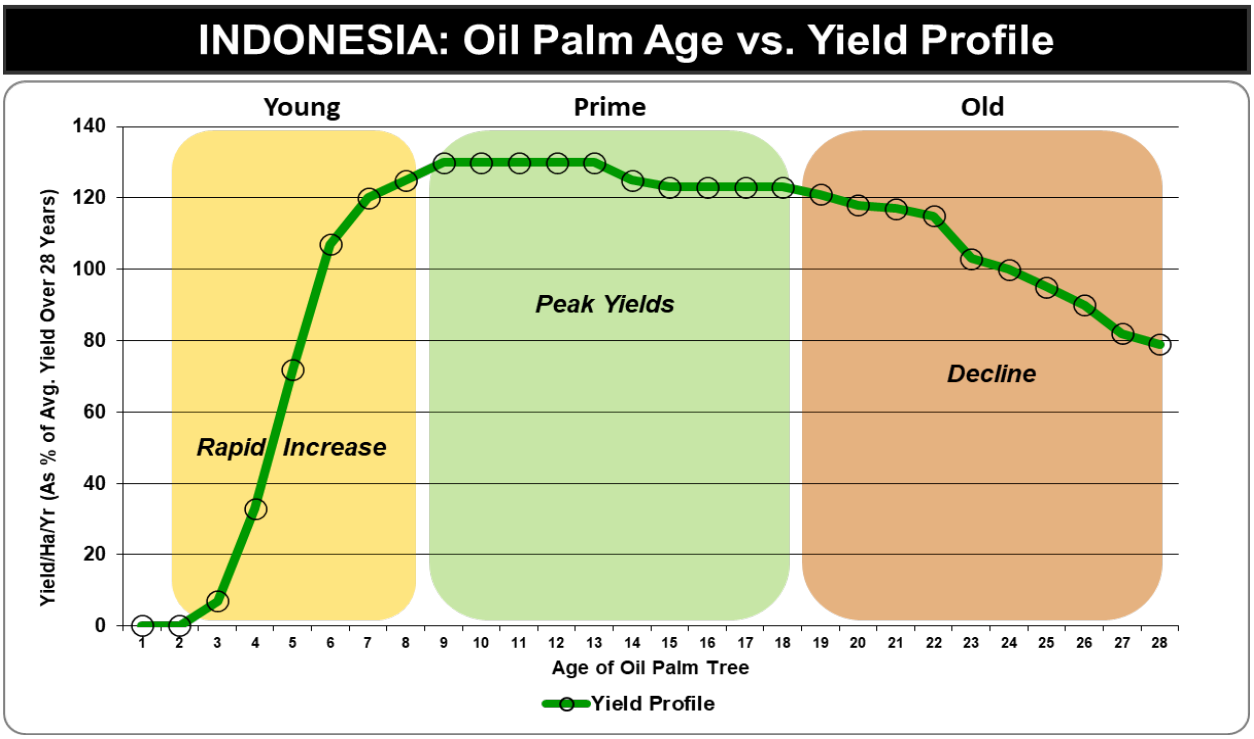

Figure 13. Indonesia palm oil tree age compared to yield profile. Source: Adapted from A.H. Ling – Malaysian Palm Oil Conference, Oct 2012

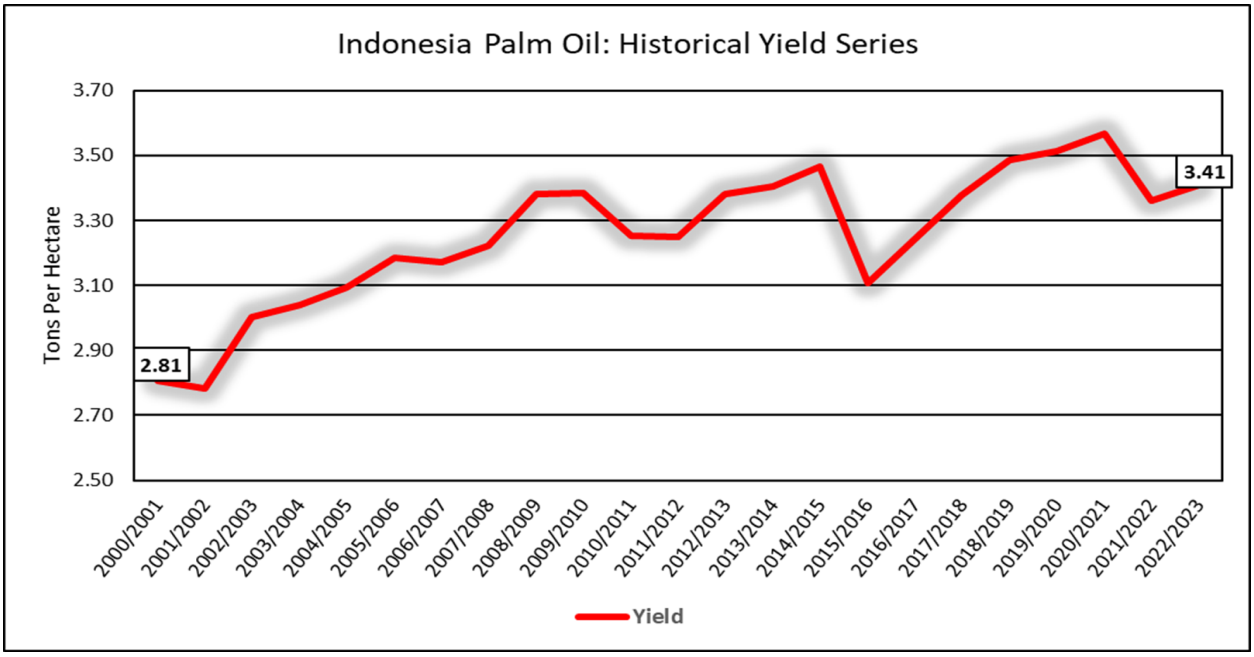

Figure 14. Indonesia palm oil historical yield time series. Source: United States Department of Agriculture PSD online.

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