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"THREE-IN-ONE PRODUCT" FROM OIL PALM PLANTATIONS: VEGETABLE OIL, BIOMASS, AND ENVIRONMENTAL SERVICES

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RESUME

Through natural processes (photosynthesis and biosequestration), global oil palm plantations can produce three groups of products at once (three in one), namely vegetable oil, biomass, and environmental services. These three "products" are produced simultaneously (joint products) and do not mutually exclude each other (substitute). The potential utilization of these three products is so large that they need to be optimized to further increase the economic value of oil palm plantations and the contribution of oil palm plantations as part of mitigating global climate change.

INTRODUCTION

The oil palm plantation industry is a vegetable oil producer that has long been recognized and enjoyed by the global community. Of the 17 types of vegetable oils known to the global community, palm oil stands out as of the main and largest vegetable oils. A publication by USDA (2023) noted that around 40 percent of global vegetable oil production and consumption is contributed by palm oil.

Apart from producing vegetable oil, oil palm plantations also produce two other products which are equally important and whose roles are increasingly crucial for the global ecosystem. These two products are biomass and environmental services. These two products have enormous potential and are not widely known to the public.

The interesting and unique thing about these three products is that palm oil, palm biomass, and environmental services are joint products. This means that in a single production process, oil palm plantations produce palm oil, biomass, and environmental services all at once or simultaneously.

This article will discuss how oil palm plantations are an industry that produces three-in-one product. The discussion starts with the production system for the three products in the oil palm plantation production process. The discussion then continues with the potential of the products that could be utilized by the global community.

OIL PALM PLANTATIONS AS A NATURAL "BIOREACTOR"

Plant photosynthesis is the world's largest-scale process in harvesting solar energy and converting inorganic compounds carbon dioxide (CO_2) and water (H_2O) into organic compounds by releasing oxygen (O_2). This process generates organic material, energy, and oxygen essential for life on Earth. Approximately 220 billion tons of organic material are produced from the process of plant photosynthesis annually. Food, energy, and environmental issues are closely related to the process of plant photosynthesis. Without this process, it is impossible to guarantee the preservation of life on planet Earth (Li *et al*., 2023).

The sole source of energy in the solar system is solar energy. Even though solar energy is available in abundance, its use for life requires energy harvesting "tools". Green plants, including oil palm plants, have been given the ability by God Almighty to act as bioreactors to harvest solar energy, which is then converted/stored in the form of chemical energy.

Energy is radiated by the sun onto the entire surface of planet Earth. To harvest this energy, bioreactor beds are needed. Oil palm plantations are one of biological bioreactor beds which function as a means of capturing energy from the sun (PASPI, 2023). In general, the wider the oil palm plantation bed is, the greater the amount of solar energy that can be harvested. In simple terms, the oil palm plantation production system can be described as follows (Figure 1).

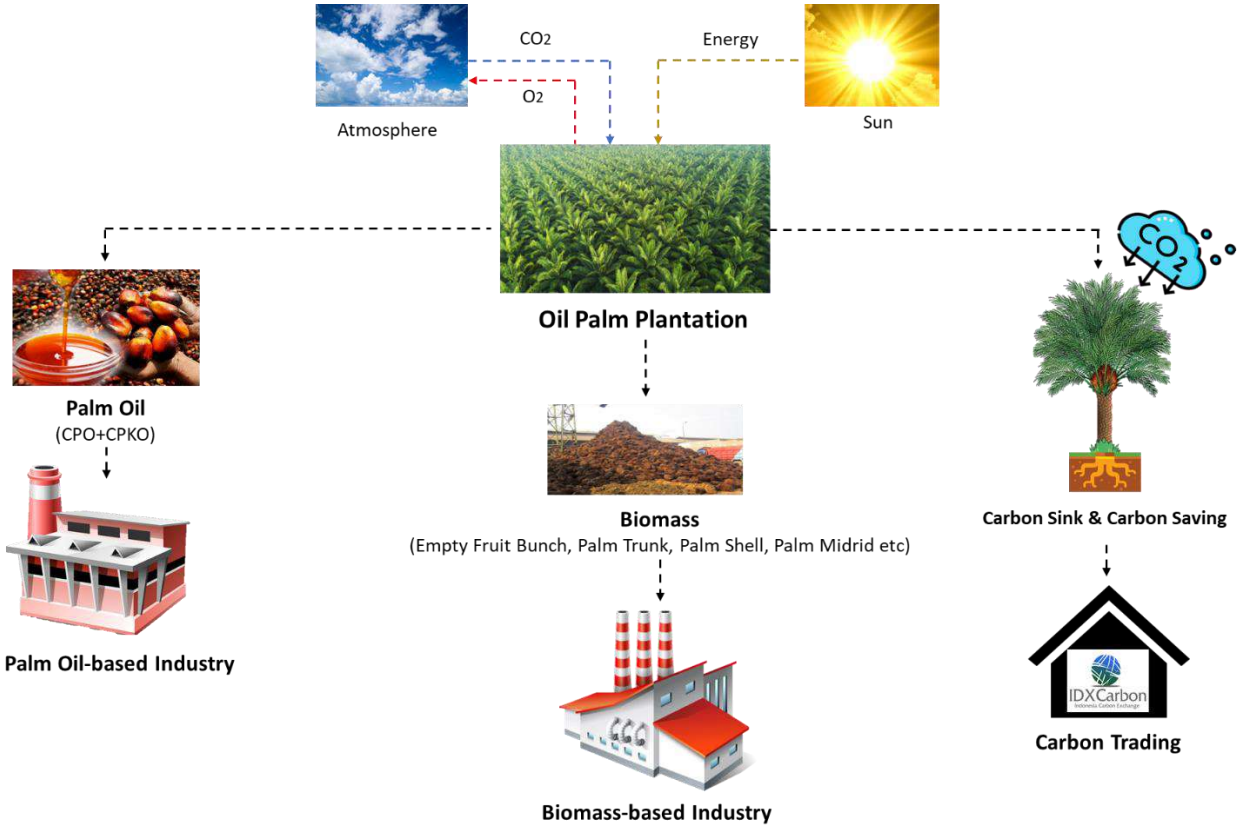

Figure 1. Oil Palm Plantation Production System and Process in Producing Palm Oil, Biomass and Environmental Services

In general, there are three aspects related to the process of oil palm plantations harvesting solar energy and absorbing carbon dioxide (CO_2) from the Earth's atmosphere, which is then stored in the form of chemical energy. ***First***, through the mechanism of the photosynthesis/assimilation process, plants absorb CO_2 from the Earth's atmosphere and water from the soil (which contains dissolved nutrients) to capture energy from sunlight, which is then converted into organic material [$(CH_2O)n$] and releases oxygen (O_2) into the Earth's atmosphere.

Second, in the plant respiration process, some of the organic compounds/biomasses are broken down to obtain the energy needed by plants with the help of oxygen absorbed from the Earth's atmosphere and the remainder in the form of CO_2 and water is released into the Earth's atmosphere. And ***third***, from the process of harvesting solar energy, oil palm plantations, on a net basis, absorb CO_2 from the Earth's atmosphere and produce O_2 into the Earth's atmosphere.

This process demonstrates that oil palm plantations provide environmental services as part of preserving the CO_2, H_2O, and O_2 cycles for life on planet Earth. In this case, oil palm plantations become part of the "lungs" of the planet Earth's ecosystem by cleaning the Earth's air through absorbing carbon dioxide and producing oxygen into the Earth's atmosphere. When this natural biological process takes place, oil palm plantations simultaneously produce organic material both in

the form of palm oil (Crude Palm Oil and Palm Kernel Oil) and in the form of biomass (fronds, stems, shells, fruit bunches, fibers).

THREE-IN-ONE PRODUCT PRODUCTION

Thus, it can be understood that through this biological process, global oil palm plantations can produce three groups of products simultaneously (three in one), namely vegetable oil, biomass, and environmental services. These three "products" are produced simultaneously (joint products) and do not mutually exclude each other (mutual substitution).

First, oil palm plantations produce two types of vegetable oils (PASPI, 2023). Vegetable oil extracted from palm fruit's flesh or mesocarp (Figure 2) is known as Crude Palm Oil (CPO). Meanwhile, vegetable oil extracted from palm kernels (kernels) is known as Crude Palm Kernel Oil (CPKO). This makes oil palm the only vegetable oil plant in the world that can produce two different types of vegetable oils.

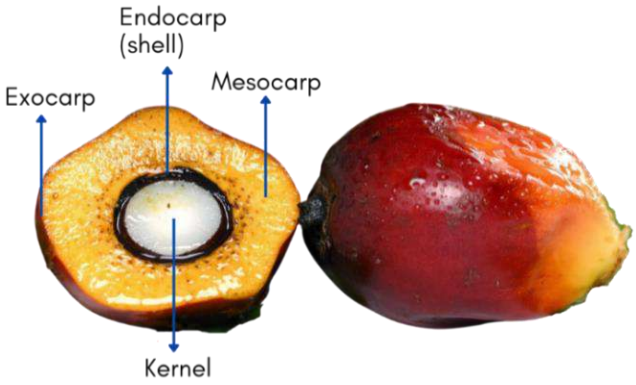

Figure 2. Morphology of Oil Palm Fruit/Loose Fruit (*Brondol*)

In addition to producing two different types of vegetable oils, oil palm is also the plant that produces the highest amount of vegetable oil (edible oil) in the world (PASPI Monitor, 2021[a]; PASPI, 2023). Global palm oil productivity currently reaches around 4.3 tons of oil/hectare/year or approximately 8-10 times higher than the productivity of other main vegetable oils (soybean oil, rapeseed oil, and sunflower oil).

The data from USDA (2023) showed that the global production volume of palm oil (CPO+PKO) for the 2022/2023 period reached 86.35 million tons or around 40 percent of the total global vegetable oil production. This shows that with the global oil palm plantation area of around 26.5 million hectares in 2022, solar energy harvested in the form of palm oil reaches around 86.35 million tons every year.

Internationally, palm oil (Kojima *et al.*, 2016; Parcell, 2018; Shigetomi *et al.*, 2020) is used by various industries to produce food products (oleofood complex), oleochemical products (oleochemical complex), and biofuel products (biofuel/bioenergy). These palm oil-based products are available globally and are consumed by people around the world. The World Wildlife Fund publication in 2017 also revealed that palm oil is found in almost 71 percent of global food products and 24 percent of consumer products (including cosmetic products and toiletries) and around 50 percent of products on the shelves of supermarkets worldwide contain consumer goods that contain palm oil.

Second, oil palm plantations produce relatively large biomass. The largest organic material from oil palm plantations is not palm oil but biomass. According to a study by Foo-Yuen (2011), biomass production from oil palm plantations includes biomass from empty fruit bunches of around 1.4 tons of dry matter/hectare/year, biomass from oil palm fibers and shells of around 2.4 tons of dry matter/hectare/year, biomass from oil palm fronds of around 9.3 tons of dry matter/hectare/year, and biomass from oil palm trunks of around 2.9 tons of dry matter/hectare/year. In total, palm biomass production reaches approximately 16 tons of dry matter/hectare/year. The volume of palm

biomass production is about 3-4 times that of palm oil production. With a global oil palm plantation area of around 26.5 million hectares, this means that around 424 million tons of biomass (dry matter) are produced by oil palm plantations each year.

This biomass is a new renewable energy source or also called second generation biofuel (PASPI Monitor, 2023[c]). Through thermochemical, biological, chemical, physical conversion technology (Naik *et al.,* 2010), biomass can produce various forms of energy such as bioethanol, biomethane, bioavtur, briquettes, biochar, as well as various oleochemical and biomaterial products.

The use of biomass as an energy source has been exploited locally at the Palm Oil Mill level and its surroundings. The use of palm biomass-based energy has also been carried out in several countries, for example Japan which imports Indonesian palm shells to be used as an energy source for electricity generation. However, efforts to utilize palm biomass have not been carried out on a massive scale by the international community. If the people of the European Union do not want to use palm oil because of the food-fuel trade-off issue, the use of palm biomass can be an alternative solution for new renewable energy source.

Third, oil palm plantations also produce environmental services. As explained previously, in the production process, oil palm plantations absorb carbon dioxide from the Earth's atmosphere; hence, it can reduce concentrations in the atmosphere. The absorption of carbon dioxide from the Earth's atmosphere is one of the most important environmental services globally. This concerns mitigating global climate change, which is currently a major concern for the global community.

Based on the study by Henson (1999), it was revealed that oil palm plantations absorb (through photosynthesis) carbon dioxide from the Earth's atmosphere amounting to 161 tons of CO_2 per hectare and use (in the respiration process) 96.5 tons of CO_2 per hectare; therefore, the net carbon sink is 64.5 tons of CO_2 per hectare (PASPI Monitor, 2021[b]; PASPI, 2023). The carbon sink capacity of oil palm plantations can be even greater than that of other forest plantations (Santosa *et al.,* 2023; PASPI Monitor, 2023[d]).

The carbon absorbed by oil palm plantations through the biosequestration mechanism is stored in the biomass of the oil palm plants themselves (above ground biomass). Furthermore, the biosequestration process also takes place in the underground root system (underground biomass), which is then stored in soil organic carbon and soil inorganic carbon which becomes part of the carbon stock (PASPI, 2023).

The amount of carbon stock in oil palm plantations varies depending on various factors such as plant age, productivity and plant population. In general, the increasing age of oil palm plants will be followed by a rise in carbon stocks (Singh *et al*., 2018; Lamade and Bouillet, 2015).

The study by Chan (2002) revealed that the carbon stock of oil palm plantations ranges from 16.12 - 45.28 tons of C/hectare. The study by Kusumawati *et al.* (2021) revealed that the carbon stock of oil palm plantations ranges from 43.50 - 74.7 tons of C/hectare. In addition, the study by Khasanah *et al.* (2019) also revealed that the average carbon stock of oil palm plantations is 40 tons of C/hectare. The study by Setiadi *et al.* (2020) also found that oil palm plantation carbon stock ranges from 34.16 - 69.32 tons of carbon per hectare. The carbon stock of oil palm plantations is higher than the average carbon stock per hectare of forest in France (CIRAD, 2015).

Carbon stock is sequestered in oil palm plantation locations for 25 to 30 years. Even carbon stock that has turned into soil organic carbon can survive in the soil for more than 100 years.

With the global oil palm plantation area of around 26.5 million hectares, it can be imagined how large the carbon stock found in the global oil palm plantations is. It can also be envisaged how much carbon emissions are absorbed by oil palm plantations from the Earth's atmosphere and stored in the form of biomass and carbon stock in oil palm plantations.

The carbon stock of oil palm plantations is an accumulation of the results of the process of absorbing carbon dioxide from the Earth's atmosphere. This can be seen as the palm oil industry's contribution to the international efforts to reduce carbon emissions and mitigate global climate change (PASPI Monitor, 2023[a]). Apart from being able to take part in global climate change mitigation

solutions, this potential can also be utilized by the palm oil industry to further increase the economic value of oil palm plantations through carbon trading (PASPI Monitor, 2023[b]).

CONCLUSION

Naturally, oil palm plantations can harvest solar energy, absorb carbon dioxide from the Earth's atmosphere, and produce oxygen into the Earth's atmosphere. This capability is an environmental service that global oil palm plantations provide to the community worldwide.

Apart from environmental services, oil palm plantations also produce organic material in the form of palm oil and biomass. The production of oil palm plantations provides benefits to the global community in terms of meeting their needs for food products, oleochemical products and bioenergy.

The three oil palm plantation products, namely palm oil, biomass, and environmental services, are produced simultaneously and do not compete with each other (joint product). As long as the sun still shines, palm oil, biomass and environmental services will continue to be produced by the global oil palm plantations.

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