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21º CONFERENCIA INTERNACIONAL SOBRE PALMA DE ACEITE

21st International Oil Palm Conference

Oil palm: a sustainable, high-yield, global crop and its potential role in carbon trading

Denis J Murphy
University of South Wales, United Kingdom

2025

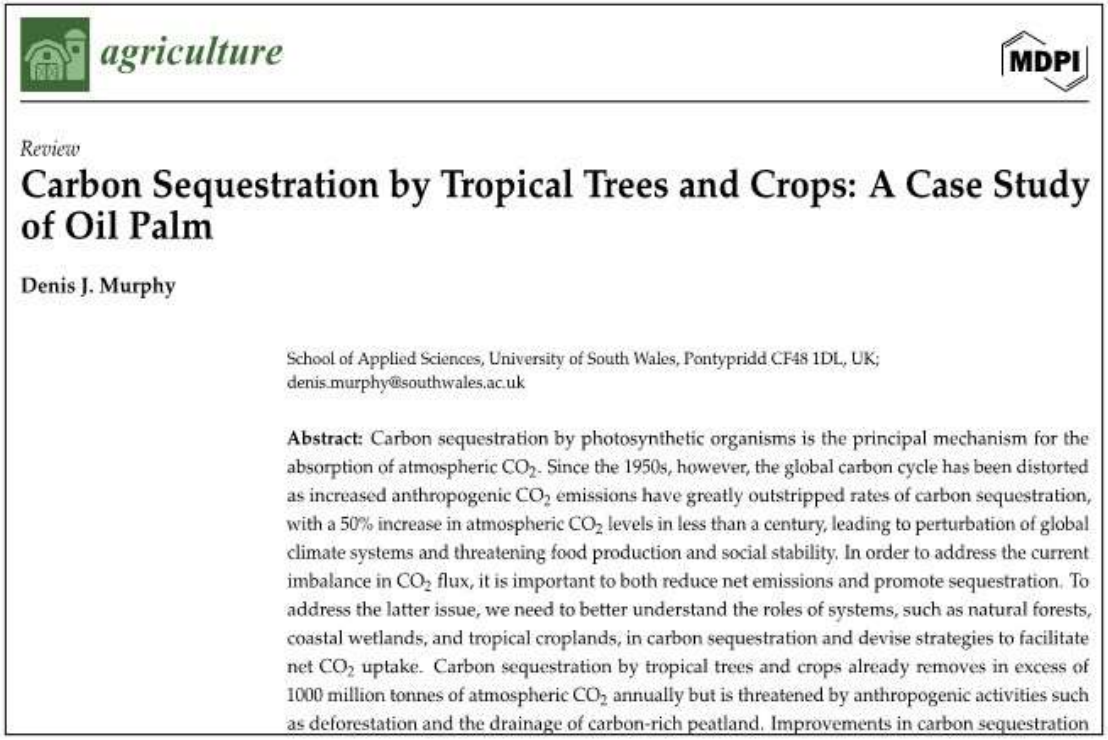
Scope of talk

21º CONFERENCIA INTERNACIONAL SOBRE PALMA DE ACEITE
21st International Oil Palm Conference

Oil palm
Food, fuels, materials
Removal of CO2 from atmosphere
Environmentally friendly
Climate resilient
Source of carbon credits - $$$$$$

- A uniquely productive global crop
- Exceptionally high carbon sequestration rates
- Potential for achieving low GHG emissions
- Scope for improved environmental sustainability
- High degree of climate resilience
- A hedge against future uncertainties
- New possibilities for carbon credit/trading schemes

Author's articles in 2024



Key articles focusing on carbon sequestration, tropical tree crops

> 10,000 downloads/citations

Author's articles in 2025

agronomy

MDPI

Review

Agronomy and Environmental Sustainability of the Four Major Global Vegetable Oil Crops: Oil Palm, Soybean, Rapeseed, and Sunfloe r

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Abstract: Four crops, oil palm, soybean, rapeseed, and sunflower, are collectively responsible for >91% of all globally traded vegetable oil production, worth an annual USD 223 billion. However, these crops fall into two distinctive categories with respect to their agronomy, yield, socioeconomic value, and overall sustainability. The dichotomy between perennial oil palm and the three annual oilseed crops is perhaps best shown in their relative efficiencies in oil production versus the amount of land that they occupy. Hence, land-friendly oil palm produces >90 Mt of oil on 29 Mha of land, with an average oil yield of 3.3 t/ha. In contrast, the three land-hungry annual crops collectively produce 121 Mt of oil on a huge land area of 191 Mha, giving a much lower average oil yield of 0.6 t/ha. In this study, the dichotomy between oil palm and the three major oilseed crops is examined further by comparing their respective carbon emission and uptake dynamics. The direct

crops

MDPI

Review

Carbon Sequestration for Global-Scale Climate Change Mitigation: Overview of Strategies Plus Enhanced Roles for Perennial Crops

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Abstract: Climatic changes threaten many forms of crop production as well as adversely affecting global ecosystems and human activities. There are two principal ways in which the balance of the global carbon cycle can be restored, firstly by decreasing anthropogenic CO_2 emissions and secondly by increasing the rates of carbon sequestration. Even if emissions are successfully reduced to net zero over the coming decades, it will still be essential to reduce atmospheric CO_2 concentrations to preindustrial levels. This can only be achieved by global-scale carbon sequestration of the order of gigatonnes (Gt) of CO_2 annually. Over recent decades, engineering approaches have been proposed to tackle carbon sequestration. However, their technological effectiveness has yet to be demonstrated at a global scale, with even the most optimistic current values at less than 0.1 Gt CO_2/yr, i.e., 50–100-fold less than required to meet IPCC targets for 2050. In contrast, biological carbon sequestration

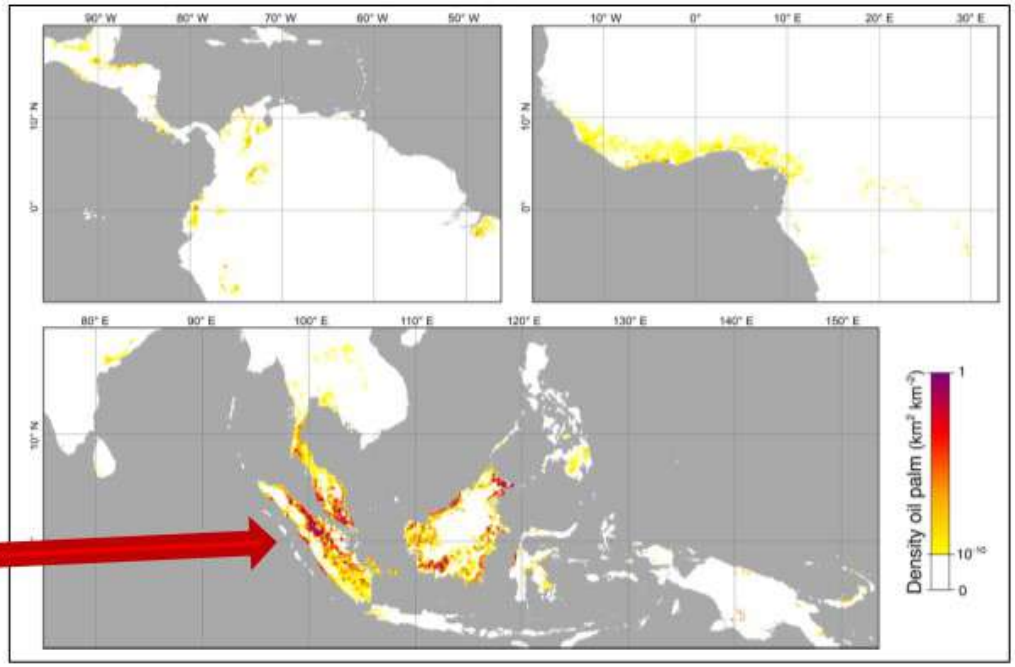
Key articles focusing on annual oil crops, sustainability & resilience

> 10,000 downloads/citations

A global crop with high productivity

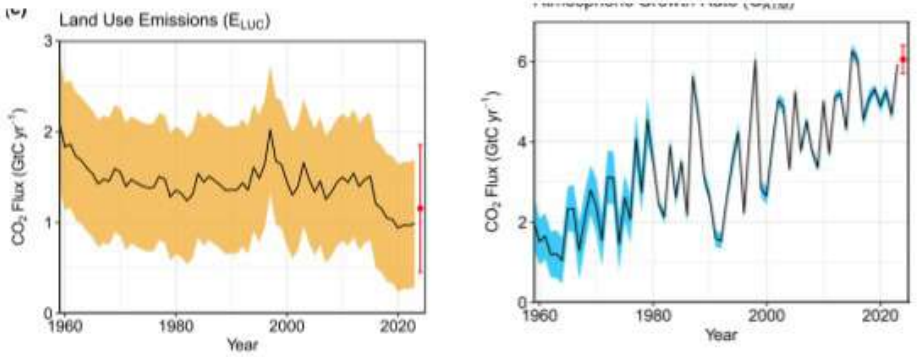
- Oil palm is the most important vegetable oil crop
- Its 90 Mt/yr production is 40% of a global market worth an annual $77 billion
- The crop is grown across the humid tropics of Asia, Africa and the Americas
- 85% of global production occurs in two countries: Indonesia & Malaysia

The map shows the density of oil palm at 5 km resolution, derived from the global oil palm layer for the period 2016–2021. Source: Descals et al, 2024.

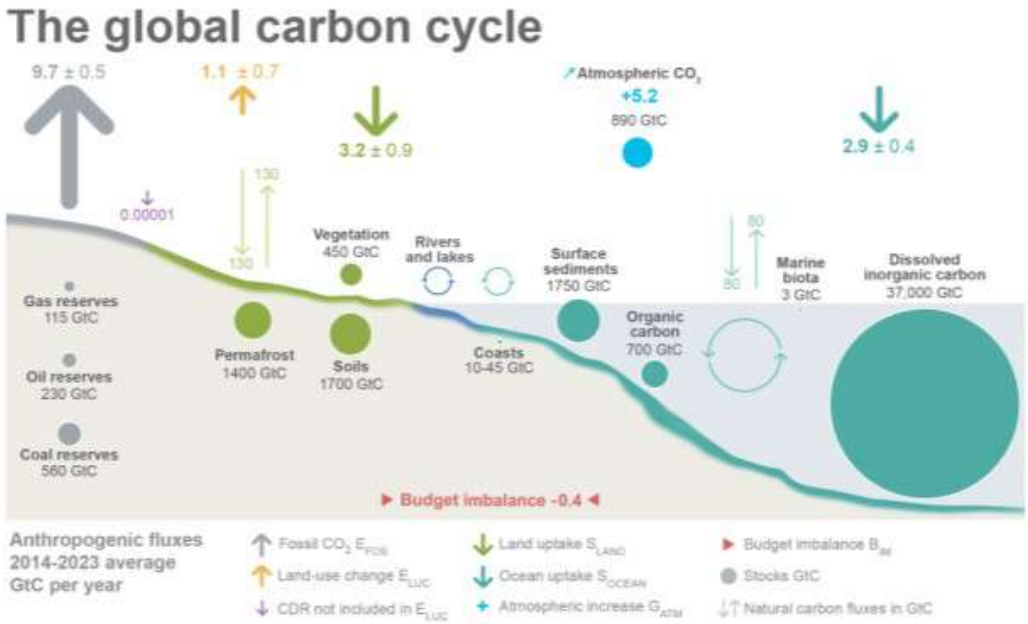


How do we decrease atmospheric CO2 levels?

1. reduce anthropogenic emissions (fossil fuels)
2. increase carbon sequestration by vegetation (tropical plants)



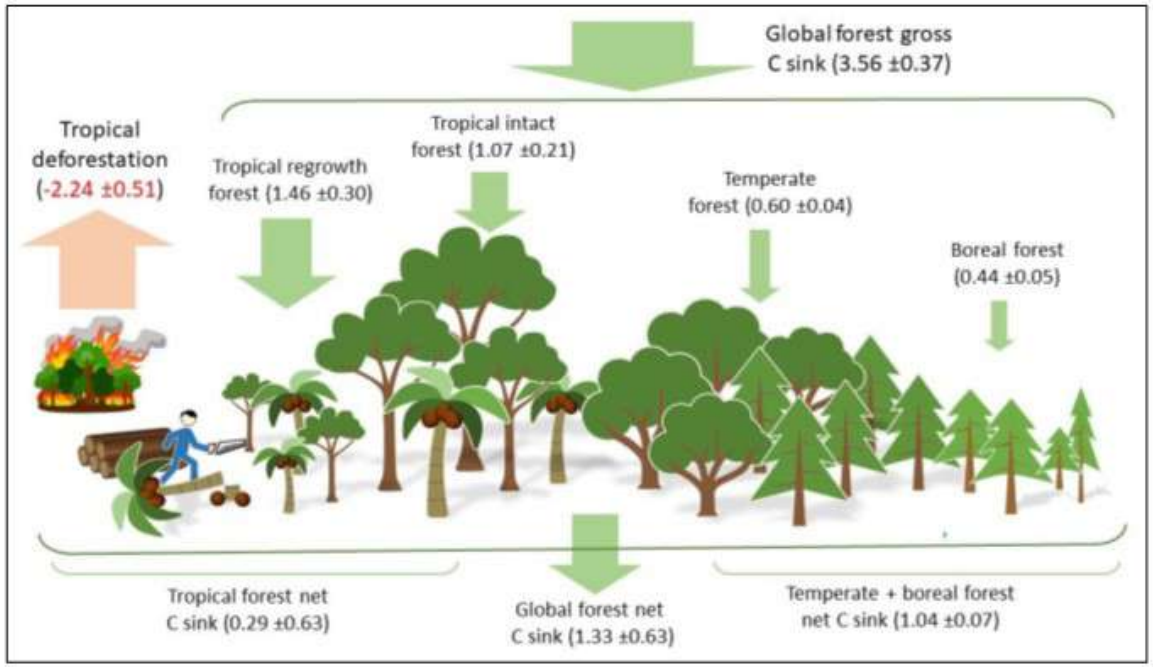
- Fossil emissions are >10 Gt/yr
- But vegetation sequestration is only 3 Gt/yr



Perturbation of the global carbon cycle caused by anthropogenic activities for the decade 2014–2023

Tropical crops like oil palm have a huge potential for carbon sequestration

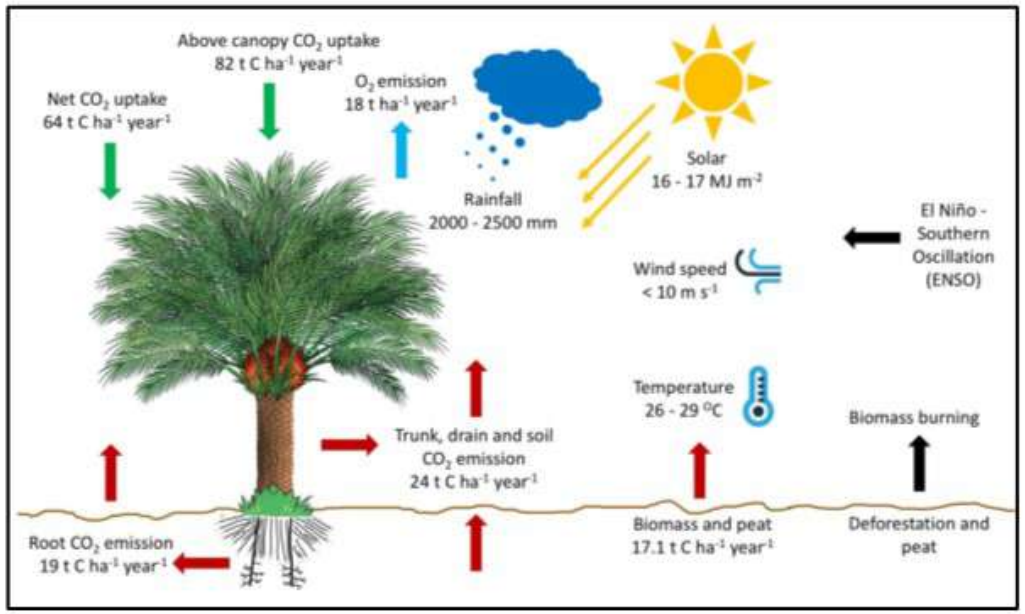
- Terrestrial vegetation sequesters 112–169 Gt C/yr playing an essential role in the global carbon cycle
- Use of optimal land management practices for natural forests and crops could unlock an extra 13.74 Gt C/yr sequestration potential
- The major global vegetative carbon stocks are found in three highly forested regions in the tropics, namely the Central Africa and Amazon River basins, and the Indo–Malay Archipelago



Carbon sinks and sources in global forests, 1990–2019 Gt C/yr
Green = C-sinks, **red = C-sources** (= **emissions**)

Carbon sequestration rates of oil palm crops can be comparable with some natural forests

- Numerous studies of oil palm carbon sequestration under both experimental and field conditions
- Above-canopy CO2 uptake is 82 t C/ha/yr, but is offset by O2 emissions of 18 t O2/ha/yr, hence, giving a net CO2 uptake of 64 t C/ha/yr
- Below-canopy CO2 emissions include 19 t C/ha/yr from roots and 24 t C/ha/yr from trunk, drain, and soil totalling 43 t C/ha/yr
- Overall CO2 uptake is 23 t C/ha/yr, although this can be greatly reduced if the crop is grown on peat soil



Achieving low emissions for oil palm

- Low emissions are possible and desirable even when additional land is required – providing well-managed Land Use Change (LUC) measures are adopted
- Other important measures include:

Introduction of perennial inter-crops

Zero tillage

Organic inputs

Raising the water table in arable peatland

Modernizing mill and refinery operations including the capture of waste methane for power generation, and putting palm oil mill effluent (POME) to better use

For new plantings LUC penalties can be minimized by avoiding use of land with C stock value of >40 metric tons Ceq/ha. This includes monocultural rubber plantations, rubber agroforest, and secondary or logged-over forests that respectively have carbon stock values in the range of 44, 177, and 65–219 tons Ceq/ha

In contrast, grasslands and shrublands with lower carbon stock values of 3 and 34 metric tons Ceq/ha, respectively, would not incur a carbon debt upon conversion to oil palm

The peat issue

- Considerable progress has been made in addressing the tropical peat issue in recent years
- For example, drained peatlands on oil palm plantations have been re-wetted in West Kalimantan, Borneo, where it has been claimed that this could reduce CO2 emissions by as much as 3.9 Mt/y
- Recent mapping data also show that across all regions of Indonesia oil palm planting peaked from 2009 to 2012 and has subsequently declined eightfold, while the proportion of peatland was never more than 21% of the converted crop area and is now reduced to 7%
- To a great extent, this reduction in overall crop area occupied by peatland is due to the avoidance of ecologically sensitive land when new plantations are established
- This underscores the need to contextualize the peat issue as being historically constrained that does not apply to oil palm cultivation as a whole
- However, the bottom line is that future peat conversion should be avoided and effective remediation measures should be implemented on existing peat-derived plantations

Environmentally sustainability

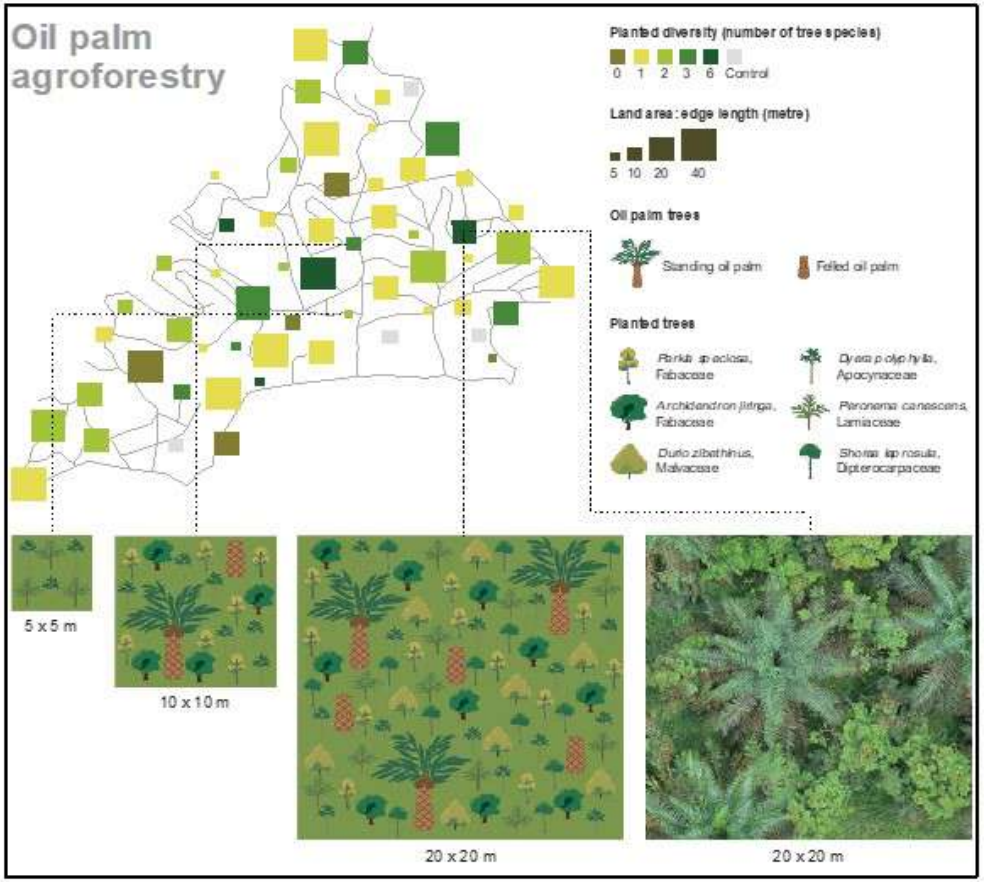
- Oil palm crops have many environmental advantages over annual oil crops
- These include uniquely high oil yields with even higher yields achievable (>10t/ha)
- OP has exceptionally low land use requirements
- OP has moderate fertilizer requirements plus considerable agroforestry potential
- High capacity for carbon sequestration comparable with some forests
- Comparatively low climate risks

Crop	Oil Yield, Mt	Land Use Mha	Oil Yield t/ha	H_2O Footprint, m^3/t Oil	Fertilizer Use	Agroforestry Potential	Climate Risks
Oil palm	90	29	3–6 (10-)	5000	Medium	Moderate	Low
Soybean	68	130	0.5 ()	4200	High	Low	Low-mid
Rapeseed	27	37	0.7 ()	4300	High	Low	Moderate
Sunflower	21	26	0.8 ()	6800	High	Low	High

Innovative treescapes for sustainable crops

- **There is an increasing body of research into palm-dominated landscapes that include tree islands**
- **There is also the potential of commercial oil palm cultivation to embrace agroforestry (in some circumstances) as part of a wider effort to increase the environmental credentials of the crop**
- **A recently reported option is to establish agroforestry schemes with species such as *Coffea liberica* and *Shorea balangeran* in threatened peatland ecosystems**

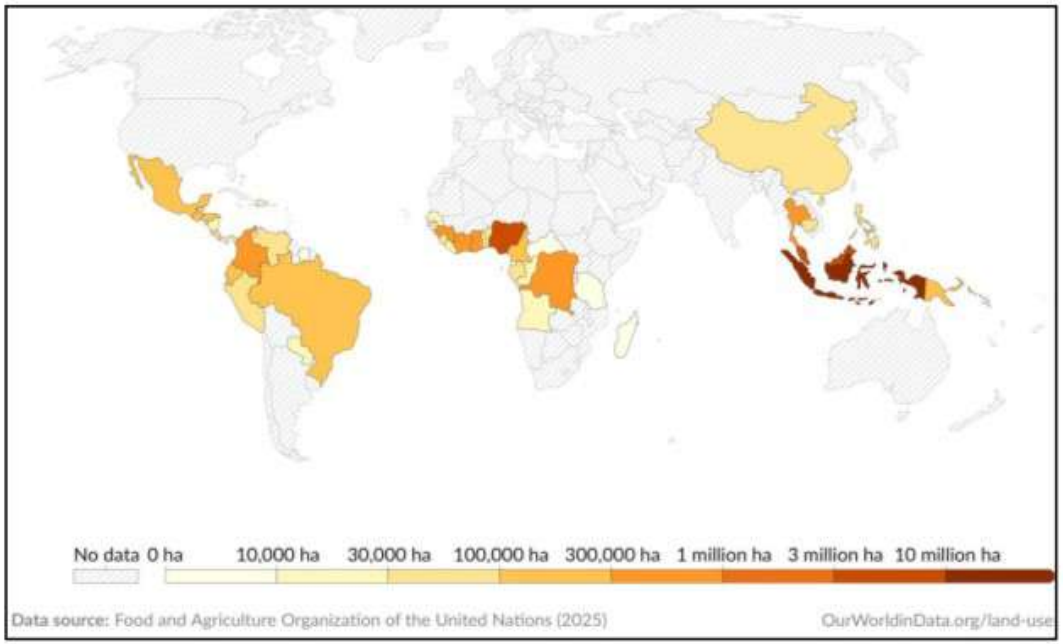
Tree island areas range from 25 to 1,600 m² with 0–6 planted species, with 52 islands in an oil palm plantation in Indonesia. Control plots are conventional oil palm monocultures. Source: Meijaard et al, 2024, based on Zemp et al. 2023.



Prof. Alain RIVAL presenting results from the TALENT Programme at ICOPE 2025 Conference, Indonesia

Climate resilience

- Global oil crop production is threatened by climate change
- This is especially serious for annual crops that are sensitive to increasing drought and higher temperatures
- In contrast, oil palm has greater resilience to currently predicted climate effects
- OP also has great potential for increased sustainable production without expansion into sensitive habitats



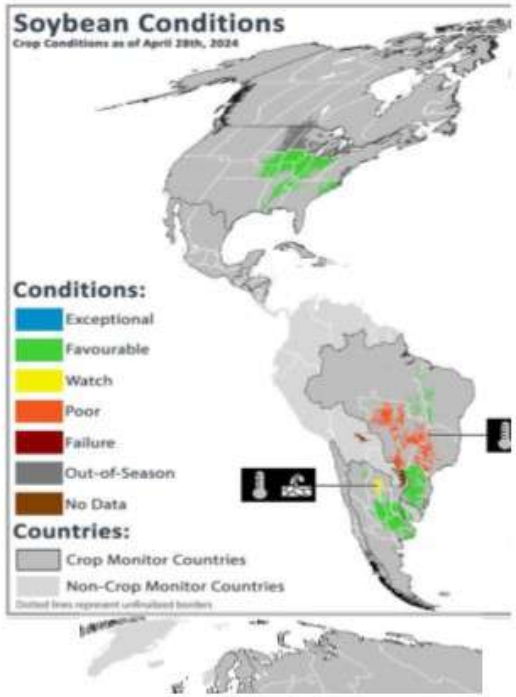
Global oil crop production
Indonesia & Malaysia dominate due to their high-yield oil palm crops
Annual oil crops, such as USA, Brazil, China & India are much lower

Climate resilience

- **Sunflower and rapeseed have low resilience**
- **Soybeans have moderate resilience**
- **Oil palm has higher resilience**

Sunflower production is mainly concentrated in **southern Europe**, especially in Ukraine & western Russia. Future oil yields of sunflowers are probably more susceptible than other oil crops to predicted climatic shifts that entail more erratic rainfall patterns

Rapeseed production is threatened by increasing heat and drought stresses, requiring new agronomic solutions, such as eco-friendly fertilizers, stress-resistant varieties, plant growth-promoting bacteria and beneficial micronutrients to mitigate abiotic stresses



Soybean crops in 2024.
The map shows major centers of production in Brazil, the USA, and Argentina. Crop conditions were generally favorable with the exception of the drought-affected Brazilian cerrado

A highly uncertain future

- Over recent years a series of geopolitical and climatic shocks have caused uncertainty in many agricultural sectors, including oil crops
- Overall, edible oils appear the most secure as populations increase at least until 2050
- High-carbon products from tropical tree crops also have good potential in mitigating CO2 emissions
- In contrast, biofuels, especially biodiesel, are entering a period of uncertainty as fossil fuel companies and governments reduce commitments to net zero and decrease investments in future growth in the medium term

- So, what is the prognosis for oil palm sector?

Biodiesel trade losing momentum

SEP 18, 2025

Trade in biodiesel is showing a decline in 2025

Global oil giant Shell has halted the construction of its planned 820,000 tonnes/year biofuels plant in Rotterdam

The decision followed Shell's cancellation of its SAF project on Bukom Island, Singapore, in March 2023

Shell's move follows Finnish forestry/paper mill company UPM's announcement in May 2025 to halt plans for the development of a biofuels refinery at the Port of Rotterdam due to "technical, commercial and strategic evaluations"

Sectors such as Sustainable Aviation Fuel (SAF) are increasingly exposed by these developments

Oil palm as the global vegetable oil crop of choice in future decades

- The three annual crops, soybean, rapeseed and sunflower together supply about 52% of the world's supply of vegetable oil on an extensive land footprint totalling 203 Mha
- In contrast, oil palm crops supply 40% of the world's supply of vegetable oil on a more modest land footprint of a mere 23 Mha, making it almost ninefold more efficient in terms of oil production per land unit
- Oil palm has many environmental advantages over annual crops including its already high, but greatly improvable, oil yields, its capacity for carbon sequestration that is comparable with some forests, its lower vulnerability to currently predicted climate effects, and its future capacity for considerably increased sustainable production without expansion into sensitive natural habitats
- Global vegetable oils requirements for will continue to grow over the coming decades, although supplies might become increasingly constrained due to factors such as climate change and poor land use.
- This might require a re-examination of the current focus on low-yielding, climate-sensitive annual oil crops and a more effective and imaginative use of improved and updated versions of the high-yielding, land-sparing oil palm cropping system.

The past

(low biomass inefficient annual crops)

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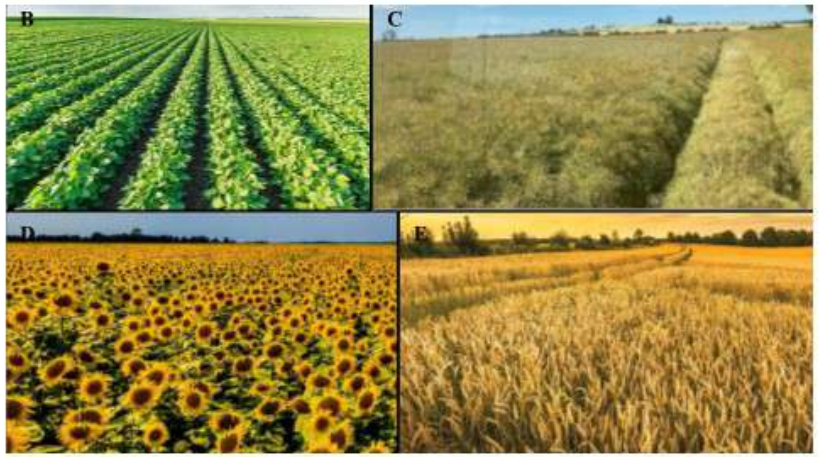

The future

(High biomass oil palm crops - including carbon trading)

👍

Carbon trading – a way forward for oil palm?

- In late 2024, a new set of carbon market rules were agreed at COP29 with many welcoming a new start after the scandals of the past while others were more cautious about whether the reforms will really be able to help developing countries benefit from funds to drive sustainability initiatives
- In terms of a practical real-world example, it was reported that the global software company Microsoft had purchased carbon credits from Brazil in order to offset some its GHG emissions as part of its planned move towards a net zero operation. In this case, Microsoft has bought credits to remove <5 Mt of CO_2 carbon via reforestation, meaning that it was effectively funding several reforestation projects in Brazil totaling $10-20/t C
- The carbon credit price is predicted to rise to ~$30/t in 2030, This could make it financially attractive to reforest roughly half of the pastureland in Brazil. It was also estimated that, in contrast to the $10-40 cost to sequester 1t of CO_2 by tree planting

Carbon trading – a way forward for oil palm?

- This shows how carbon trading can potentially unlock biological carbon sequestration to serve as a cheaper and more readily implemented approach than industrial schemes.
- In another example, we can consider the use of tropical perennial crops as reforestation agents. Restored Brazilian forests could account for 15% of the world's potential for carbon removal through reforestation and Indonesia might have a comparable potential.
- This raises the possibility of using high-yield commercial forests, such as oil palm plantations, within such a market. It would be necessary for oil palm plantations to be classified as forests for this purpose, but this already happens in Scandinavia where commercial tree plantations are judged to be forests and are allowed into carbon trading schemes despite the fact that they capture far less carbon than tropical tree crops.
- It is estimated that in order to reach the IPCC target of 5-10 Gt/yr by 2050, carbon-removal markets would be worth >$200 billion making them an attractive prospect for investors.

Carbon trading – a way forward for oil palm?

- **Carbon trading schemes have recently been launched in the UK and are being trialled in Vietnam, Brazil, Australia etc**
- **We have recently proposed some targets for carbon credit utilization linked to both natural and crop-based landscapes in Malaysia as summarized below**
  - Utilize carbon offset mechanisms to incentivize sustainable practices across the value chain, enhancing environmental responsibility
  - Monetization Opportunities for stakeholders, particularly smallholders, to create additional income streams to enhance economic viability
  - Integration with International Markets to facilitate global trading of carbon credits, to expand carbon markets and increase revenue
  - Wetland Agriculture: Promote practices to maintain elevated peatland water tables to support sustainable crop cultivation and generate carbon credits and novel products providing income for farmers via sustainable peat management
  - Forest Preservation Incentives: Incentivize preservation of tropical forests by highlighting the benefits of carbon credits, biodiversity protection, and sustainable tourism to counteract drivers of deforestation

Johari Abdul Ghani Minister for Plantation & Commodities and Natural Resources & Environmental Sustainability (centre) is driving new carbon trading schemes in Malaysia and partners with new developments priced at >US$ 100 million scheduled to be announced in November 2025

MUCHAS GRACIAS
&
THANK YOU FOR YOUR ATTENTION

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