Systematic Tools for Sustainable Oil Palm Plantation Development - A Response to European Union Resolution on Palm Oil

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RESEARCH TEAM

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ABOUT

• Degree(s):
  • MEng (Hons.) Chemical Engineering: (Uni of Nottingham, Malaysia)
  • Ph.D in Engineering (Uni of Nottingham, Malaysia)

• Position: Assistant Professor

• Affiliation: Heriot-Watt University, Malaysia

• Other Qualifications: CEng MIChemE, GradEng (BEM)
Brief History of Heriot-Watt University

- Edinburgh, Scotland
- Founded in 1821
- Dubai Campus (2005)
- Malaysia Campus (2014)
Heriot-Watt University in Malaysia

City of Putrajaya, West Malaysia

36.8 km from Kuala Lumpur
22.6 km from KLIA
EMERGENCE OF PALM OIL

YIELD

PRODUCTION COST

ECONOMIC LIFESPAN

VERSATILE PRODUCT

YEARS TO MATURITY

DIVERSIFIED MARKET

PALM OIL
CRUCIAL COMMODITY

<table>
<thead>
<tr>
<th>Oil palm</th>
<th>Coconut</th>
<th>Olive</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>7</td>
<td>5</td>
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</table>

- Palm: 3.8 oil (tons) per hectare
- Rape: 0.8
- Sunflower: 0.7
- Soy: 0.5
SIGNIFICANCE OF PALM OIL

01 AVAILABILITY (PHYSICAL)

02 ACCESSIBILITY (ECONOMIC)

03 ACCEPTANCE (SOCIAL)

FOOD SECURITY

45 MT (> 60% exports)

55% of veg oil trade

10% -20% lesser in cost compared to others

ASIA
EUROPE
AFRICA
AMERICAS
OVERVIEW OF PALM OIL INDUSTRY

OIL PALM PLANTATION

- ESTATE / SMALLHOLDERS
- FRESH FRUIT BUNCH (FFB)
- INFLUENCE OF CLIMATIC REQ ON GEO’PIC DISTRIBUTION

PALM OIL MILL

- PROCESS FFB TO PRODUCE CRUDE PALM OIL (CPO)
- BIOMASS WASTES
- CHP PLANT
- POME

- REFINED PALM OIL
INTRODUCTION

MOTIVATION

01

02
Other plant-based oils have a much higher environmental footprint & land use.

Recognize complexity and emphasizes the importance of developing a global solution.

Recognizes importance for conservation of rain forests and biodiversity.

Stresses preservation efforts should be combined with sustainable development.

Oil palm
- can deliver positive contributions to the economic development;
- but must be responsible and sustainable.
Ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems.

Ensure the conservation, restoration and sustainable use of terrestrial ecosystems and their services, in particular forests, wetlands, mountains and drylands.

Promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests.

Integrate ecosystem and biodiversity values into national and local planning during development process, poverty reduction strategies etc.

Integrate climate change measures into national policies, strategies and planning.

Achieve the sustainable management and efficient use of natural resources.
PREVIOUS WORK

- Biomass supply chain optimisation considering oil palm plantation growth rates and palm biomass export
- Considers carbon reduction targeting
- Biomass supply chain optimisation for bioenergy distribution
- Analyses feasible operating range of the entire network
PREVIOUS WORK

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PALM OIL REFINERY
- IMPURTIES, ODOUR & FFA TO PRESCRIBED LIMITS
- REFINED PALM OIL

PALM OIL
- USED FOR DIFFERENT APPLICATIONS
OIL PALM PLANTATION
- ESTATE / SMALLHOLDERS
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PALM OIL
- USED FOR DIFFERENT APPLICATIONS

CURRENT WORK
INCREASE IN VEGETABLE OIL DEMAND

OIL PALM EXPANSION

DEFORESTATION

ENVIRONMENTAL IMPACTS

UN Sustainable Palm Oil Production due to LUC

Increase in population
Rise in income
Urbanization

FOOD SECURITY

Agronomic & Economic advantages

RESEARCH PROBLEM
STATEMENT OF PROBLEM

The sustainability crisis plaguing the palm oil industry is mainly due to unplanned excessive land use change of sensitive ecosystems (tropical forests) to oil palm plantations.

This phenomenon was fed by increased vegetable oil demand. With continuing increase in demand and vulnerability of forests to large scale deforestation, it remains a big challenge to ensure food security along with sustainable palm oil production.

OBJECTIVE OF RESEARCH

To develop decision support tools that aid decision makers in making systematic and scientific decisions on sustainable oil palm plantation development
Analysis Tool to Assess Expansion in Palm Plantations based on LUC costs

ENV accounted as LUC Tax

Land types considered
- Tropical forest (TF)
- Peat forest (PF)
- Grasslands (GL)

To develop a systematic tool to carry out expansion analysis for oil palm plantation development

DECISION VARIABLES
- Deforestation/land clearing cost
- Planting cost
- LUC Tax

OUTCOMES
- Optimised LUC for sustainable oil palm plantation expansion
- Demand to which expansion is absolutely necessary
- The expansion cost associated with different expected demands over the timeline
240,613 tons of FFB/year

Palm Oil Mill

Fresh Fruit Bunch

Superstructure

Existing palm plantations

Potential lands for new palm plantation development

CPO

KPO

Kernel cake

Fibre

Nut shell

EFB

POME

CPO / KPO Refinery

Refined Palm Oil

Refined Kernel Palm Oil

Drying

Power

Steam

Treated water

CHP

90 t/h (fixed)

240,613 tons of FFB/year

90 t/h (fixed)
Analysis Tool to Assess Expansion of Palm Value Chain based on Costs, Carbon and Water Footprints

To develop a systematic tool for sustainable expansions in palm value chain

**Decision Variables**
- Deforestation/land clearing cost
- Planting cost
- LUC tax
- Operating costs
- Land costs
- Revenue – palm oil, power
- Carbon emissions – logistics, LUC
- Water footprint – plantations, mills, CHP

**Outcomes**
- Optimised LUC for sustainable oil palm plantation expansion
- Trade-Offs between economic performance, carbon and water footprints
Superstructure

273,374 tons of FFB/year

30 t/h
Mill_1
CPO
By-Pass CPO
Refined Palm Oil

45 t/h
Mill_2
KPO
By-Pass KPO
Refined KPO

Kernel Cake

45 t/h
Mill_3
Fibre

10 MW

Shell

EFB

Drying

POME
By-Pass POME

CHP

Electricity

WWTP

Treated Water

Steam
Minimum Carbon

**EP1**
- Fresh Fruit Bunch
- EFB

**NP9**
- ByPass

**NP5**
- ByPass

**EP4**
- CPO
- KPO
- Drying
- Shell

**EP5**
- CPO Refinery
- KPO Refinery

**EP2**
- CPO
- ByPass

**EP3**
- KPO
- ByPass

**EP6**
- Mill_1
- Mill_2
- Mill_4
- Mill_2
- CHP
- 3 MW

**EP7**
- ByPass

**EP8**
- CPO

**EP9**
- CPO

**EP10**
- CPO

**EP1**
- Fresh Fruit Bunch

**NP5**
- ByPass

**NP9**
- ByPass

**EP4**
- CPO
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<table>
<thead>
<tr>
<th></th>
<th>Profit /year (USD)</th>
<th>Carbon/year (tCO$_2$)</th>
<th>Water (m$^3$/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Profit</td>
<td>29,256,230</td>
<td>50,546</td>
<td>218,300,500</td>
</tr>
<tr>
<td>Minimum Carbon</td>
<td>24,981,770</td>
<td>588</td>
<td>90,934,930</td>
</tr>
<tr>
<td>Minimum Water</td>
<td>21,134,290</td>
<td>28,547</td>
<td>57,259,260</td>
</tr>
<tr>
<td>Multi-Objective</td>
<td>27,727,050</td>
<td>958</td>
<td>90,934,930</td>
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Carbon Emissions

DEPENDS ON SELECTION OF LANDS

Plantation Water Footprint

Mill Water Footprint

CHP Water Footprint

DEPENDS ON SELECTION OF LANDS
Multi-Period Planning Tool to Assess Storage Options for Oil Palm Plantation Expansion

**OUTCOMES**
- Optimised LUC for sustainable oil palm plantation expansion considering the varying yield due to maturity
- Storage capacity optimisation and its influence on expansion – LUC & investments

**OBJ**
To develop a systematic tool to plan storage, accounting the varying yield of palm plantations due to maturity in expansion analysis

**DECISION VARIABLES**
- Deforestation/land clearing cost
- Planting cost
Superstructure

240,613 tons of FFB/year

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POME

WWTP

Refinery

Refined Palm Oil

Refined Kernel Palm Oil

Power

Steam

CHP

Treated water
*Assumption - In the year 2021, plantations P1 and P2 were existing with maturity of 15 and 20 years respectively.
Annual Investments needed for optimised plantation expansion

Cost in millions (USD)

Year

2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045

P3, P6
P8
P5, P7, P9
P1
P10
Planning Tool to Assess Required Maturity for Oil Palm Plantations for Future Demands

**OUTCOMES**

Optimisation of expansion based on maturity profile optimisation

**OBJ**

To determine the required maturity of plantations to meet future demands based on the plantation profiles

**DECISION VARIABLES**

Deforestation/land clearing cost

Planting cost
THANK YOU FOR YOUR ATTENTION

FEEDBACK, QUESTIONS & SUGGESTIONS