Life Cycle Assessment of biodiesel using jatropha as feedstock under the frame of the JatroMed project implementation

Elena Koukouna

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Outline

• Introduction
• Goal of Study
• Methods
• Impact Results
• Conclusions
• Recommendations
Introduction

JatroMed (www.jatromed.aua.gr), is a 4-year demonstration project, coordinated by the Agricultural University of Athens, Greece and co-financed by European Union.

The programme is focusing on the cultivation of energy crop *Jatropha curcas* L. in small-scale, community-based initiatives for local uses in Morocco, Algeria and Egypt.

Case study used for thesis project; Essaouira, Morocco
Morocco

Essaouira Region: commune Hadd Dra - 31° 34’ 39.56″ N, 09° 32’ 19.45″ W
Goal of the study

**Main goal**
Comprehensive LCA of jatropha biodiesel
*(proper data bookkeeping, evaluation of methodological choices)*

**Main Objective**: **comparative analysis**
- of biodiesel system performance and the equivalent petroleum diesel system;
- of the cultivation treatments used within JatroMed *(Michoacan and JCLMax)*
Goal of the study

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Comprehensive LCA of jatropha biodiesel
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Introduction

**Definition**
Life Cycle Assessment (LCA) is an analytical method that measures the energy and resource inputs and corresponding environmental releases of a product (good, or service) and evaluates its environmental performance.
Methodology

Methods
The model was constructed in CMLCA software of Leiden University, NL
The LCA adheres to the principles, framework and guidelines in ISO-14000 series standard

Inventory data collection
• JatroMed demonstration fields (*nurseries & cultivation*)
• Ecoinvent database
• Literature review
• Interviews
Methodology

**Product system properties**
- Functional unit; 1km of driving a lorry running on diesel
- System boundaries are set from cradle to grave
- Allocation is based on both economic and **energy flows**

**Reference scenario**
**A1B2** Low fertilization/ High irrigation

(170 kg Urea/ha.yr, 900 m³ irrig.water/ ha.yr)

**3500 kg** DM seed yield/ ha.yr (basic assumption)

20 years lifetime

**TREATMENT A1: Fertilization**
10 g of urea per plant
Every month both doses will be increased by 5 g

**TREATMENT B2: Irrigation**
8L/hour every 7 days
System Boundaries of jatropha biodiesel

System boundaries set for the study
Cradle to Grave
Preliminary Impact Results

Conventional VS Alternative system

Normalized Impact Results - Energy Allocation

- jatropha biodiesel lorry
- petroleum diesel lorry
Preliminary Impact Results
Conventional VS Alternative

Conventional VS Alternative system
Normalized Impact Results - Energy Allocation

- abiotic depletion (reserves)
- abiotic depletion (foss-fuels)
- GWP
- ozone depletion
- human toxicity
- terrestrial ecotoxicity
- photochemical oxidation
- acidification
- eutrophication

jatropha biodiesel lorry
petroleum diesel lorry
Preliminary Impact Results
Conventional VS Alternative

Conventional VS Alternative system
Normalized Impact Results - Energy Allocation
Major contributors of Impact Categories

Major contributors of GWP along *jatropha* biodiesel life cycle (%)

- Use phase: 50%
- Energy consumption (combustion of fossil fuels): 40%
- Industrial waste: 30%
- Transport: 20%
- Mining (minerals, metals): 10%
- Fertilizer production: 0%
- Materials and chemicals use: -10%
- Fossil resource extraction: -20%
- Cultivation: -30%
- Application of jatropha residues to the crops: -40%
- Others: -50%
Major contributors of Acidification along *jatropha* biodiesel life cycle (%)

- **Use phase**
- **Energy consumption (fossil fuels)**
- **Building machines use (fuel combustion)**
- **Transport**
- **Others**
Major contributors of Eutrophication along *jatropha* biodiesel life cycle (%)

- **anaerobic digestion (j.residues)**
- **use phase**
- **energy production (combustion of hard coal)**
- **building machines use (fuel combustion)**
- **transport**
- **others**
Eutrophication scenarios

Eutrophication (kg PO4 eq.)

- Reference system
- No fertilization
- no j.residues application
- petroleum diesel
Delivering 1km driving on jatropha biodiesel

- **Land use change;** 0.142 m² yr land
  - Almost entirely due to occupation of arable land
  - Occupation of industrial land

- **Land use change due to C-stock change;** -1.3 tn CO₂ / ha yr
  *(IPCC methodology)*

- **Water footprint;** 0.116 m³ water

- **Energy consumption;** 7.83 MJ *(fossil based)*

- **Oil demand;** 0.336 kg crude j.oil or
  0.271 kg j.biodiesel
Conclusions

- GWP for petroleum diesel system is 5 times larger than biodiesel, while acidification and eutrophication are lower by 35% and 70% respectively.

- For biodiesel system, negative global warming emissions are due to CO2 fixation (*distinction btw short and long life carbon*)

- By-products treatment may considerably affect the life cycle emissions
Recommendations for further research

- Agronomic practices (*soil quality improvement, water use enhancement, crop residue and fertilizer management*)
- Nutrient cycling by using by-products
- Possibilities of intercropping
- Energy consumption in agricultural, refining and manufacturing processes
- Biodiesel conversion technologies (*processing conditions, catalysts use*)
Thank you for your attention

Acknowledgement

The data used in this work was taken from the EU funded project JatroMed (www.jatromed.aua.gr)

This work was supported by the European Union
These supports are gratefully appreciated
## Major contributors per impact category

<table>
<thead>
<tr>
<th>Abiotic depletion:</th>
<th>Terrestrial ecotoxicity:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Mining</td>
<td>- Materials production ~65%</td>
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<tr>
<td>- Extraction of fossil fuels</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>GWP:</th>
<th>Acidification:</th>
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</thead>
<tbody>
<tr>
<td>- Use phase (highest contributor)</td>
<td>- Use phase 55%</td>
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<tr>
<td>- Energy production (fossil)</td>
<td>- Energy production</td>
</tr>
<tr>
<td>- Industrial waste</td>
<td>- Transport</td>
</tr>
<tr>
<td>- Mining of heavy metals</td>
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</tr>
<tr>
<td>- Fertilizer production</td>
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<th>Human toxicity:</th>
<th>Eutrophication:</th>
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<tr>
<td>- Intensive materials production;</td>
<td>- Application of <em>jatropha</em> residues</td>
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<tr>
<td><em>Steel production 25% &amp;</em></td>
<td>62% <em>(mineral nutrient over-enrichment)</em></td>
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<td><em>Copper production 13%</em></td>
<td>- Use phase 28%</td>
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### Eutrophication:
- Application of *jatropha* residues
  62% *(mineral nutrient over-enrichment)*
- Use phase 28%