Life Cycle Assessment of Jatropha biodiesel product system

under the frame of the JatroMed project implementation

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Outline

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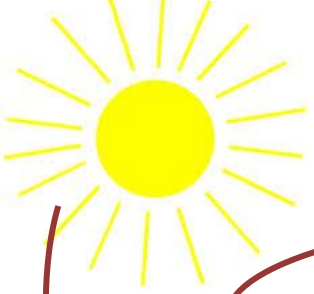
- Goal of Study
- Methods
- Impact Results
- Conclusions and Remarks
- Recommendations

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.

Jatropha biodiesel Life Cycle



emissions

CULTIVATION

EXTRACTION

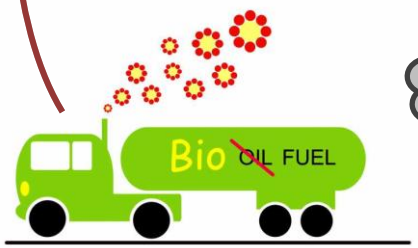
WASTE

ENERGY &
MATERIAL INPUT

CO2 biogenic

BY-PRODUCTS

REFINING



emissions

TRANSPORTATION
FUEL

BIODIESEL CONVERSION

ALCOHOL

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)*

Methodology

Methods

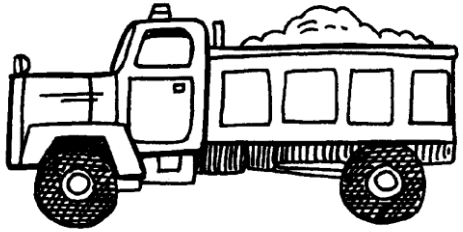
The model was constructed in CMLCA software of Leiden University, NL

The LCA adheres to the principles, framework and guidelines in ISO-14000 series standard

Inventory data collection

- JatroMed demonstration fields *(cultivation & pre-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 **energy flows**

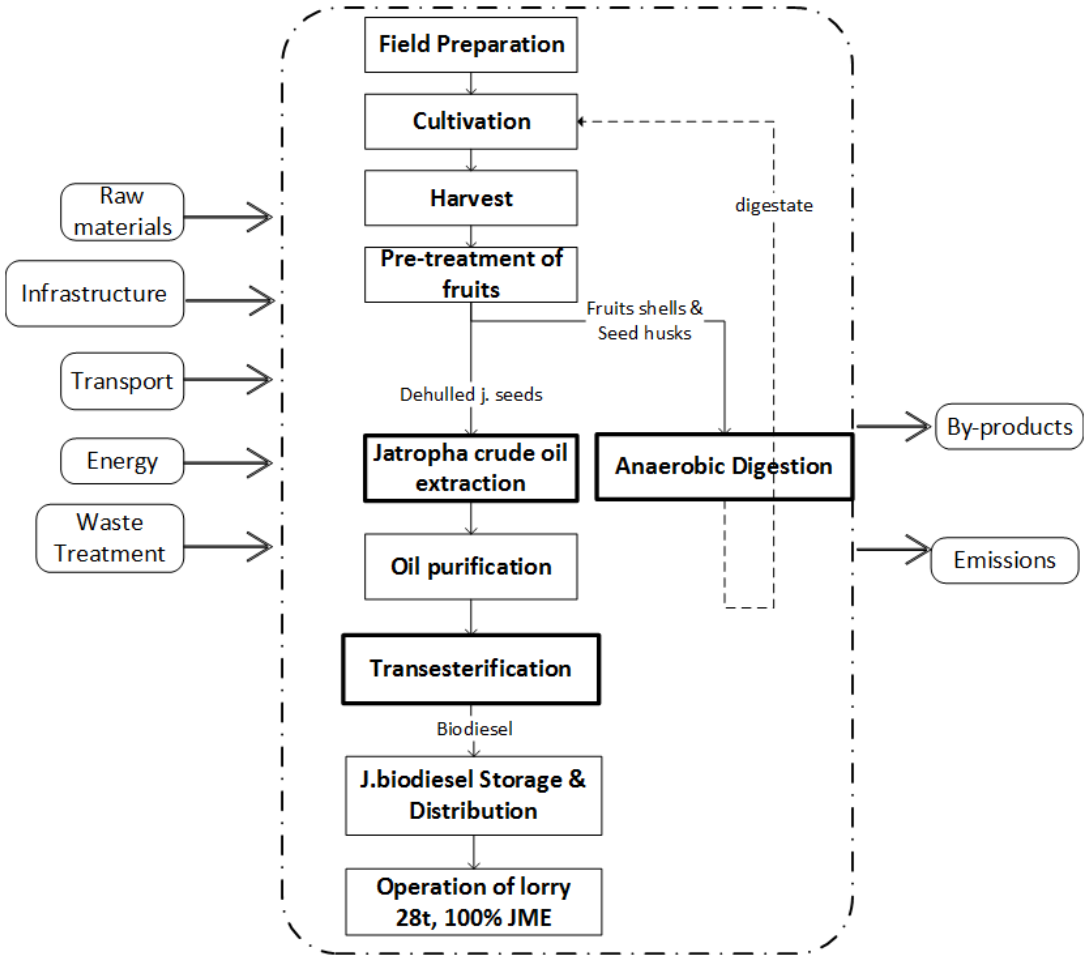
Baseline scenario

A1B2 Low fertilization/ High irrigation

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

20 years lifetime

System Boundaries of jatropha biodiesel

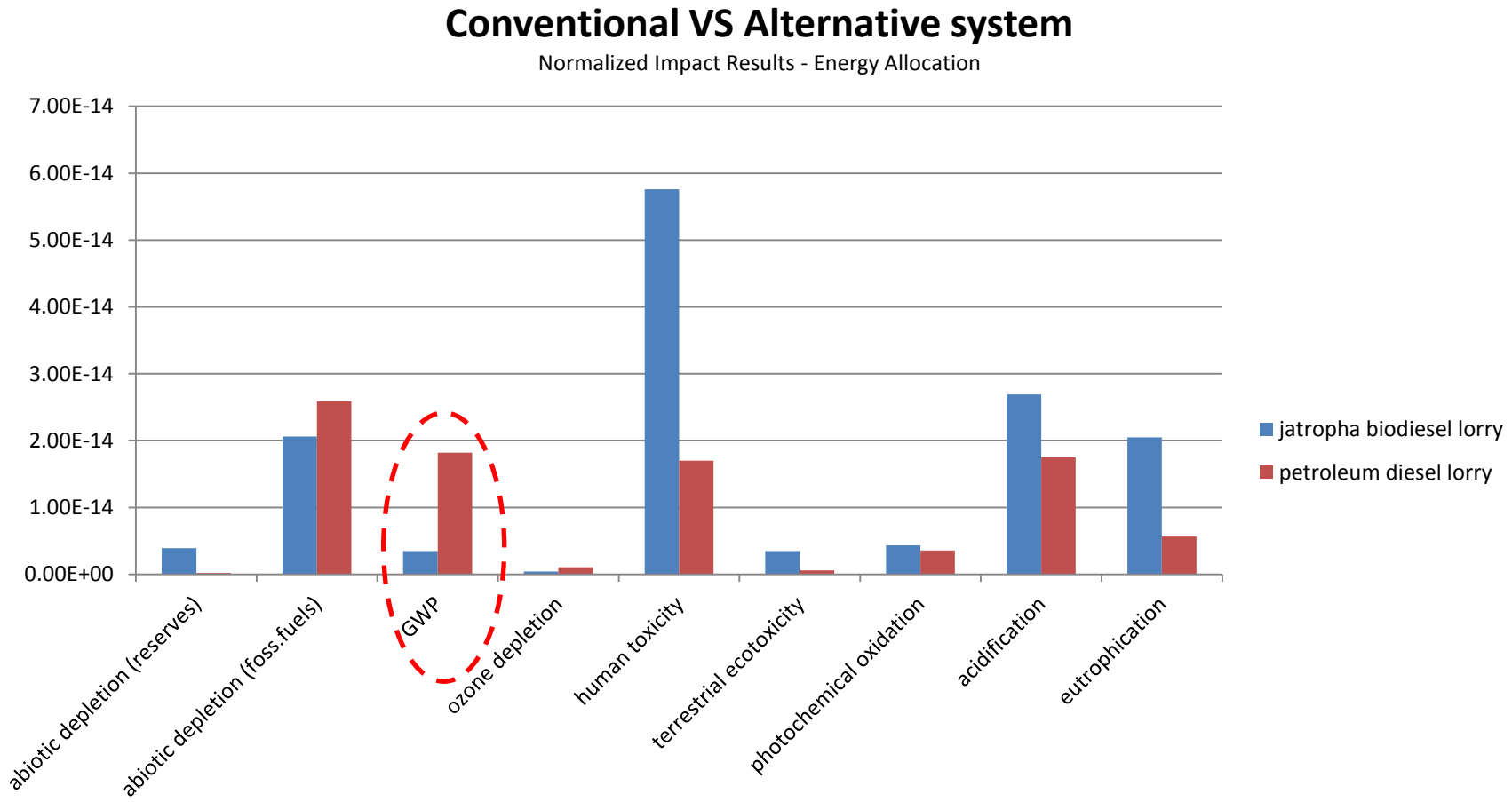


System boundaries set for the study

Cradle to Grave

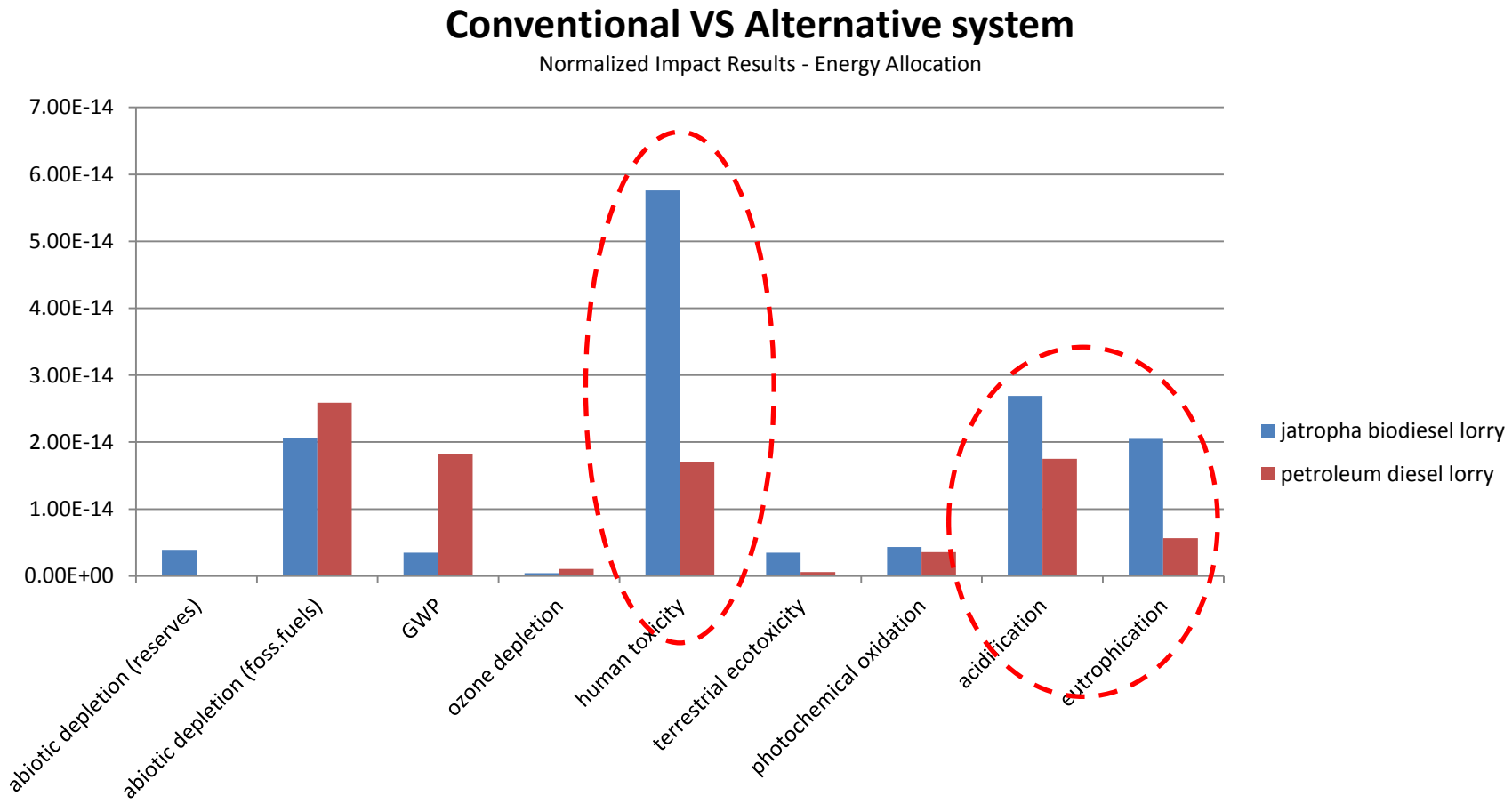
Preliminary Impact Results

Conventional VS Alternative



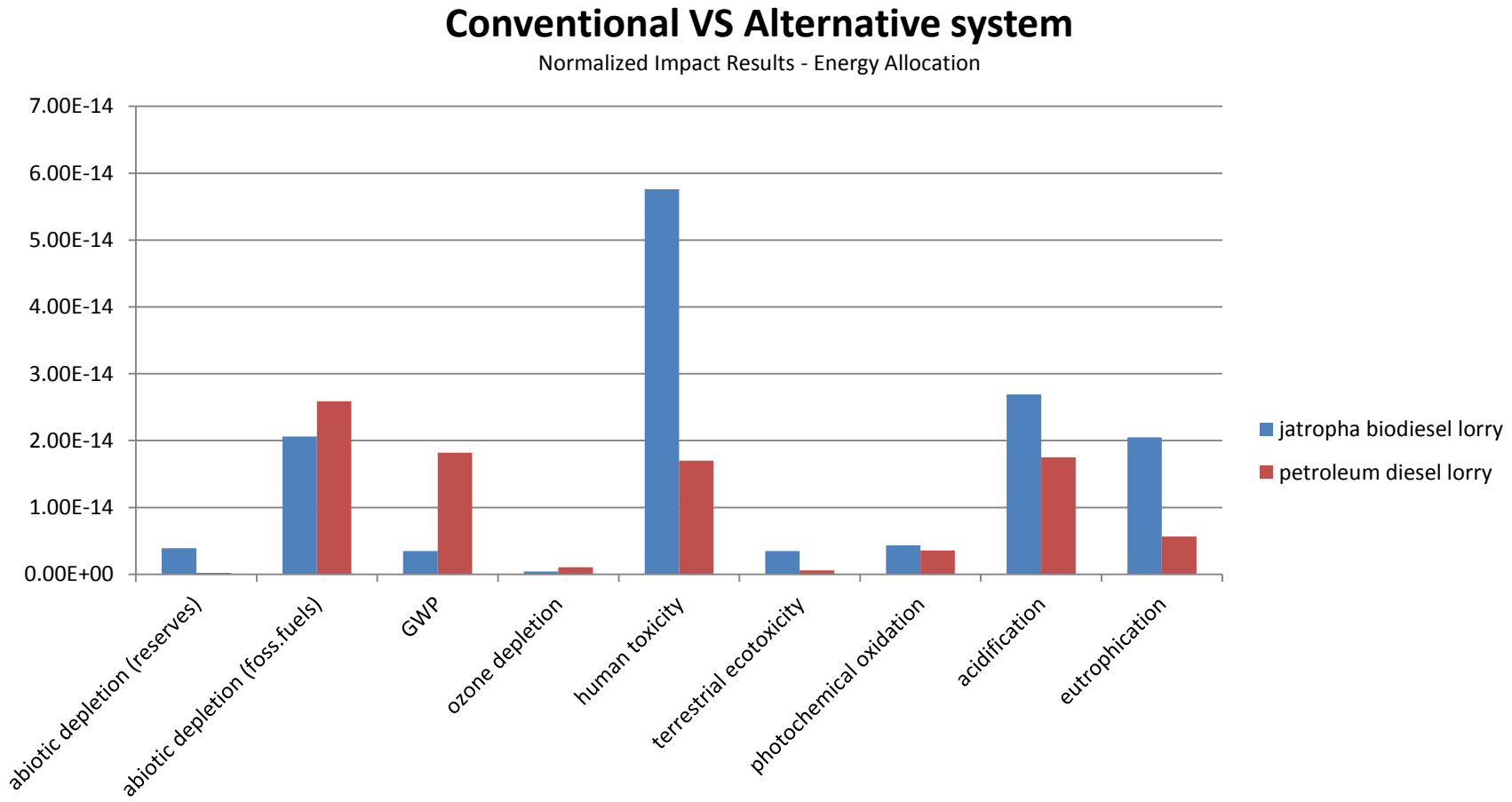
Preliminary Impact Results

Conventional VS Alternative

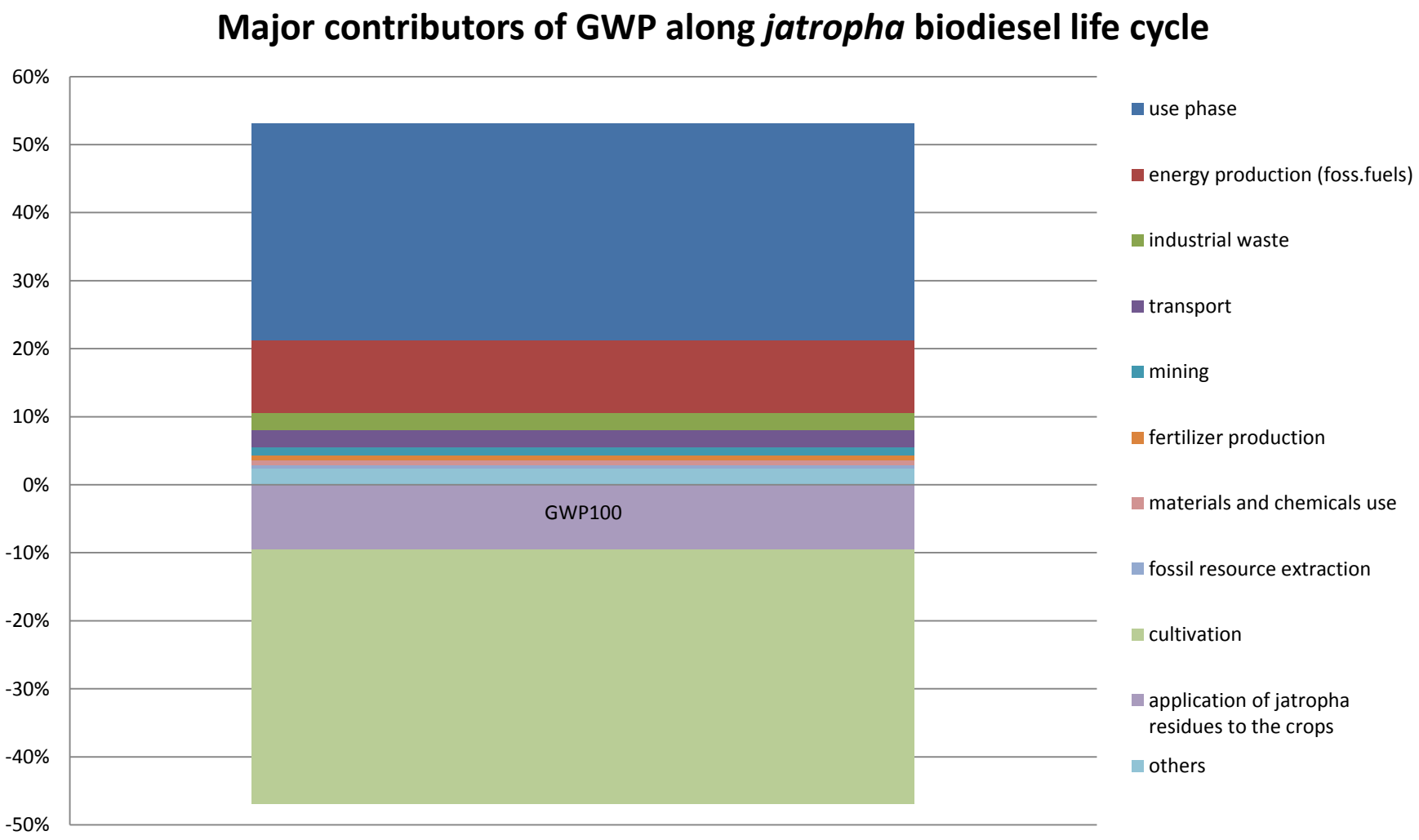


Preliminary Impact Results

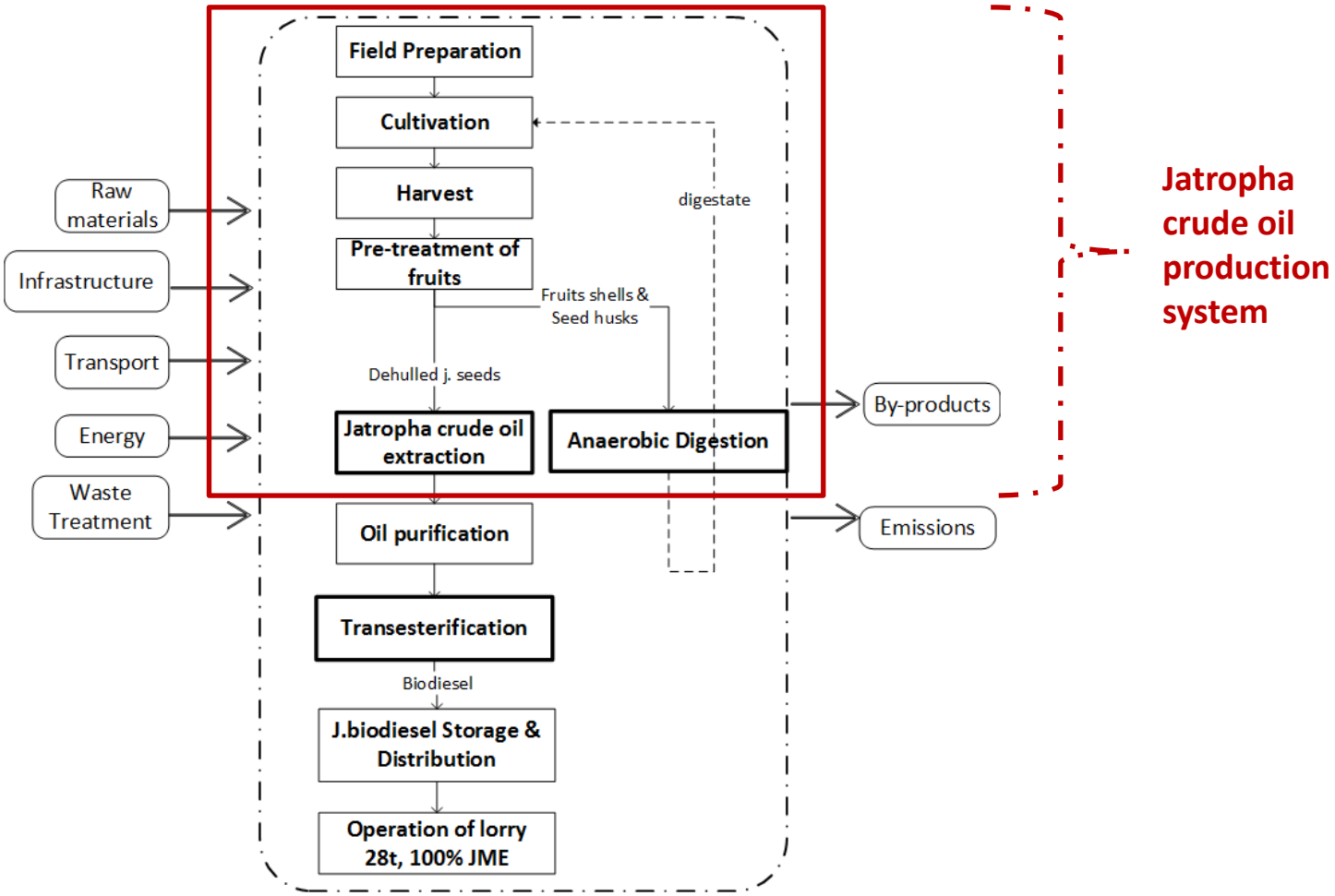
Conventional VS Alternative



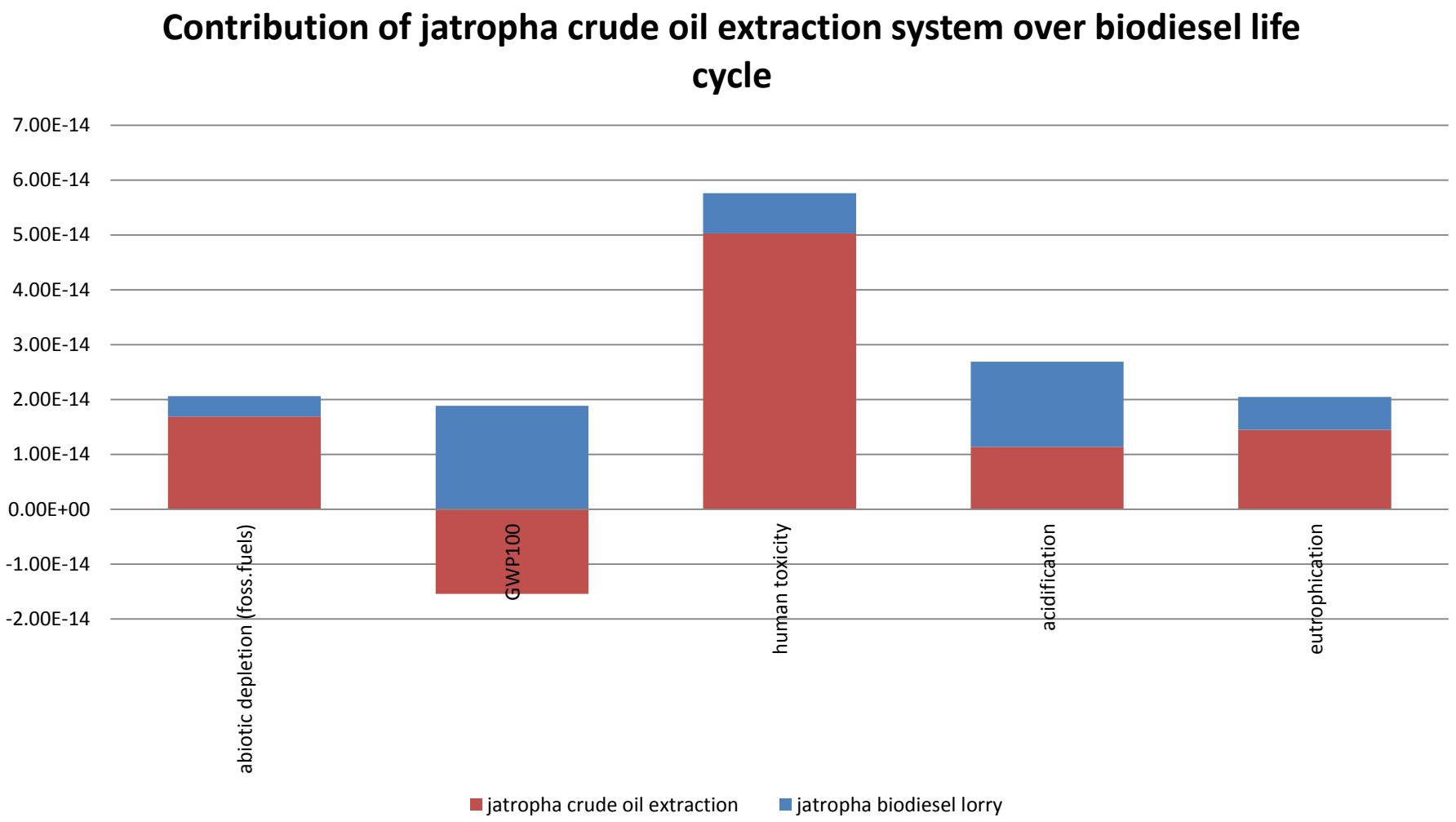
GWP of jatropha biodiesel



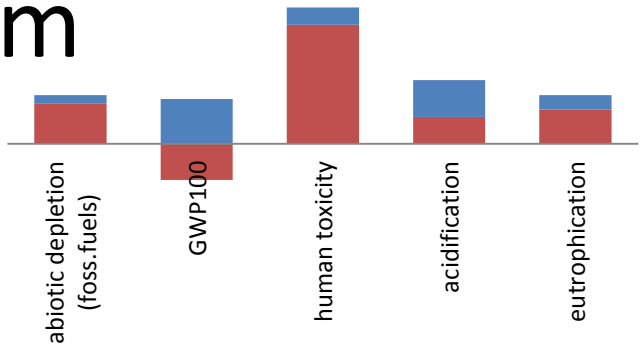
Jatropha crude oil extraction



Crude oil production



Major contributors of jatropha oil production system



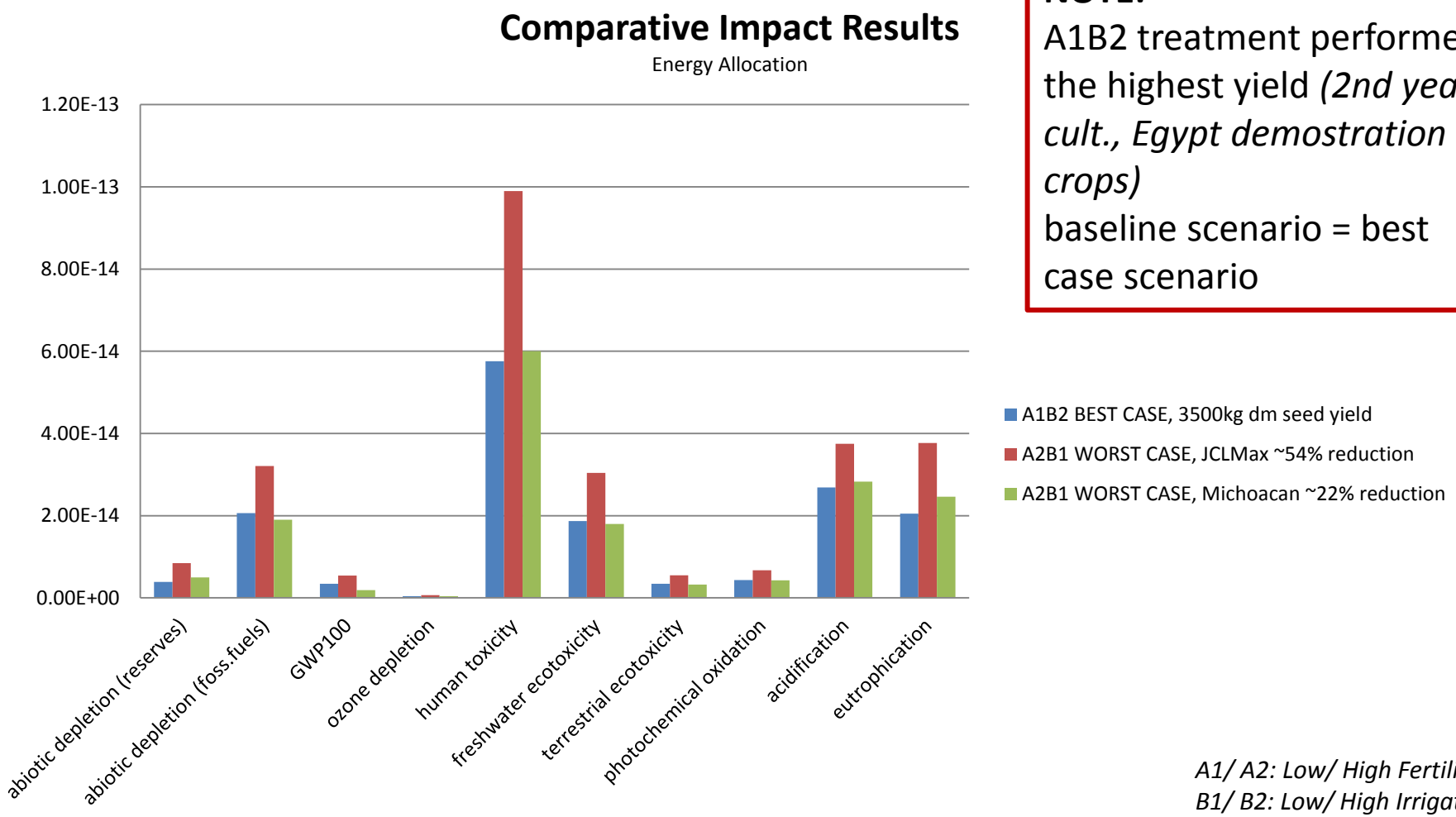
- Human toxicity; due to material intensive infrastructure and equipment
- Eutrophication; due to application of jatropha residues to the crops ~90%
- Abiotic depletion; due to fossil fuel extraction
- Acidification; due to energy production and transport

CULTIVATION
Fertilizer prod.
Machinery use
Infrastructure

Preliminary Impact Results

Evaluation of treatment scenarios

2nd year of cultivation



NOTE:
A1B2 treatment performed the highest yield *(2nd year cult., Egypt demostration crops)*
baseline scenario = best case scenario

A1/ A2: Low/ High Fertilization
B1/ B2: Low/ High Irrigation

Major contributors per impact category

Abiotic depletion:
- Mining
- Extraction of fossil fuels

GWP:
- Use phase (highest contributor)
- Energy production (fossil)
- Industrial waste
- Mining of heavy metals
- Fertilizer production

Human toxicity:
- Intensive materials production;
Steel production 25% &
Copper production 13%

Terrestrial ecotoxicity:
- Materials production ~65%

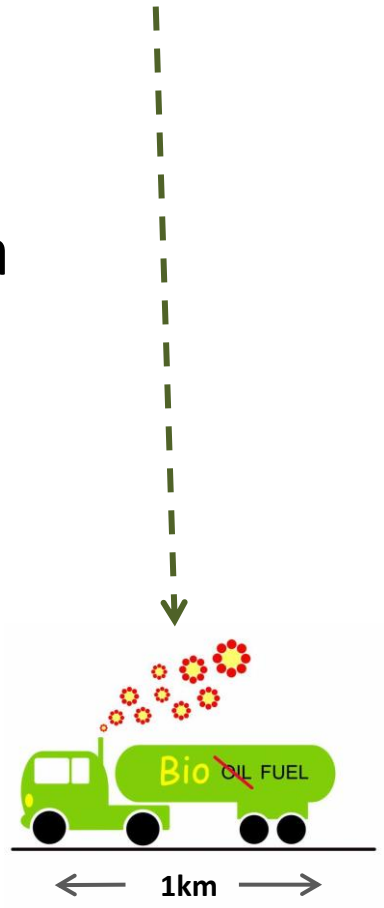
Acidification:
- Use phase 55%
- Energy production
- Transport

Eutrophication:
- Application of *jatropha* residues 62% *(mineral nutrient over-enrichment)*
- Use phase 28%

Input requirements to deliver 1km driving on jatropha biodiesel

(baseline scenario)

- 1.28 m2 land
- 0.111 jatropha infants
- 0.45 kg dried seeds (6% moist.)
- 0.336 kg jatropha crude oil *or* 0.271 jatropha biodiesel
- 0.022 kg urea (46% N)
- 0.116 m3 irrigated water
- 7.83 MJ energy



Conclusions

- GWP for petroleum diesel system is 5 times larger than biodiesel, while acidification and eutrophication are lower by 35% and 70% respectively.
- *Jatropha* crude oil poduction is contributing approx. 80% to the total life cycle emissions (excl.GWP)
- For biodiesel system, negative global warming emissions are due to CO2 fixation *(distinction btw short and long life carbon)*
- A1B2 has the highest environmental performance and highest yields for both Michoacan and JCLMax.

Summing up …

Under steady state conditions life cycle assessment:

- Quantifies the overall environmental burden
- Identifies inefficient processes in the system under study
- Can be used as a benchmarking tool of product system options
- Serves as a decision making tool

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)

Supported by European Union and JatroMed

Thank you for your attention

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