Life Cycle Assessment of Jatropha as feedstock for biodiesel production

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INDUSTRIAL ECOLOGY
INNOVATIVE BY NATURE

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Delft University of Technology

Universiteit Leiden

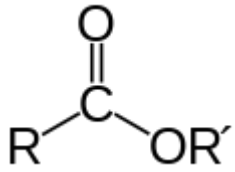
Outline

- Introduction in the Biofuel Sector
- Goal of Study
- Life Cycle Assessment
- Fuel-Food Dilemma
- Case Study
- Outcomes of the research
- Recommendations

Biodiesel Timeline

Brundtland Commission **1987**

Diesel Engine **1890s**



Transesterification **1937**

Environmental Movements **1980s**

Rudolf Diesel *(1858-1913)*

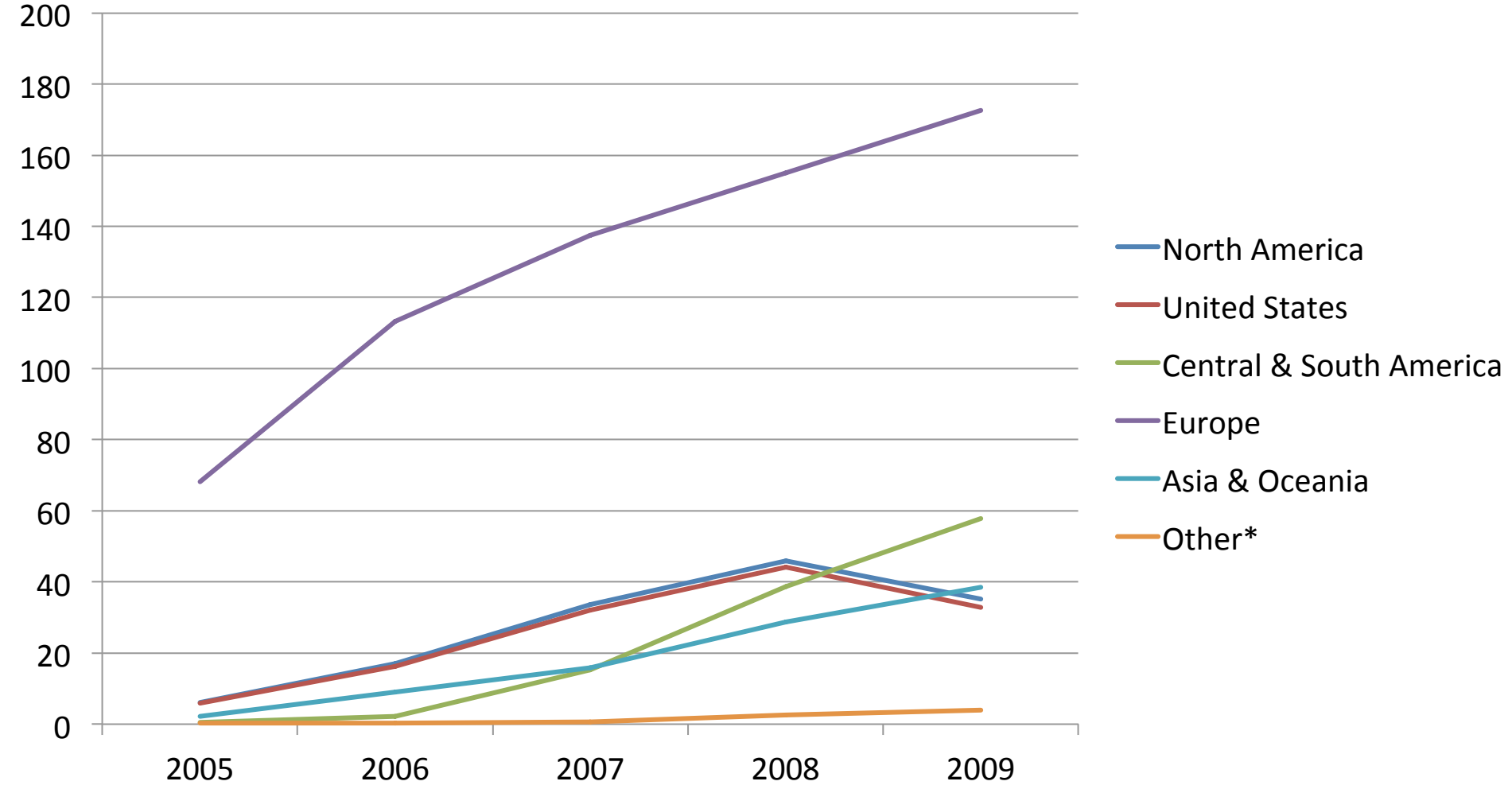
1900 World's Fair, Paris

Post WWII and 1970s oil crisis period

Millenium Goals 2015 Roadmap to low carbon economy 2050

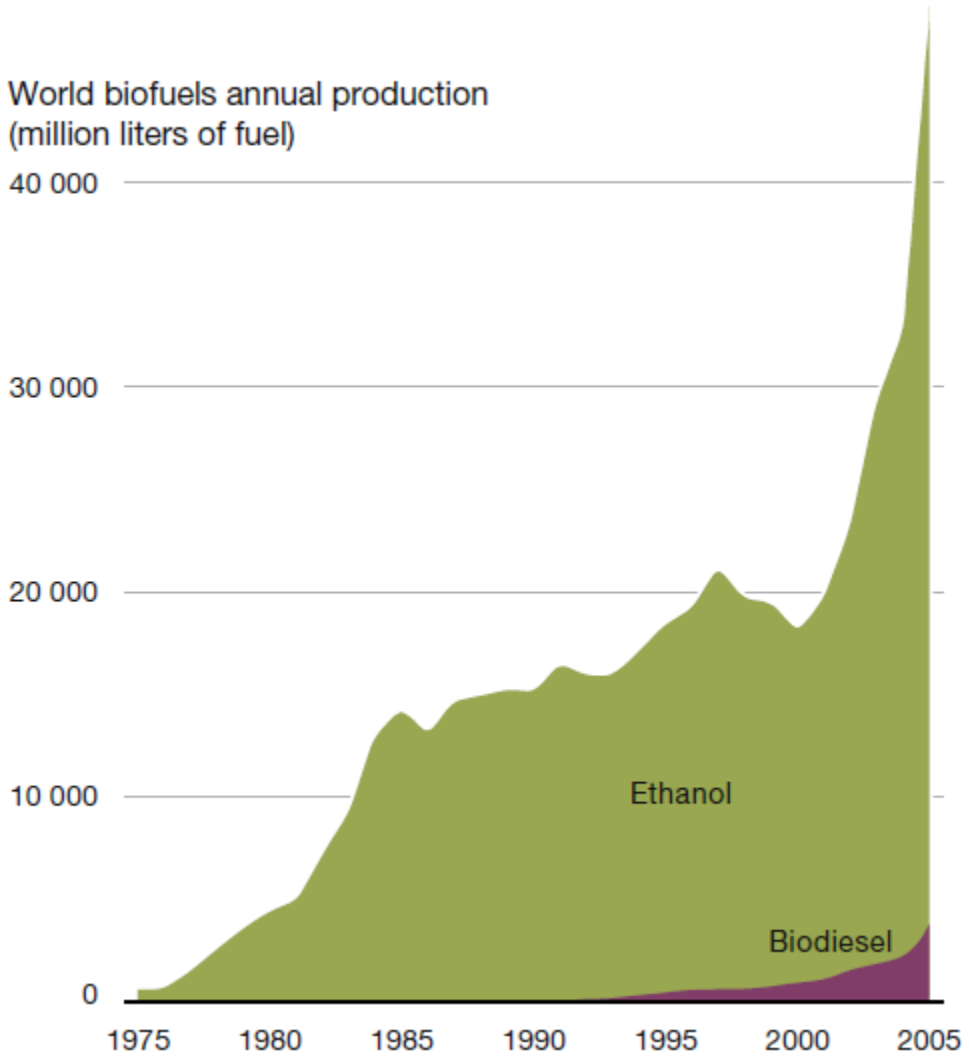
World Biodiesel Production 2005-2009

(Thousand barrels per day)



Source: US Department of Energy, "World's Biodiesel Production" 2011

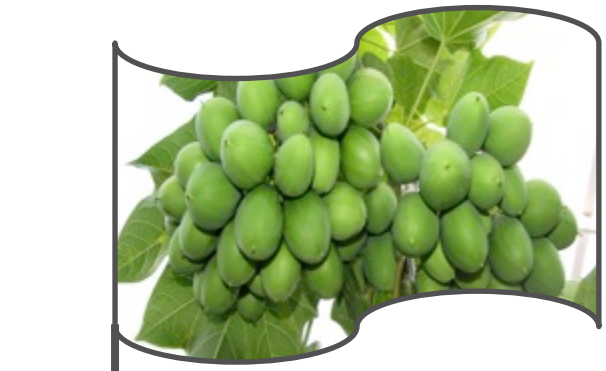
World's Bioethanol and Biodiesel Production



Source: Earth Policy Institute, 2006

Goal of Study

To appraise jatropha as an energy crop in the realm of biofuels



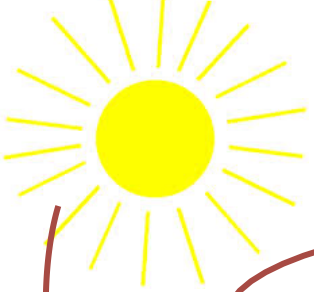
System Analysis

↓

Environmental Performace

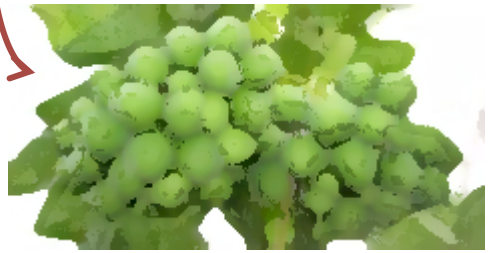
(LCA analytical tool)

Life Cycle Thinking



HARVEST

EXTRACTION



WASTE

ENERGY &
MATERIAL INPUT

CO2

BY-PRODUCTS

REFINING

TRANSPORTATION
FUEL

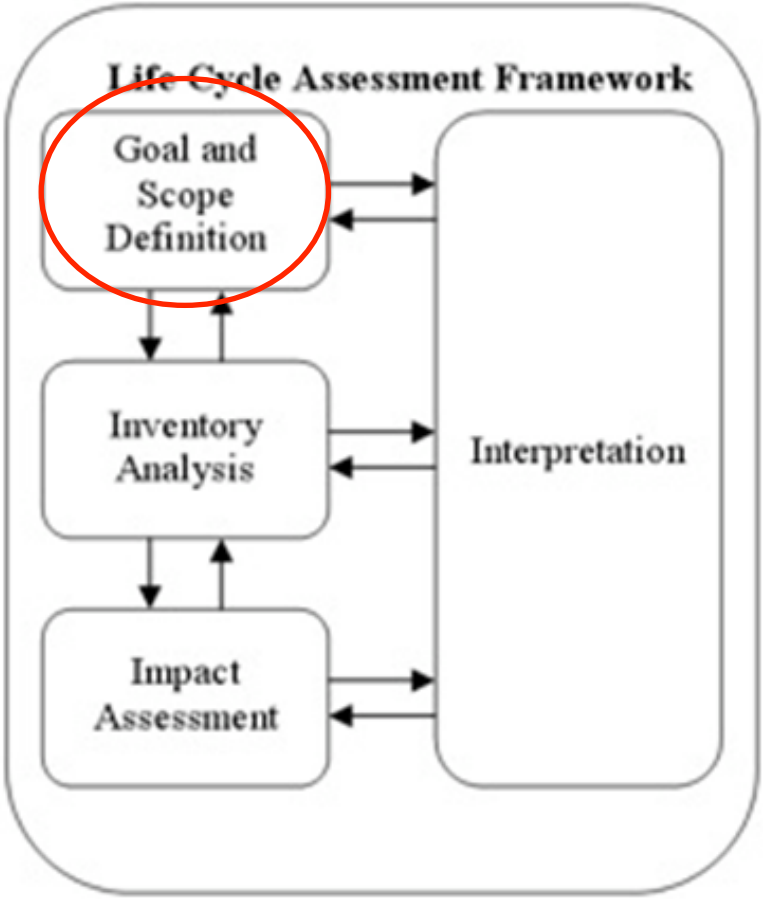
TRANSESTERIFICATION

ALCOHOL

Life Cycle Assessment
LCA tool

"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of product system throughout its life cycle"

Standardization ISO 14044: 2006



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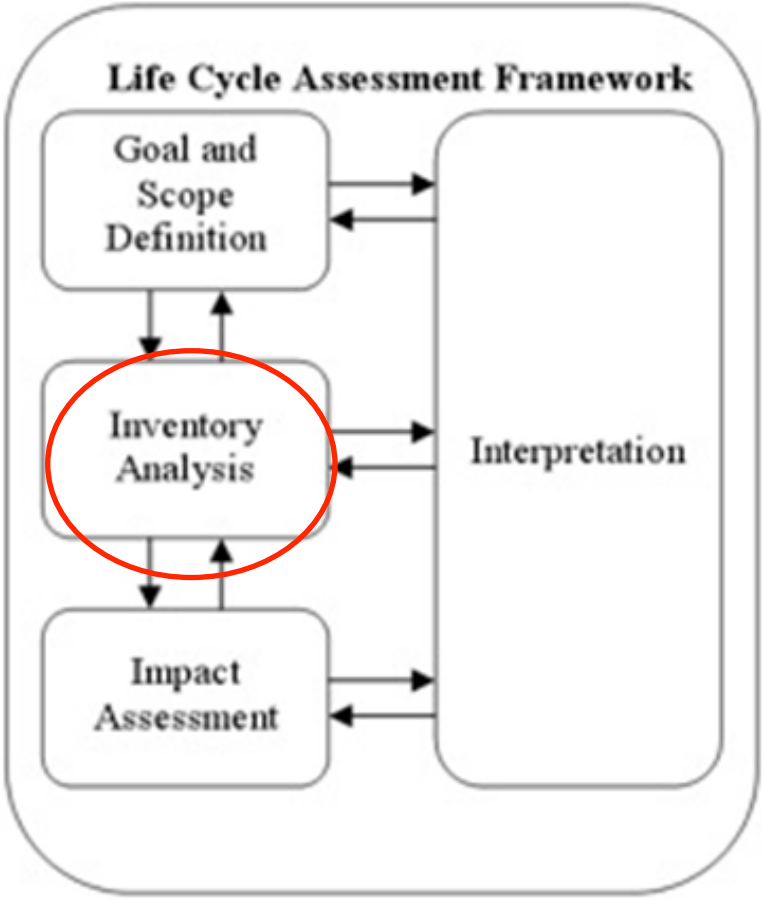

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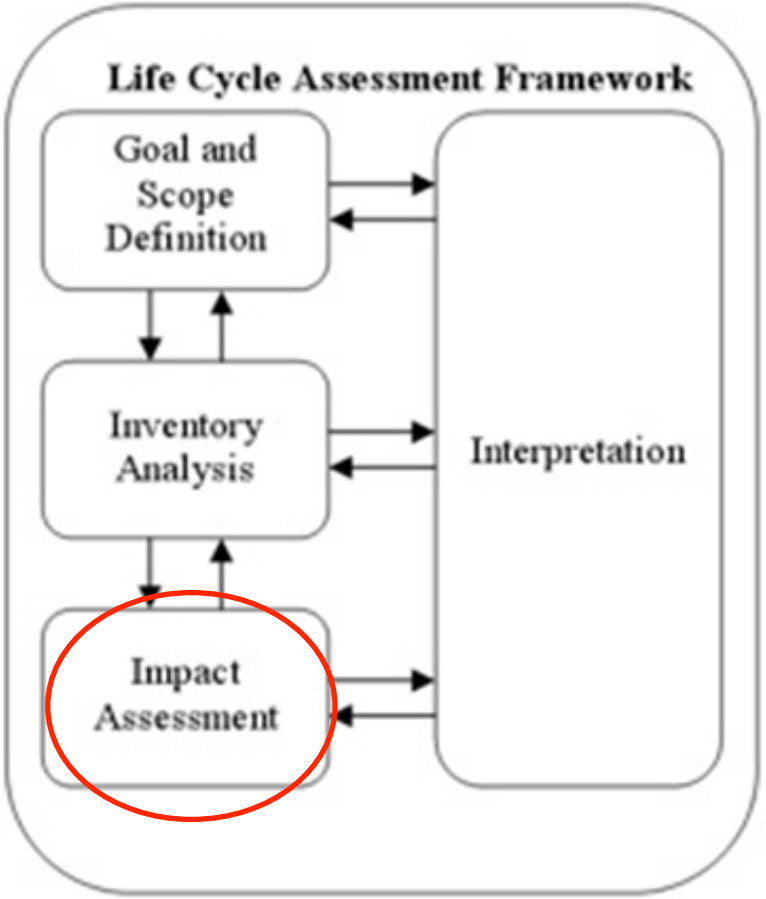

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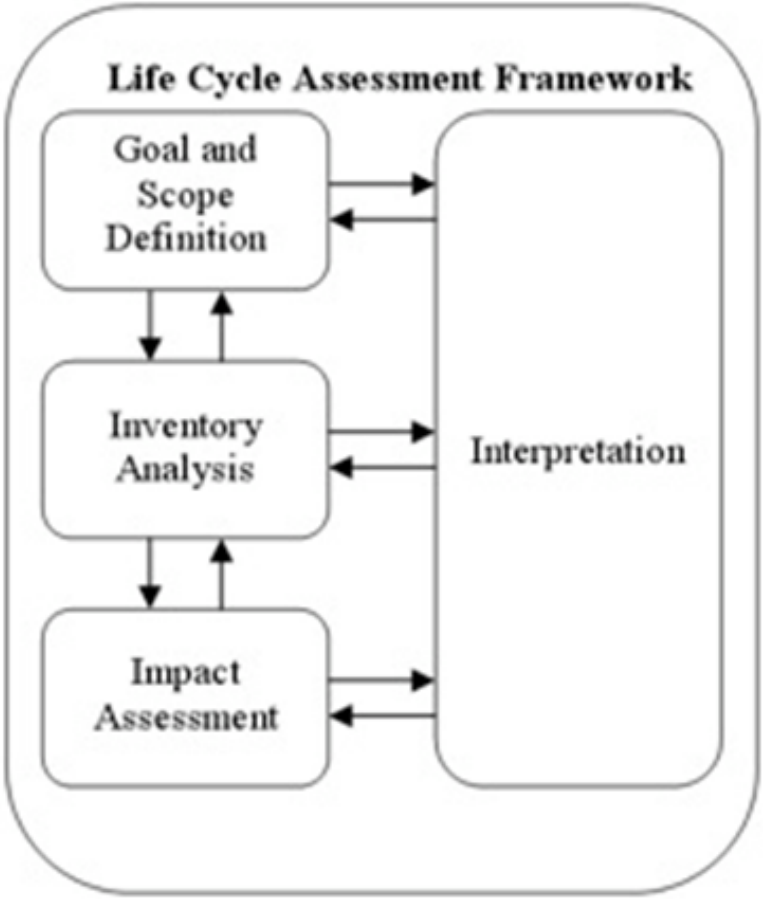


Jatropha process tree (LCI)

Field preparation

Cultivation

Harvest

Storage

Transportation of jatropha Fruits

Oil Extraction

Biodiesel Corversion

Biodiesel Distribution

End-Use

Land

Raw materials

Soil amendments

Infrastructure

Capital equipment

Energy input

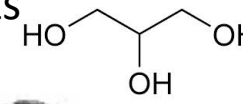
Other resources

inflows

outflows

Main product

By-products



Waste

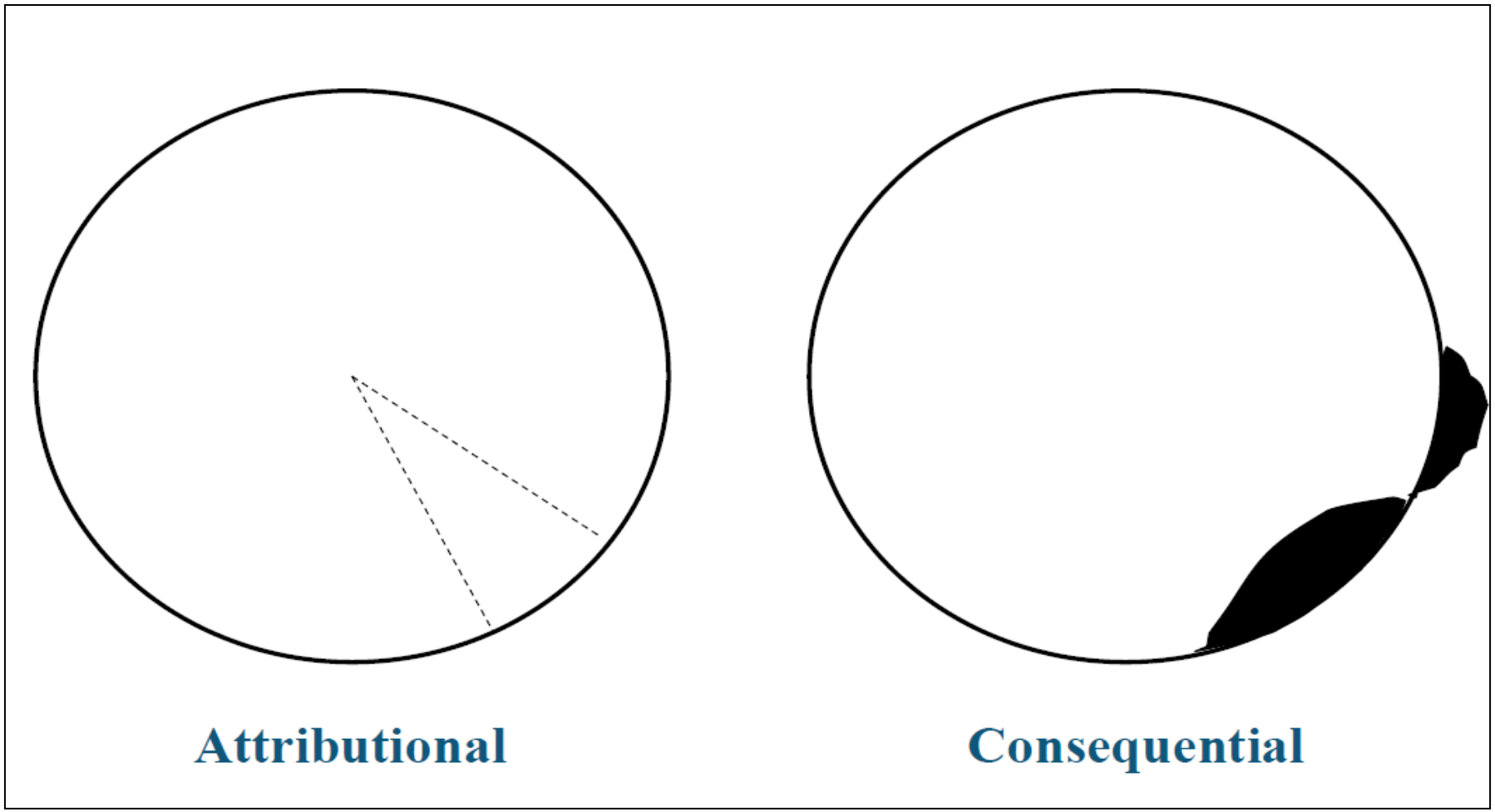
Emissions

Fuel-Food Dilemma

The Dilemma

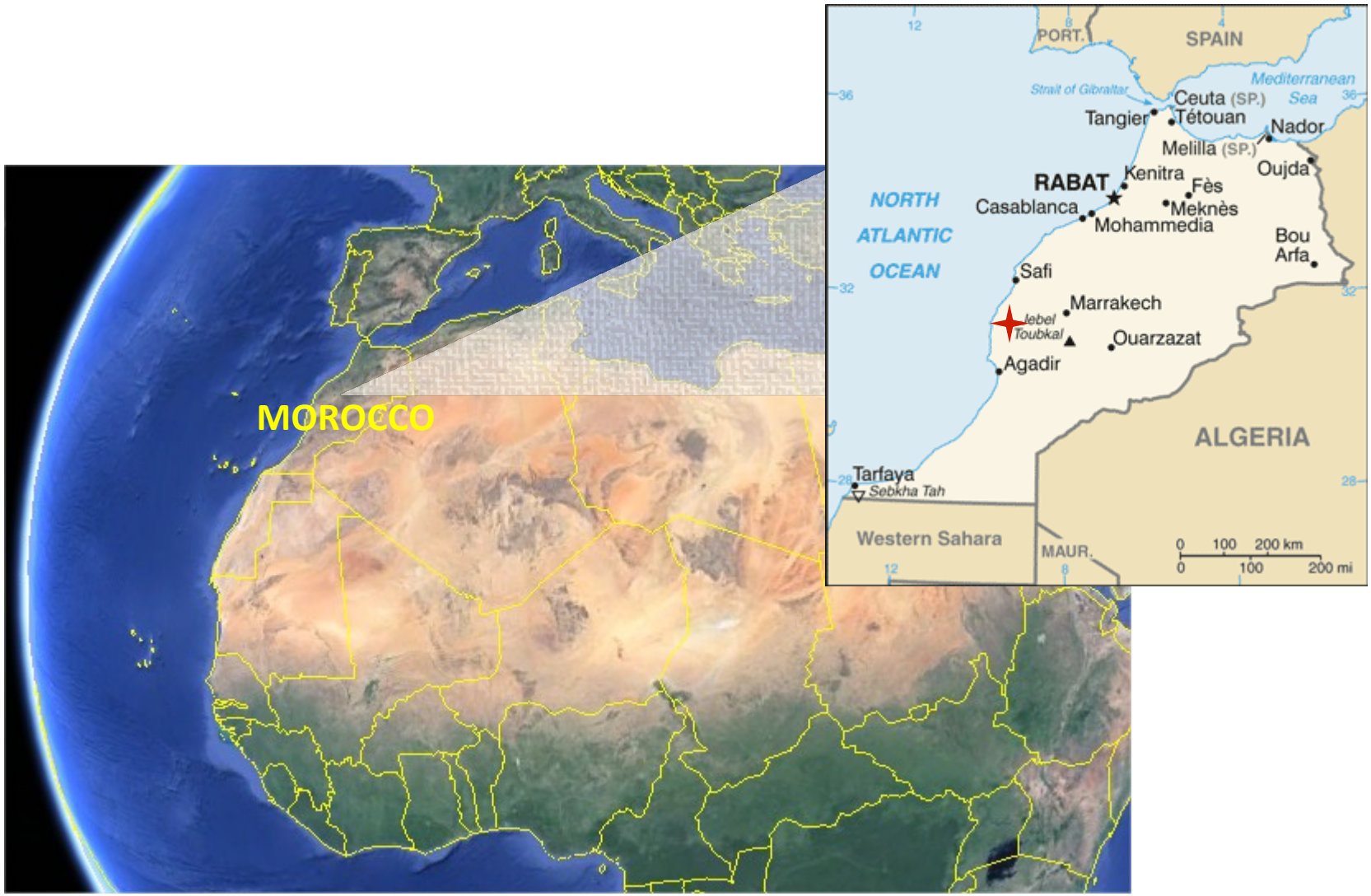
- Increase in biofuel demand due to oil prices increase
- 2007–08 world food price crisis
- Intensive agriculture
- Shortage of agricultural land

LCA contribution to the dilemma

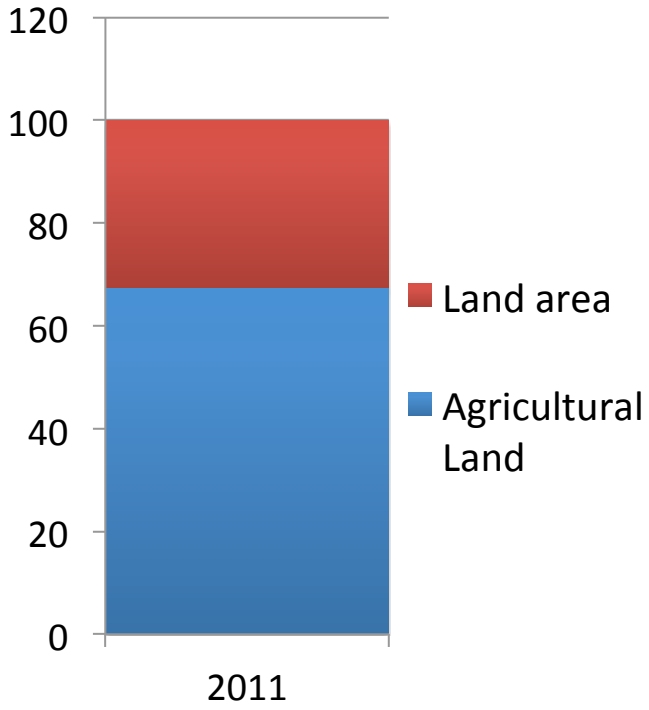


Attributional and consequential modelling

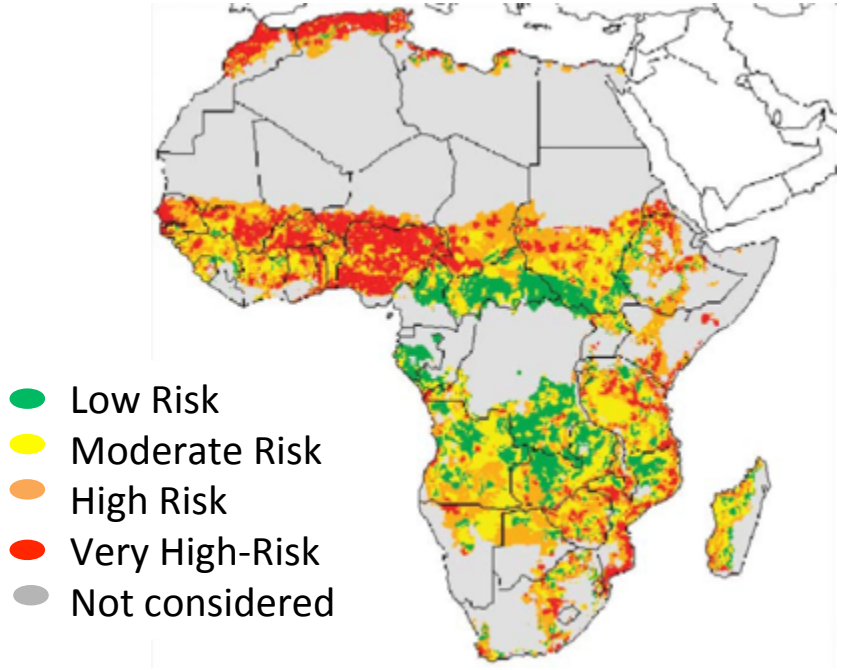
Study area


MOROCCO
PORT.
SPAIN
Strait of Gibraltar
Mediterranean Sea
Ceuta (SP.)
Tangier
Tétouan
Nador
Melilla (SP.)
Oujda
RABAT
Kenitra
Fès
NORTH ATLANTIC OCEAN
Casablanca
Meknès
Mohammedia
Bou Arfa
Safi
Marrakech
Jebel Toubkal
Ouarzazat
Agadir
ALGERIA
Tarfaya
Sebkha Tah
Western Sahara
MAUR.
0 100 200 km
0 100 200 mi

Local Stressors



% Agricultural land/ land area



Risk of human-induced desertification *(2001)*

LCA possibilities

Water use ✔

Land use change ❗✘

Nutrients management ✔

Control of pest-diseases ✘

Optimal use of by-products ✔

Recycling loops ✔

Other analytical tools or research methods can be employed !

Outcomes of the study

Study-area driven:
- **to calculate and determine the major environmental burdens along jatropha biodiesel life cycle**
- **to compare jatropha-based system with a conventional fossil fuel-based system in terms of environmental performance**
- **to make system optimization suggestions**
Methodologically driven:
- **to address methodological issues when applying LCAs to energy crops**
- **to propose/ derive a "prototype" methodological approach about jatropha LCAs, based on case-specific characteristics**
- **to list sustainability criteria as lessons learnt from the LCA study**

Recommendations

Complete system

Consistent analysis

Discrepancies and uncertainty

Model for optimization with complete criteria set

Use of LCA along with other analytical tools

Supported by European Union and JatroMed

JatroMed

Thank you for your attention

Elena Koukouna

Life Cycle Assessment Framework

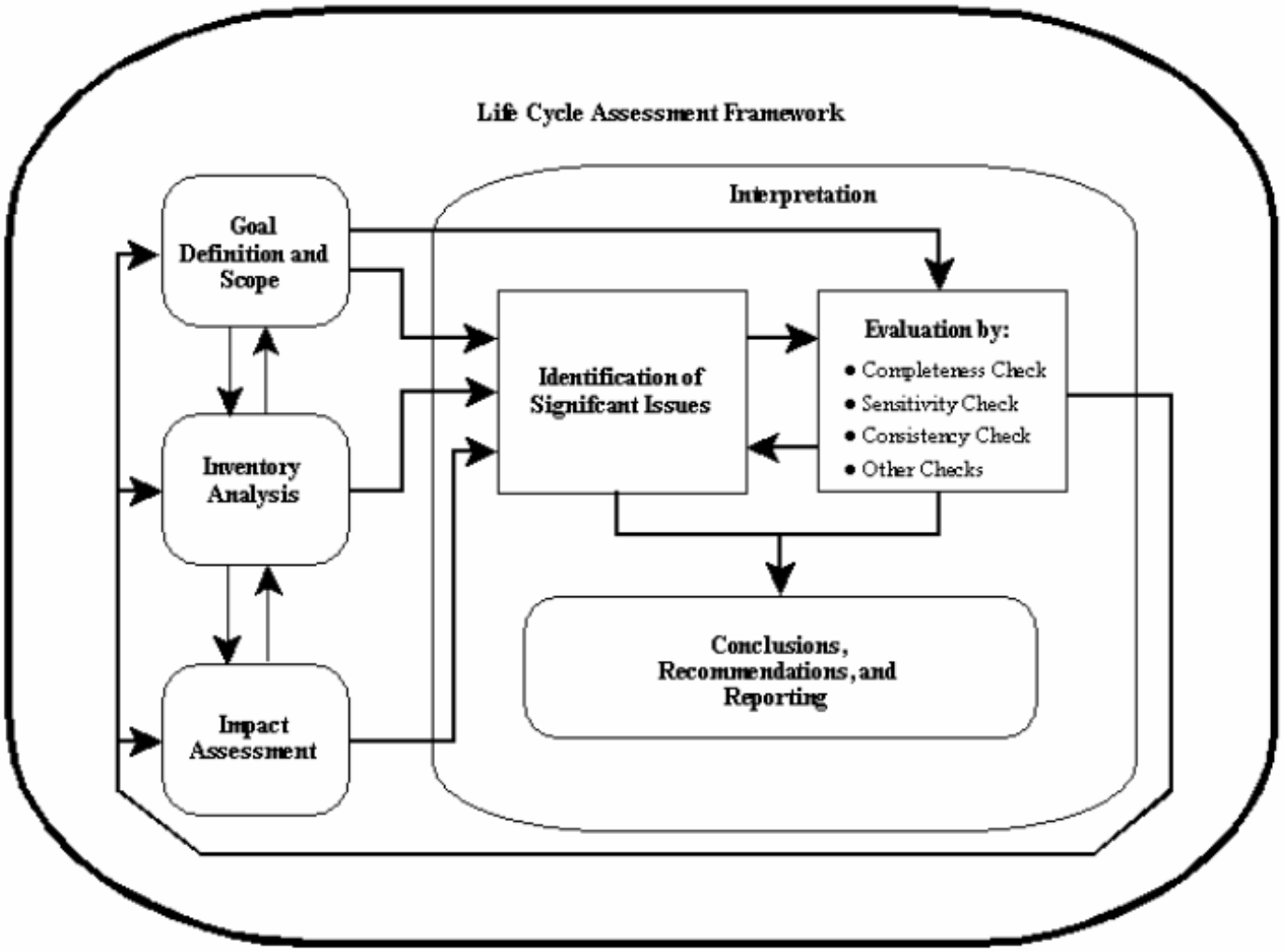


Exhibit 5-1. Relationship of Interpretation Steps with other Phases of LCA (Source: ISO, 1998b)

Consequential – Attributional LCA

- UNEP/SETAC (2011). Shonan LCA database guidance principles:
  - **Attributional approach**: System modelling approach in which **inputs and outputs are attributed** to the functional unit of a product system by linking and/or partitioning the unit processes of the system **according to a normative rule**.
  - **Consequential approach**: System modelling approach in which activities in a product system are linked so that **activities are included in the product system** to the extent that they are expected to change **as a consequence of a change in demand** for the functional unit.