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LIFE-CYCLE ASSESSMENT OF SUNFLOWER ADDRESSING LAND USE CHANGE

Filipa Figueiredo, Érica Castanheira e Fausto Freire

ADAI-LAETA, Center for Industrial Ecology
http://www2.dem.uc.pt/CenterIndustrialEcology
University of Coimbra
Portugal

UNIVERSITY of COIMBRA

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Background and Motivation

Recent life-cycle assessment (LCA) studies of sunflower oil and biodiesel production have shown

Agricultural phase

has an important contribution to the total environmental impacts

Portugal produces sunflower oil for food consumption and biodiesel production

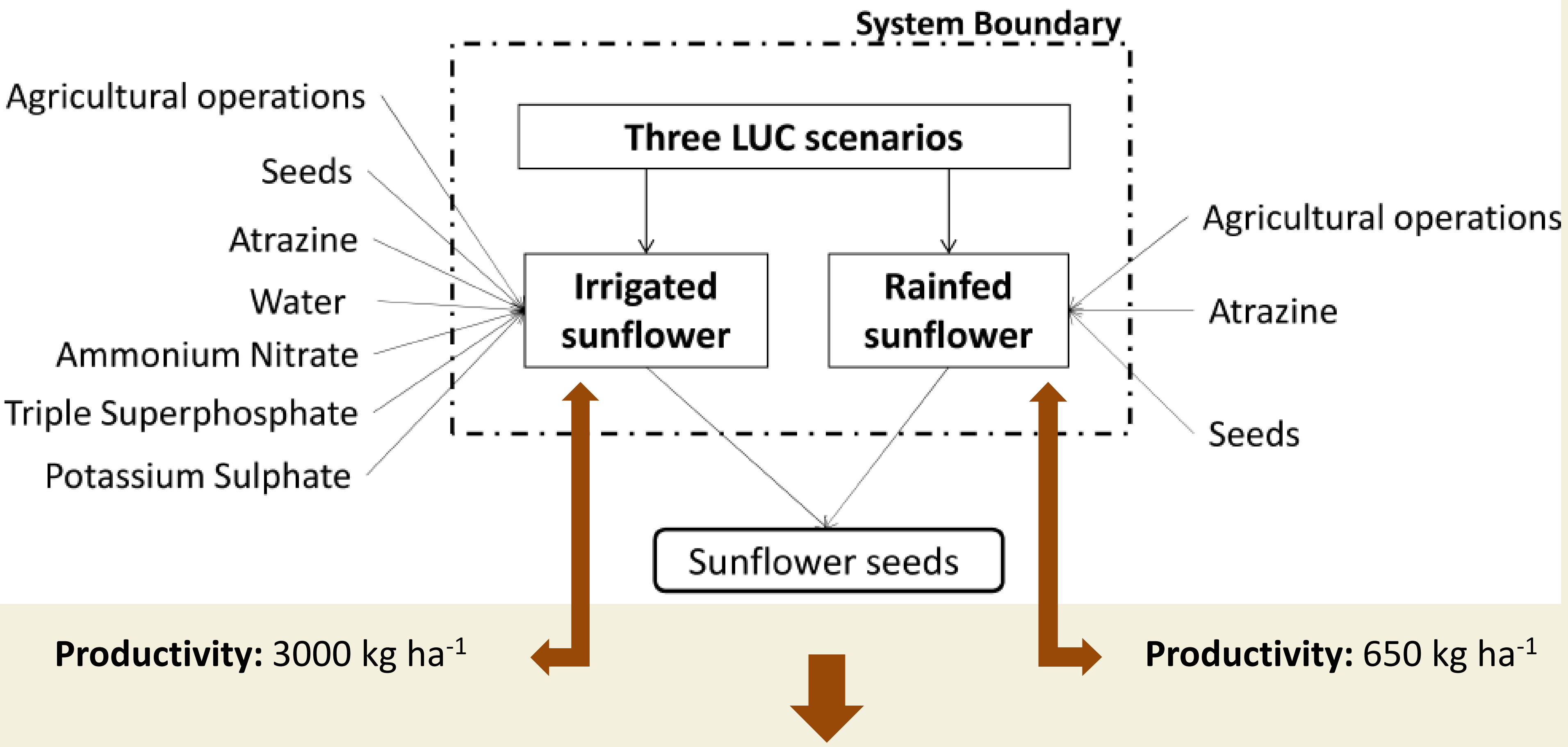
This motivates a comprehensive assessment of the cultivation of sunflower in Portugal.

Main goal

The main objective of this paper is to present a LCA of sunflower seeds produced in Portugal

- Comparing two agriculture practices (irrigated and rainfed)
- Addressing the carbon-stock changes caused by alternative land-use change (LUC) scenarios
- Identify the major contributors to the environmental impacts of sunflower cultivation

Life Cycle model



Functional Unit: 1 kg sunflower seeds

Land Use Change Scenario and Carbon calculations

Reference land use	Actual land use	e_1 ($kgCO_2eq\ kg_{seeds}^{-1}$)
Grassland (SD-mi)		**-0.04**
Perenial (NT-hi (w/))	Irrigated sunflower	**4.3**
Perenial (NT-hi (w/o))		**3.4**
Grassland (SD-mi)		**0.2**
Perenial (NT-hi (w/))	Rainfed sunflower	**20.2**
Perenial (NT-hi (w/o))		**16.3**

The emissions from carbon-stock changes caused by LUC (e_l, kg CO_{2eq}/kg_{oil}) were calculated using IPCC Tier 1 and adapting the following equation from the Renewable Energy Directive

$$e_l = (CS_R - CS_A) \times 44/12 \times 1/20 \times 1/P$$

$$CS_i = SOC_i + C_{veg} = (SOC_{ST} \times F_{LU} \times F_{MG} \times F_I) + C_{veg}$$

e_l – annualized GHG emissions from carbon stock change due to LUC (kg CO_2eq/kg)

CS_R - carbon stock associated with the each reference LU (grassland or perennial) (kg CO_{2eq}/ha)

CS_A - carbon stock associated with the actual LU (sunflower cultivation) (kg CO_{2eq}/ha)

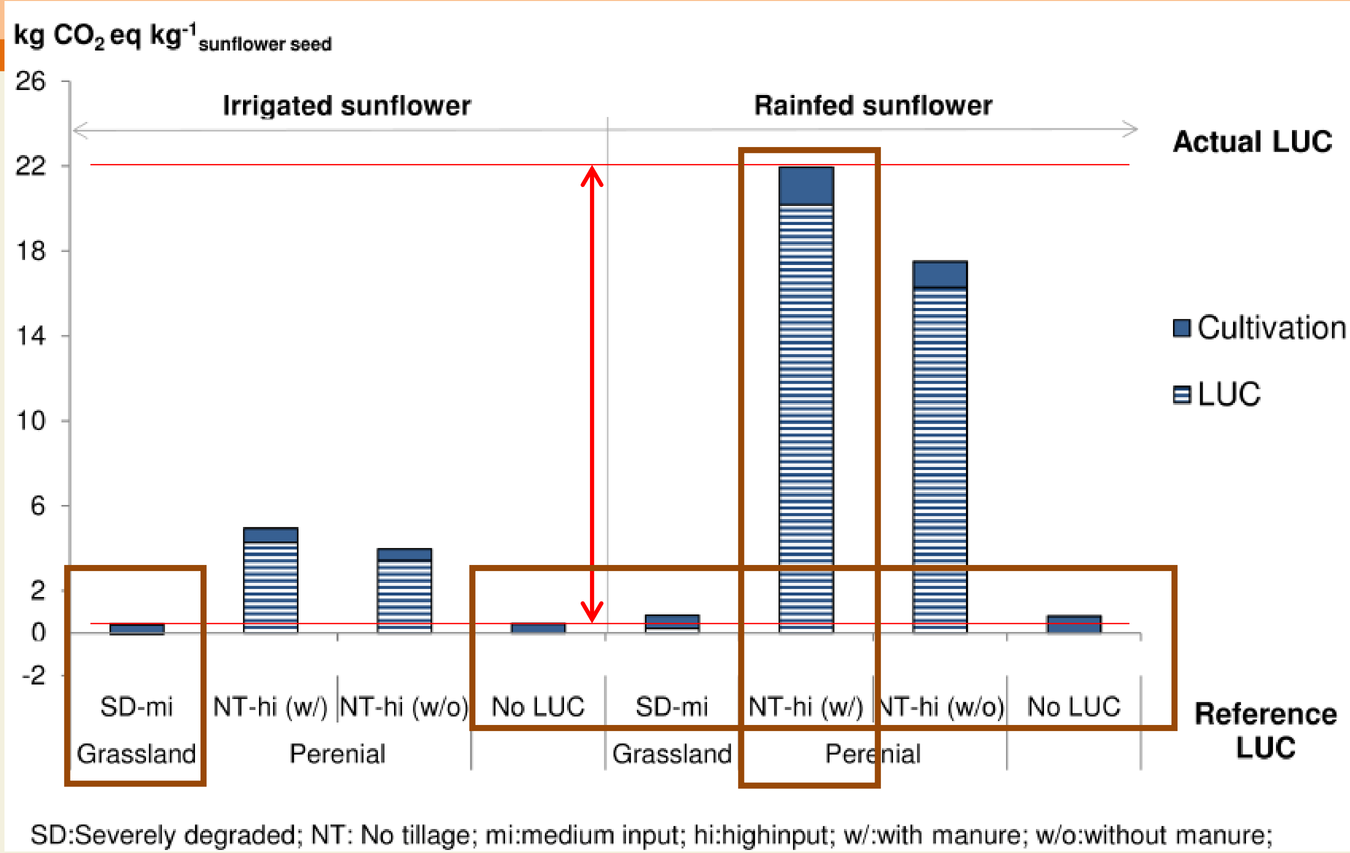
P - sunflower productivity (kg/ha per year)

SOC_{ST} - standard value of soil organic carbon

F_{LU}, F_{MG}, F_I - factors reflecting the difference in SOC associated with type of land use, management practice and different levels of carbon input to soil compared to the SOC_{ST}

C_{veg} - above and below ground vegetation carbon stock in living biomass and in dead organic matter

LUC scenario analysis



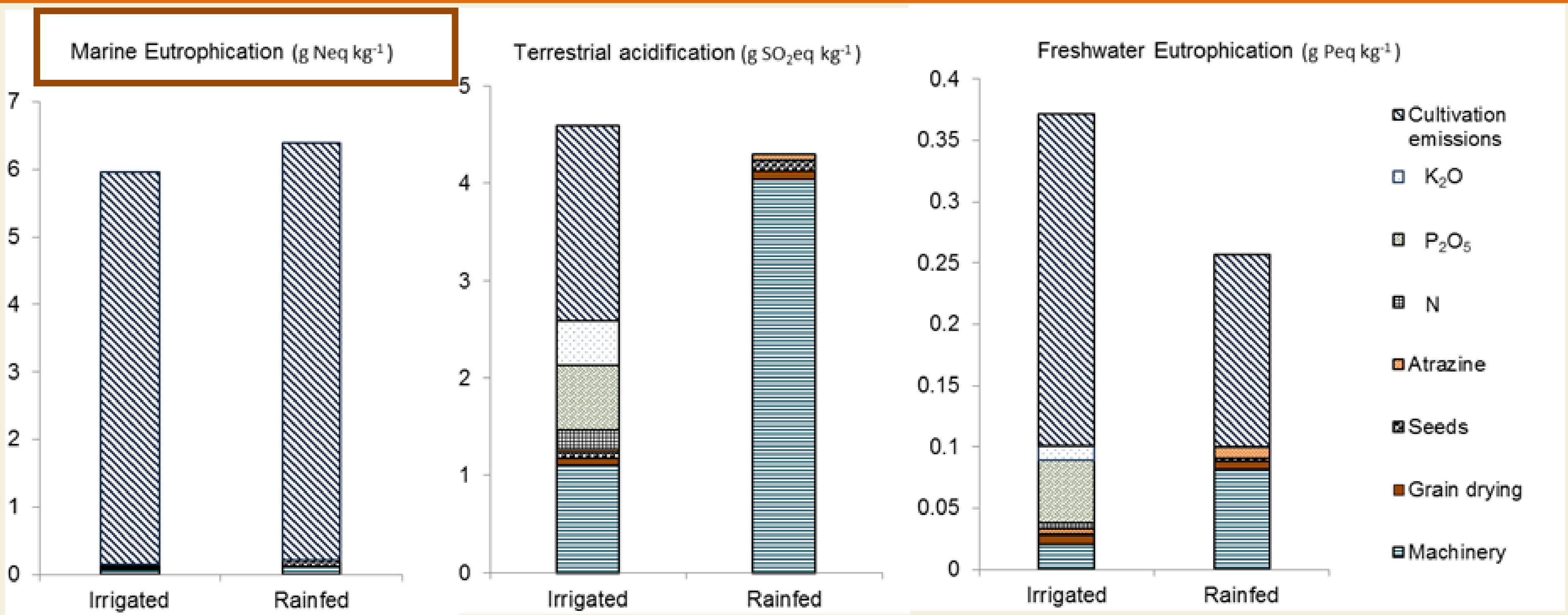
Vary widely
(0.3 and 22 kg CO_2eq kg^{-1})

↓

LUC scenario

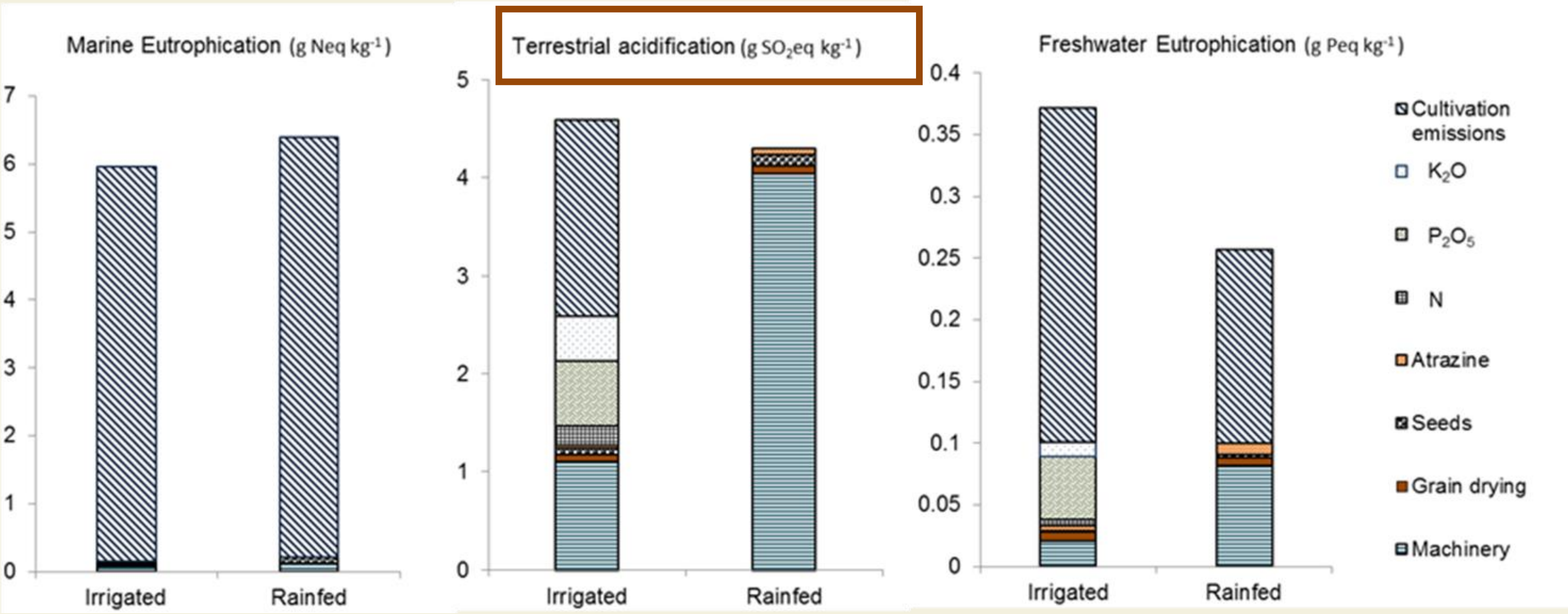
- Highest emissions → perennial crops (no tillage, with manure) ↪ into rainfed sunflower
- Lowest emissions → severely degraded grassland ↪ into irrigated sunflower.
- Comparison of the two agricultural sunflower systems shows that irrigated sunflower have lower GHG emission due to the high productivity compared with rainfed.

LCIA results



- Irrigated sunflower had lower impacts than rainfed sunflower (mainly due to a high productivity of irrigated sunflower).
- The most significant contribution were cultivation emissions (mainly NO_3^-, but also NH_3 and NO_x emissions), that represent more than 96% of the impacts in both agricultural practices.

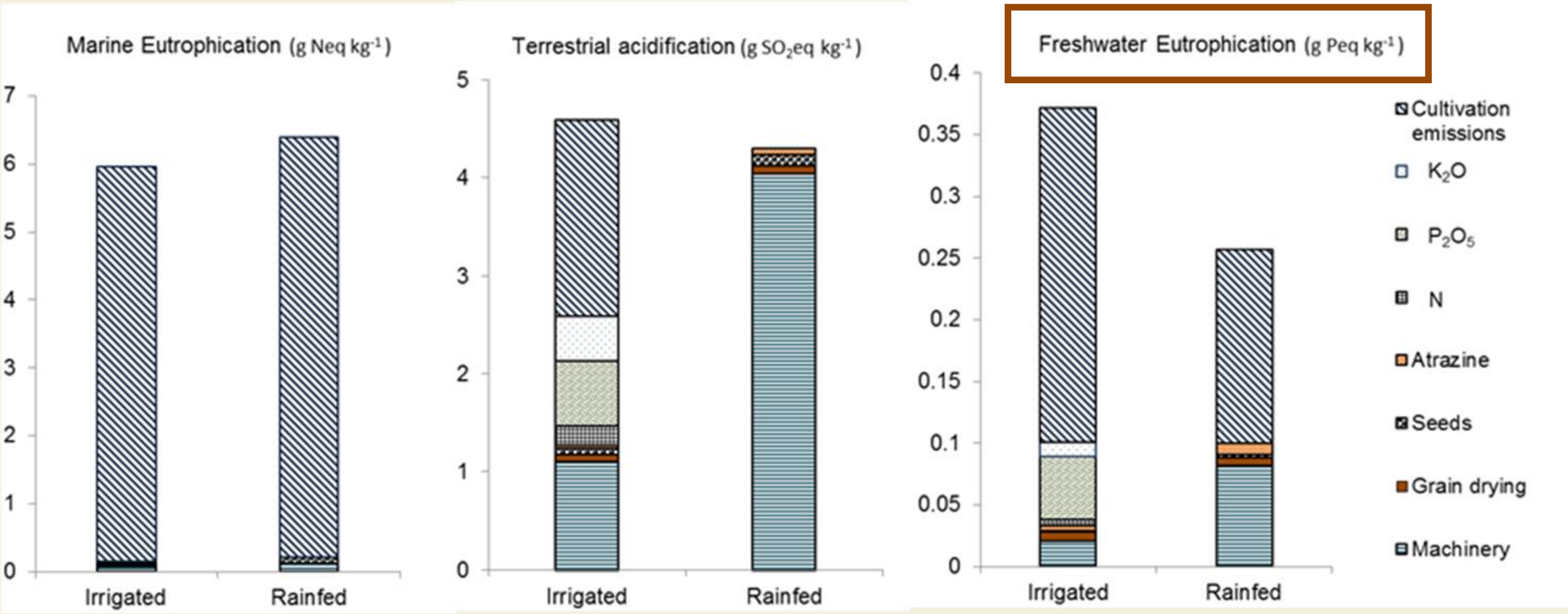
LCIA results



- The impacts were slightly higher for irrigated sunflower, due to fertilizers (production and use), with NH_3 emissions representing about 43% of all emissions.

- For rainfed sunflower, machinery (with diesel production and combustion) was the main contributor to the impacts: 92% of total TA

LCIA results



- The impacts were 39% higher for irrigated sunflower than rainfed, due to the production and use of triple superphosphate fertilizer.
- The main contributor to the impacts were (in both cultivation practices) cultivation emissions.

Conclusions

- Rainfed sunflower had higher environmental impacts in CC and ME essentially because of the low productivity per ha (650 kg (ha*year)$^{-1}$) and in ME due to high NO_3^- emissions.

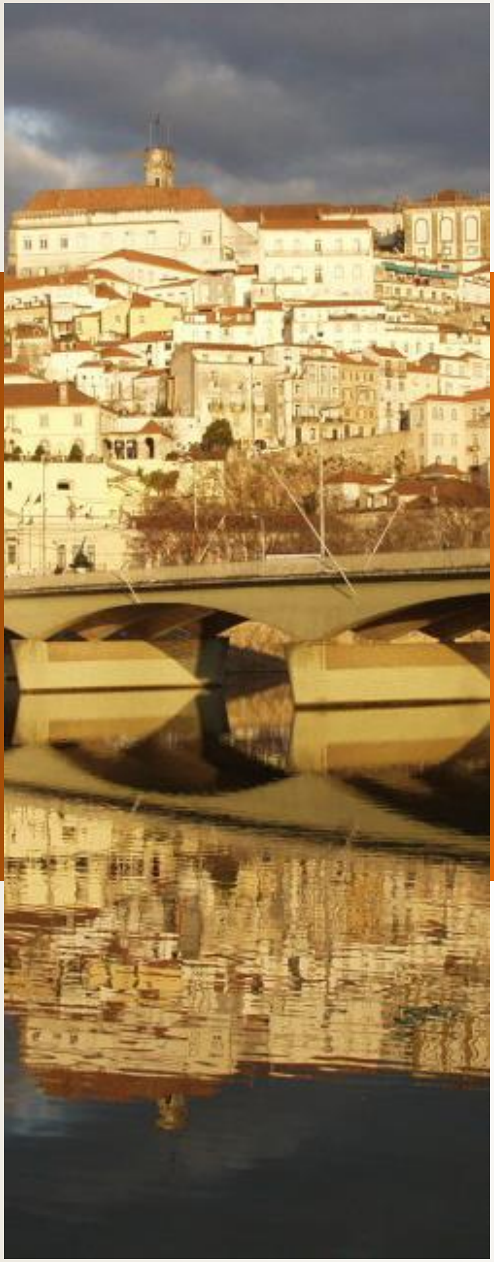
- Sunflower cultivated in irrigated land (3000 kg (ha*year)$^{-1}$) had higher impacts in TA and FWE due to the use of fertilisers.

- LUC scenarios showed a huge variation in the GHG intensity for sunflower seeds in Portugal, (0.3-22 kg CO_2eq kg_{seeds}^{-1}).

Conversion of SD grassland into irrigated sunflower

Conversion of perennial crops (NT, w/) into rainfed sunflower

The results demonstrate that both agricultural practices and LUC scenarios have an important influence on GHG intensity.



Thank you!

Questions and Comments

Center for Industrial Ecology
http://www2.dem.uc.pt/CenterIndustrialEcology
Faculty of Sciences and Technology
University of Coimbra.

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E-mails:

filipa.figueiredo@dem.uc.pt; fausto.freire@dem.uc.pt; erica@dem.uc.pt;

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