MEDYWAT **WEBINAR**

ADDRESSING ENVIRONMENTAL IMPACTS OF AN AGRICULTURE WATER SUPPLY SYSTEM WITH LIFE CYCLE ASSESSMENT (LCA)

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MedYWat
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EUROPEAN UNION

LARGE SCALE IRRIGATION MANAGEMENT TOOLS FOR SUSTAINABLE WATER MANAGEMENT IN RURAL AREAS AND PROTECTION OF RECEIVING AQUATIC ECOSYSTEMS

Interreg Greece-Italy IR2MA
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IR_2MA project at a glance

About the Project

IR_2MA project was launched in April 2018 within the framework of the Cooperation Programme Interreg V/A Greece-Italy 2014-2020. The project lasts 24 months and involves 6 partners (regional authorities, research centres, universities and water management organizations) from regions of Epirus (Greece) and Apulia (Italy).

LP – University of Ioannina Research Committee
P2 – Hellenic Republic Region of Epirus
P3 – Consiglio Nazionale delle Ricerche ISPA Istituto di Scienze delle Produzioni Alimentari
P4 – CIHEAM Bari
P5 – Consorzio per la Bonifica della Capitanata
P6 – Regione Puglia

6 partners

WATER-ENERGY-FOOD-ECOSYSTEM NEXUS
Evaluation using life cycle thinking tools

IRRIGATION MANAGEMENT SCENARIOS
Performance evaluation of irrigation networks.

SMART DECISION SUPPORT TOOLS
On-farm optimization of water and nutrient use.

DEMONSTRATION SITES
Cloud-based technologies, Guidebooks.

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OUTLINE

Introduction

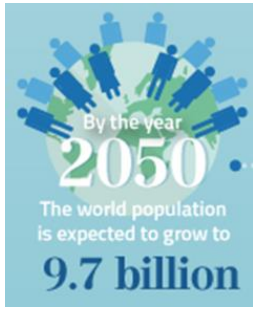
What is Life Cycle Assessment (LCA methodology)

Phases of a Life Cycle Assessment (LCA) study

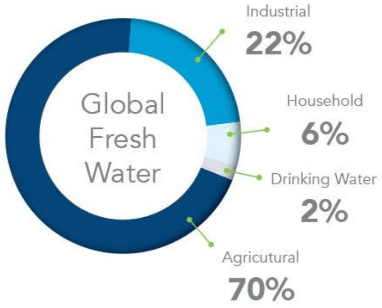
Application of the LCA (case study)

DRIVERS FOR ENVIRONMENTAL IMPACT ASSESSMENT

- Agricultural production is one of the most pervasive drivers behind a number of global pressures on the environment resulting from a growing human population and changing patterns of food consumption.



- Sustainability of irrigation is an important theme of water resource management in order to sustainably increase the global food supply (70% of water is diverted to agriculture) (FAO, 2017).



- With elevated concerns related to environmental impacts, a life cycle assessment (LCA) framework can be used to determine areas of greatest impact and compare reduction strategies for agricultural production systems (CAFFREY AND WEAL 2013).

WHAT IS LCA? AND WHY IS IT SO IMPORTANT?

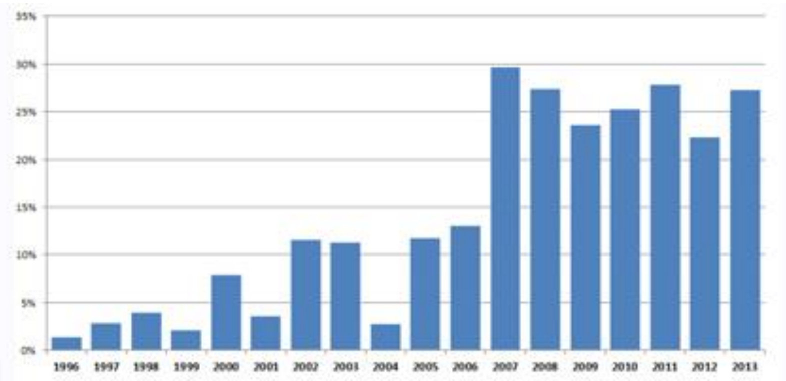
- **Life cycle assessment** (LCA) is a multi-step procedure for calculating the lifetime environmental impact of a product or service.

- **Lifecycle** – "Consecutive and interlinked stages of a product system, from raw material acquisition …to final disposal".

- The **<u>result of a LCA-study is an environmental profile</u>** of a product or activity: a 'score list' with environmental effects.

Agriculture-related LCAs Keep Evolving

- ISO-compliant life cycle assessment **<u>is the most reliable method</u>** to verify environmental impacts, support claims and identify where we can most effectively take action.



LCA give a more holistic approach to environmental aspects of products.

Source: Pre-sustainability

THE PHASES OF LIFE CYCLE ASSESSMENT (LCA)

The standardized LCA process has four major steps:

1. Goal and Scope Definition – What are we trying to learn?

Define and describe the product, process or activity. Establish the context in which the assessment is to be made and identify the boundaries and environmental effects to be reviewed for the assessment.

2. Life Cycle Inventory (LCI) – What's embedded in the product?

Identify and quantify energy, water and materials usage and environmental releases (e.g., air emissions, solid waste disposal, waste water discharges).

3. Life Cycle Impact Assessment (LCIA) – What effects does it have?

Assess the potential human and ecological effects of energy, water, and material usage and the environmental releases identified in the inventory analysis.

4. Data Interpretation – What does it all mean?

Evaluate the results of the inventory analysis and impact assessment to select the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results.[1]

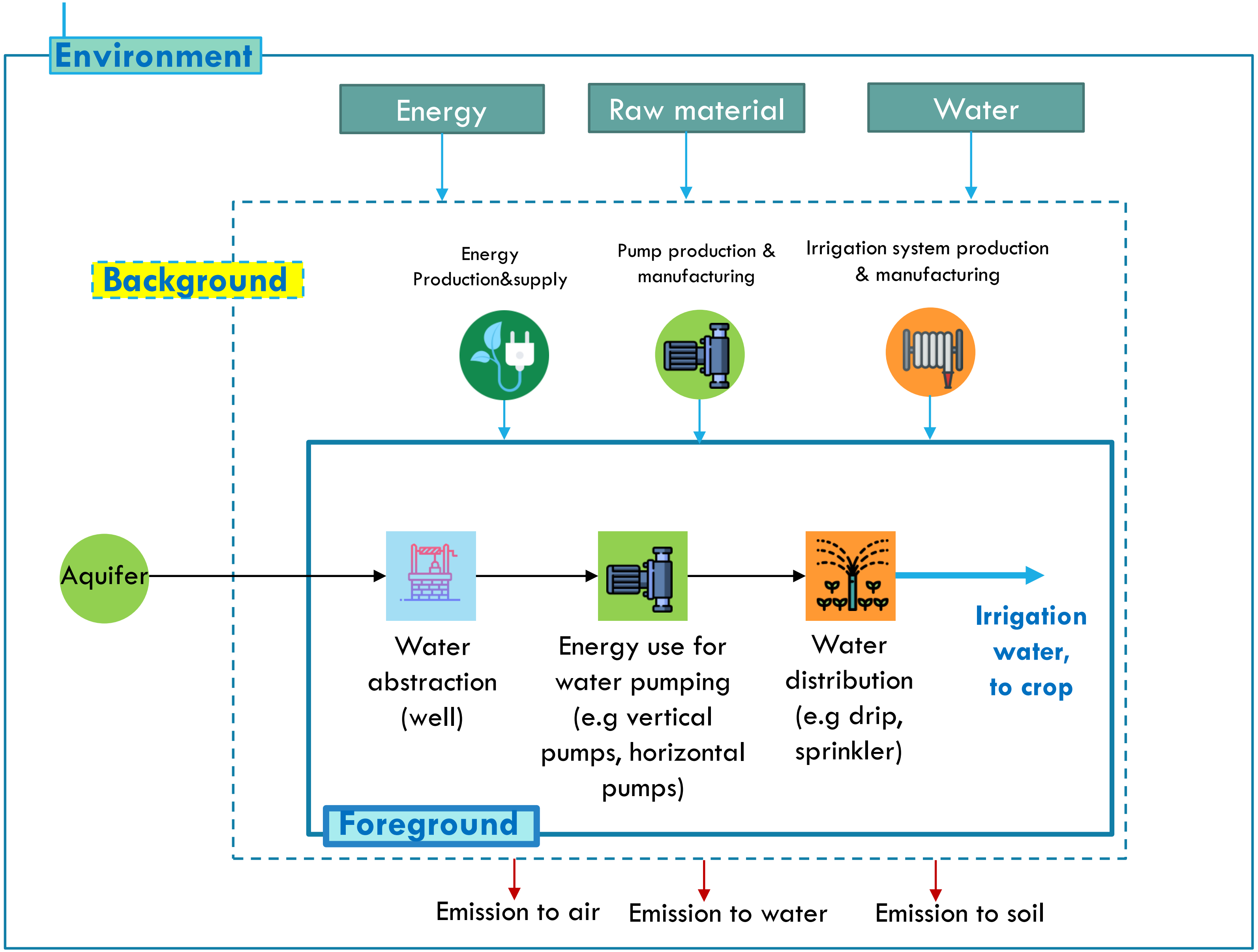
Source: http://www.paradigmsustain.com/life-cycle-assessment

CASE STUDY – LCA OF IRRIGATION WATER SUPPLY SYSTEM

1. GOAL AND SCOPE DEFINITION – What are we trying to learn?

What are we trying to understand?	The goal is to generate a quantitative environmental profile of groundwater based irrigation water supply in Italy.
What are the System functions and functional unit (FU) ?	The function of the studied system is to provide groundwater for agricultural purposes. Quantified performance of a product system for use as a reference unit. The FU is 1000 **m^3 water supplied at farm gate.**
Intended use and audience	The target group of this study are all stakeholders involved in the water supply and use, i.e. consortium and farmers and/or regional government.
Public, comparative	The results of this study are intended to be used in comparative assertions intended to be disclosed to the public.

CASE STUDY – SYSTEM BOUNDARIES



Boundaries for which processes in the products life cycle that is included in the LCA.

The system boundaries should at least include:

- The water supply train which is to be studied.
- Energy production required for the pumping.
- Production of materials/chemicals/additives required for the pumps and irrigation systems.

An assessment cannot cover everything so system boundaries clarify what it will include.

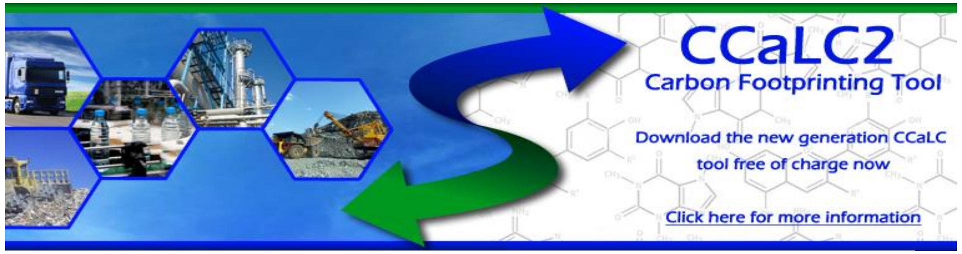
CASE STUDY – MODELLING PROCESSES AND INVENTORY ANALYSIS

Type of Processa	Name	Input Primary/secondary flow/dataset	How to calculate	Amount
Product flows	Irrigation, drip irrigation system/IT			1000 m^3
Foreground	1. Water Abstraction and Supply	Water, well, ground, IT		1000 m^3
	2. Irrigation Energy	Pumping, irrigation, 50 m total head, 100% electricity	$\text{Power\_Elec\_KWh} = \frac{\text{Frac}_{\text{electric}} \times \text{Volume} \times 3.6 \times (9.81 \times \text{D}_{\text{liquid}} \times \text{TDHm})}{\frac{(\text{El\_Motor\_Eff} * \text{Pump\_Eff})}{3600}}$	250 kWh (TDH = 50 m, eff_motor 0,8, eff_pump 0,66)
Background	1. Electricity Production (electricity mix for Italy)	Electricity, medium voltage, IT		
	2. Pump production & manufacturing	Aluminium, wrought alloy - GLO Cast iron – GLO Polyvinylchloride, emulsion polymerised – GLO Synthetic rubber - GLO	$\text{Fraction per } m^3 \text{ of water } (p/m^3) = \frac{\textit{Unit (Total mass of pump)}}{\textit{Pump life (year)} \times \textit{Hourof use}\left(\frac{h}{year}\right) \times \textit{Flowrate}\left(\frac{m^3}{h}\right)}$	1,5e-05
	2. Irrigation system & manufacturing	Steel, low-alloyed, hot rolled – GLO Copper - GLO	$\text{Fraction per } m^3 \text{ of water} = \frac{\textit{Mass of irrigation system}}{\textit{Infrastrucuture life (year)} \times \textit{Total Irrigation water } (m^3/year)}$	Not considered

TOOLS : Paid licensing - SimaPro (PreSustainability), Gabi (Thinkstep) / Freeware - Open LCA (Green Delta), CCaLC (University of Manchester)

DATABASES: Paid licensing - Agri-footprint (NL), Gabi (DE), Ecoinvent (CH), SOCA / Freeware – Agribalyse, NEEDS, ELCD

CASE STUDY – MODELLING PROCESSES AND INVENTORY ANALYSIS



Functional unit: 10 kW ASHP 1 kWhth

Stage: Raw Materials

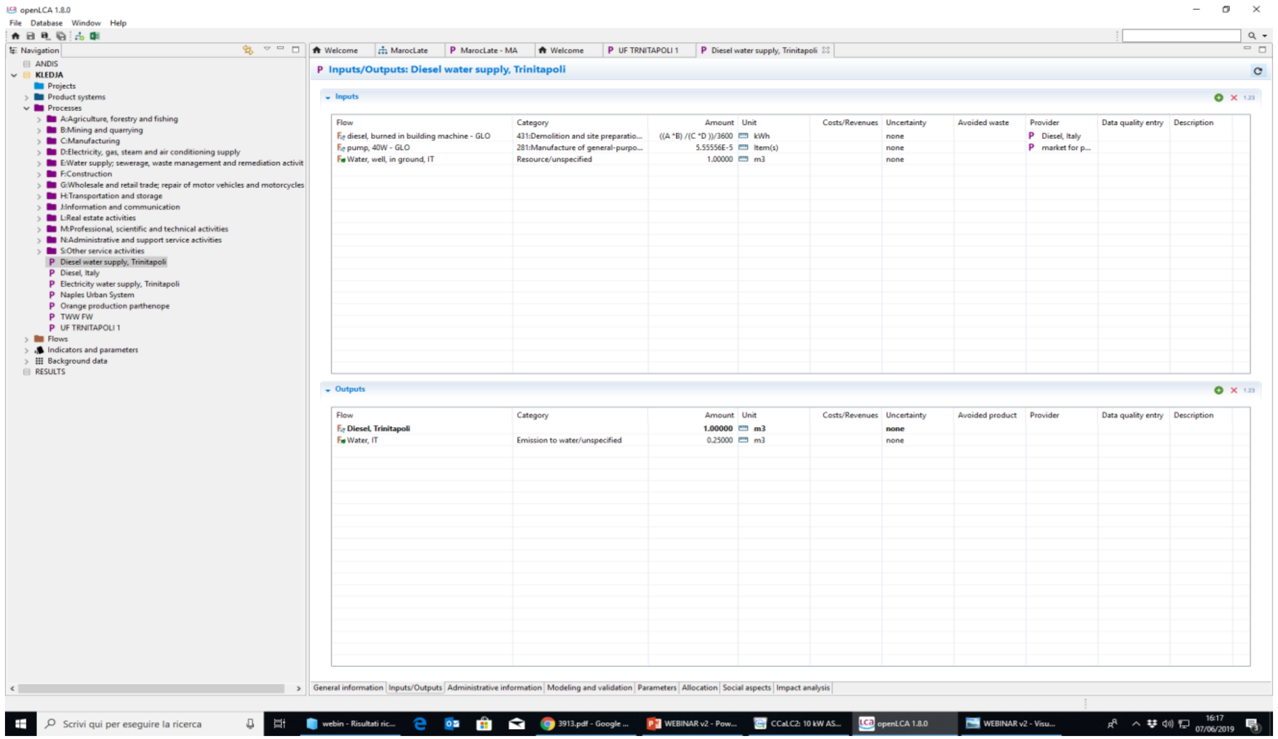
Total carbon footprint for stage:	0,087	kg CO2 eq. / f.u.
Total water usage for stage:	0.00	m³ water / f.u.
Total water footprint (stress-weighted) for stage:	0.00	m³ water eq. / f.u.

Raw material	Amount (kg/f.u.)	CO2 eq. (kg/kg raw material)	CO2 eq. (kg/f.u.)	Water usage (m³/kg raw material)	Water usage (m³/f.u.)	Water footprint (stress-weighted) (m³ eq./f.u.)	Database section	Production stage
aluminium, primary, at plant	6,29E-4	12,0	7,57E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
aluminium, secondary, from n...	5,66E-3	0,420	2,38E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
cement, unspecified, at plant	0,045	0,761	0,034	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
copper, primary, at refinery, E...	1,08E-3	1,85	2,00E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
copper, secondary, at refinery	7,50E-4	1,80	1,35E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
polyethylene, HDPE, granulat...	2,50E-5	1,95	4,87E-5	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
polyethylene, LDPE, granulat...	5,04E-3	2,10	0,011	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
polystyrene, high impact, HIP...	3,30E-3	3,50	0,012	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
polyvinylchloride, at regional s...	7,99E-5	2,01	1,60E-4	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
refrigerant R134a, at plant	5,00E-5	103	5,17E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
reinforcing steel, at plant	5,99E-3	1,48	8,88E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
sand, at mine	0,232	2,41E-3	5,58E-4	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
steel, low-alloyed, at plant	1,60E-3	1,76	2,81E-3	0.00	0.00	0.00	Ecoinvent/Ma...	Assembly
Total:	0,301	Total:	0,087	Total:	0.00	0.00		

Energy	Amount (MJ/f.u.)	CO2 eq. (kg/MJ energy)	CO2 eq. (kg/f.u.)	Water usage (m³/MJ energy)	Water usage (m³/f.u.)	Water footprint (stress-weighted) (m³ eq./f.u.)	Database section
Total:	0.00	Total:	0.00	Total:	0.00	0.00	

Packaging	Amount (kg/f.u.)	CO2 eq. (kg/kg packaging)	CO2 eq. (kg/f.u.)	Water usage (m³/kg packaging)	Water usage (m³/f.u.)	Water footprint (stress-weighted) (m³ eq./f.u.)	Database section	Production stage
Total:	0.00	Total:	0.00	Total:	0.00	0.00		

Waste	Amount (kg/f.u.)	CO2 eq. (kg/kg waste)	CO2 eq. (kg/f.u.)	Water usage (m³/kg waste)	Water usage (m³/f.u.)	Water footprint (stress-weighted) (m³ eq./f.u.)	Database section
Total:	0.00	Total:	0.00	Total:	0.00	0.00	



CASE STUDY – IMPACT ASSESSMENT

The LCI data can then be used to perform an impact assessment using the LCIA methods

LCIA SAMPLE PROCEDURE
IMPACT METHODOLOGY AFFECTS THESE!

SELECTION → **LIFE CYCLE INVENTORY** → **CLASSIFICATION & CHARACTERIZATION**

Impact assessment method/s

- AWARE (Water scarcity footprint);
- CML-IA baseline;
- Cumulative Energy Demand;
- Cumulative Exergy Demand;
- Eco-indicator 99;
- **ReCiPe 2016;**
- USEtox;
- TRACI;
- IMPACT 2002+
- ILCD Midpoint

Water 1000 m3

Electricity 250 kWh

Carbon dioxide (CO_2) = 200 kg

Ammonia (NH_3) = 50 kg

Methane (CH_4) = 10 kg

Phosphates (PO_4^{3-}) = 2 kg

Hard Coal = 60 kg

CO_2 → Global warming
NH_3 → Acidification, Fine particulate matter formation

Characterization:

- Acidification: $(x\ kg\ NH_3\ released)\left(\frac{1.96\ kg\ SO_2-eq}{kg\ NH_3}\right) = 1.96x\ kg\ SO_2 - eq$
- Particulates: $(x\ kg\ NH_3\ released)\left(\frac{0.024\ kg\ PM_{2.5}-eq}{kg\ NH_3}\right) = 0.024x\ kg\ PM_{2.5} - eq$

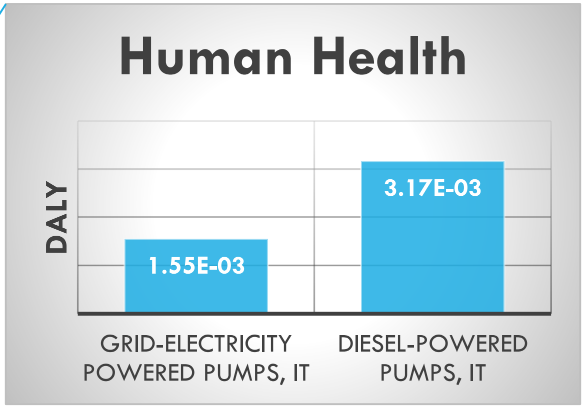
CHARACTERIZATION FACTORS (ReCiPe 2016)	Global warming	Stratospheric ozone depletion	Ozone formation, Human health	Fine particulate matter formation	Terrestrial acidification	Fossil resource scarcity
CO_2	1					
CH4	36					
N2O	298	0.011				
Ammonia (kg NH_3)				0.240	1.960	
NOX			1.000	0.110	0.360	
Hard Coal			0.180			0,42
SO2				0.290	1.000	

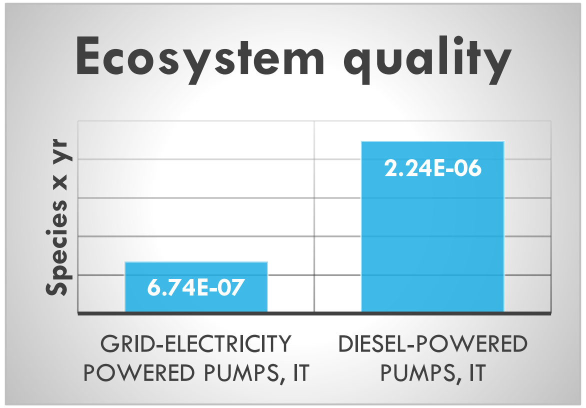
Repeat for each flow, sum results in each impact category

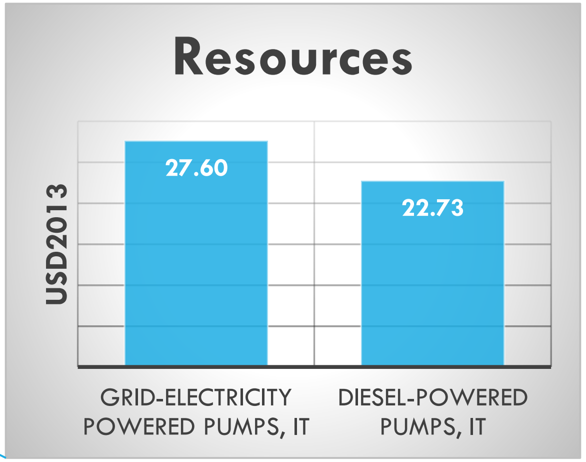
CASE STUDY – LCA RESULTS

Impact category	Unit	Grid-electricity powered pumps, IT	Diesel-powered pumps, IT
Global warming	kg CO_2-eq	▲ 163.090	▼ 154.113
Stratospheric ozone depletion	kg CFC11-eq	▼ 8.98E-05	▲ 8.98E-05
Ionizing radiation	kBq Co-60-eq	▲ 26.61	▼ 3.15
Ozone formation, Human health	kg NOx-eq	▼ 0.28	▲ 2.14
Fine particulate matter formation	kg PM2.5-eq	▼ 0.19	▲ 0.78
Ozone formation, Terrestrial ecosystem	kg NOx-eq	▼ 0.28	▲ 4.82
Terrestrial acidification	kg SO_2-eq	▼ 0.56	▲ 1.41
Freshwater eutrophication	kg P-eq	▲ 0.025	▼ 0.006
Marine eutrophication	kg N-eq	▲ 0.30	▼ 0.01
Terrestrial ecotoxicity	kg 1,4-DCB-eq	▲ 141.88	▼ 140.46
Freshwater ecotoxicity	kg 1,4-DCB-eq	▲ 2.19	▼ 0.60
Marine ecotoxicity	kg 1,4-DCB-eq	▲ 2.93	▼ 0.95
Human carcinogenic toxicity	kg 1,4-DCB-eq	▼ 2.30	▲ 2.70
Human non-carcinogenic toxicity	kg 1,4-DCB-eq	▲ 35.67	▼ 17.04
Land use	m^2a crop-eq	▲ 2.75	▼ 0.41
Mineral resource scarcity	kg Cu-eq	▼ 0.25	▲ 0.40
Fossil resource scarcity	kg oil-eq	▼ 48.66	▲ 51.45
Water consumption	m^3 consumed	▲ 601.25	▼ 600.39

Calculations performed with OpenLCA 1.8.0



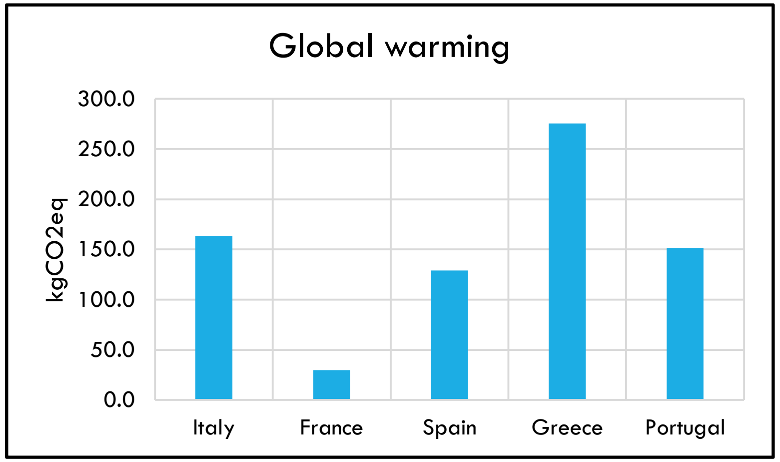


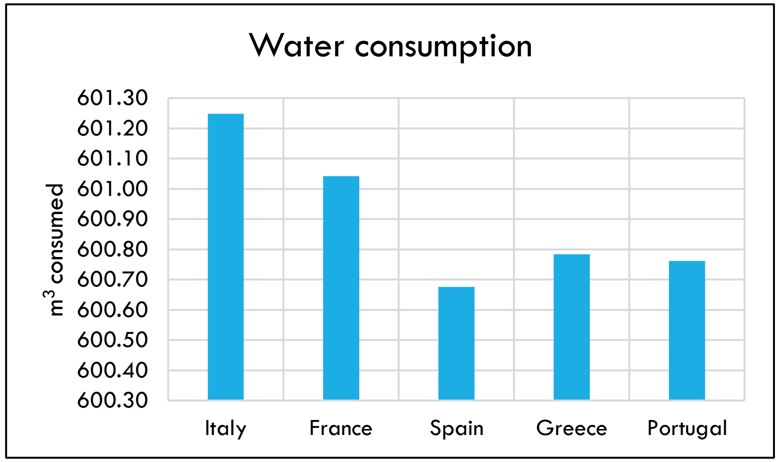


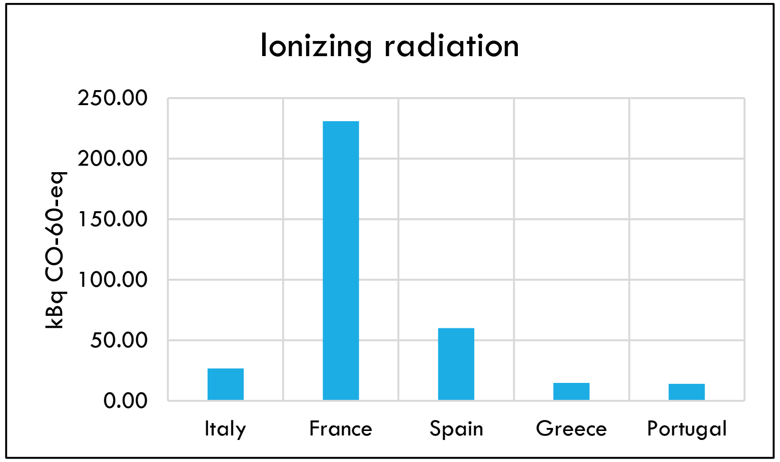
Repeat Calculations (Sensitivity):

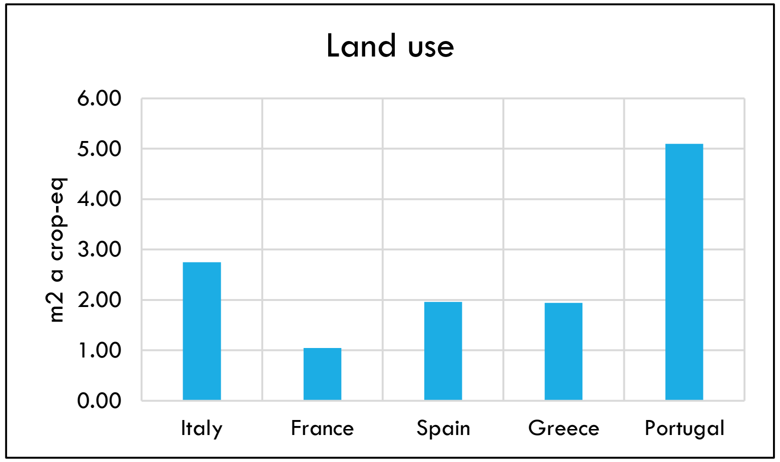
i. Depth of aquifer
ii. Efficiency of the pump;
iii. Source of Energy (electric.vs diesel)
iv. Type of irrigation system (drip vs sprinkler)

CASE STUDY – LCA RESULTS OF COUNTRY BASED ANALYSIS



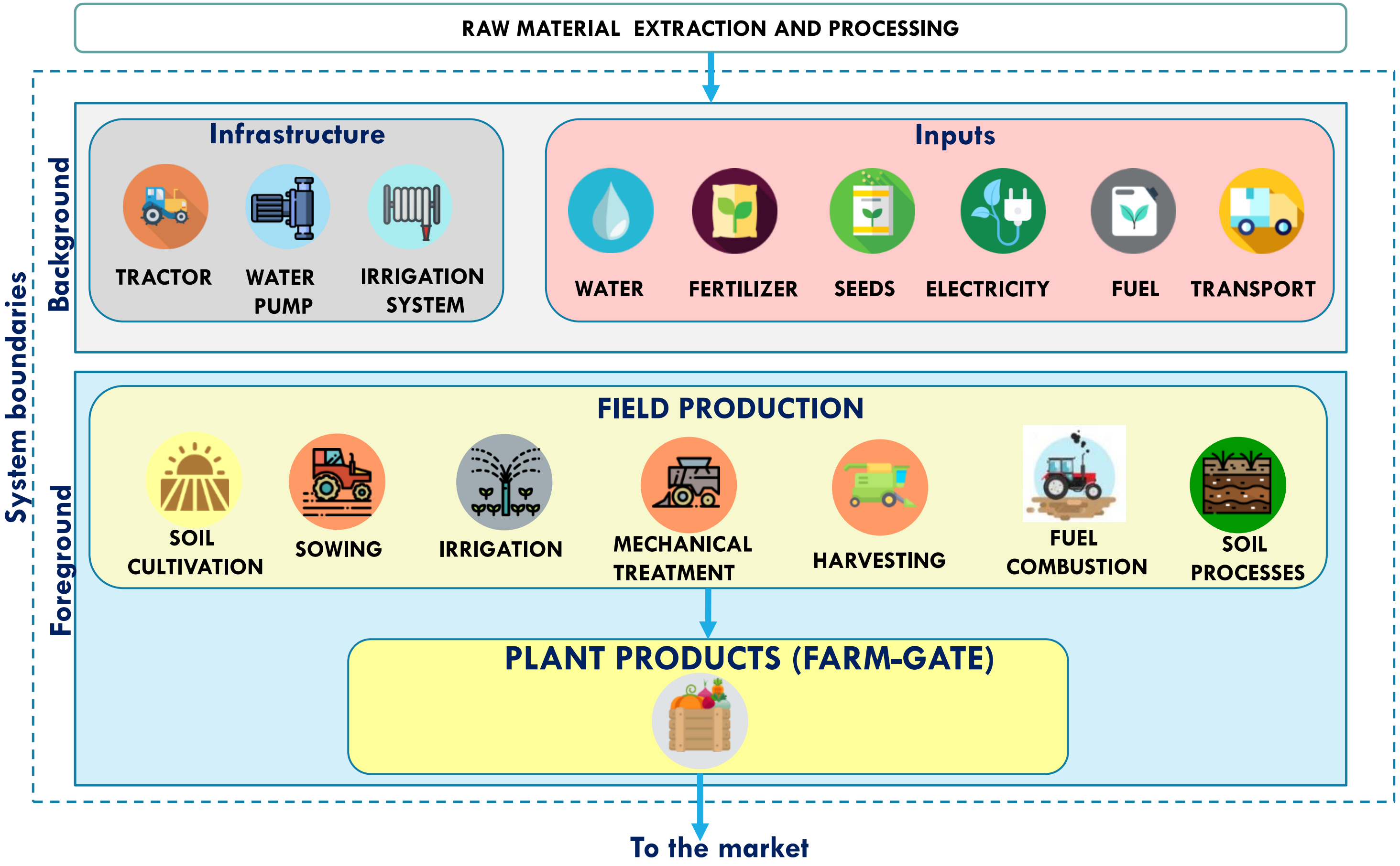


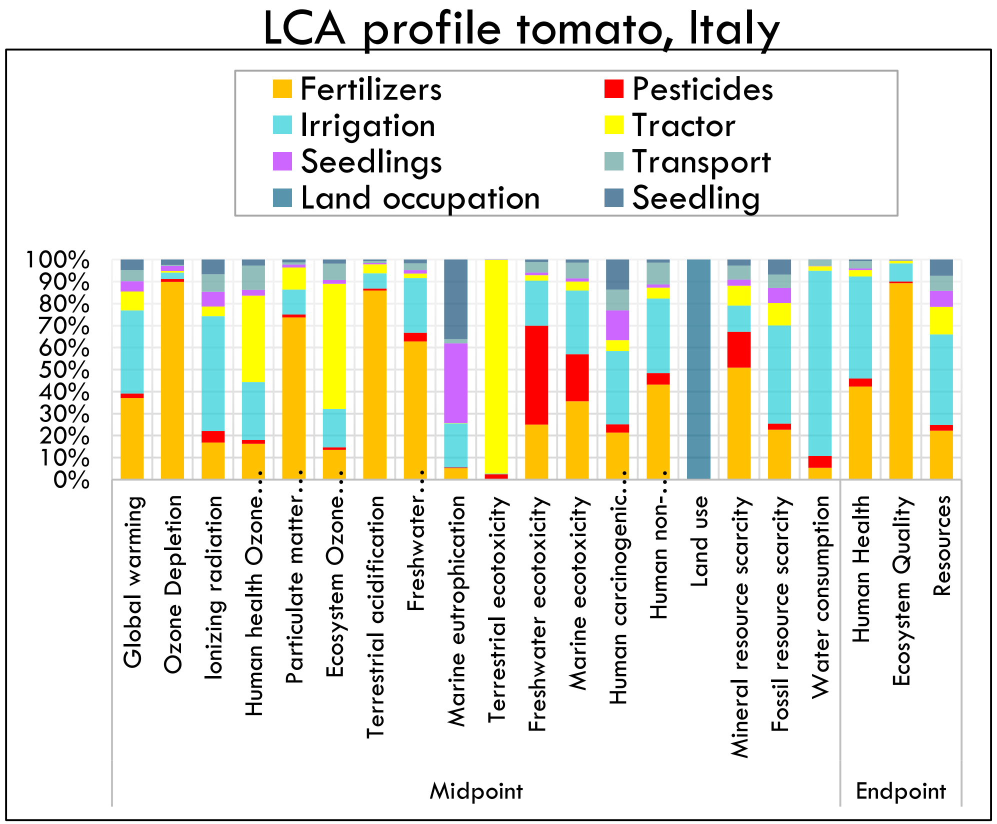




LCA ASSESSMENT BOUNDARIES – CROP PRODUCTION

Impact category	Tomato
Global warming	2344.8
Stratospheric ozone depletion	0.016
Ionizing radiation	251.5
Ozone formation, Human health	6.9
Fine particulate matter formation	8.3
Ozone formation, Terrestrial ecosystem	10.8
Terrestrial acidification	49.3
Freshwater eutrophication	0.9





WHO CARES ABOUT LIFE CYCLE ASSESSMENT?

It is increasingly being utilized within a large number of professions and for a wide variety of sustainability objectives such as:

1. Knowledge development (What are the most important environmental problems?)
2. Decision support (Where are the most effective areas for us to target resources to improve our performance?)
3. Information exchange/ communication (Communication of the effects of a company's environmental improvement efforts to authorities, neighbors, financial institutions and external stakeholders).

The preparation of an LCA requires time, skill and money. It also requires a methodology, a great deal of data, and software to manipulate the data.

Currently, for educational purposes LCAs are becoming easier to carry out with open source methodology and softwares.

Thank You for your Interest and Attention!

Any Questions?