Technische Universität Braunschweig

Institut für Siedlungswasserwirtschaft

Environmental Assessment of Sewage Sludge Management Options: A Case study

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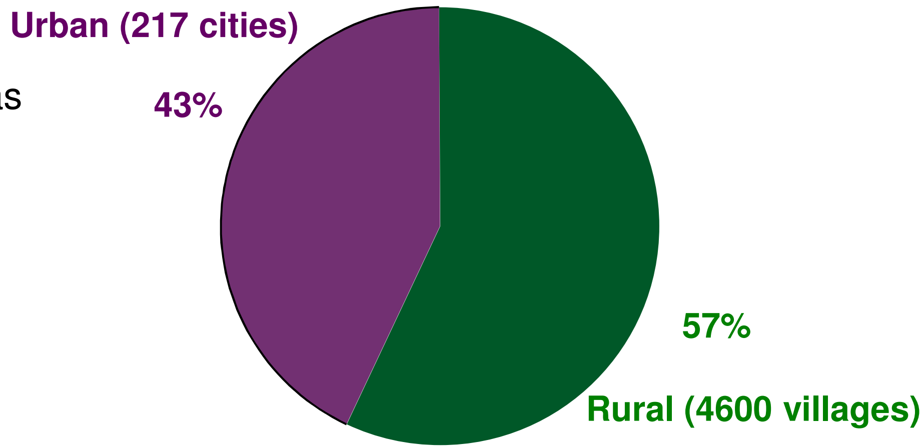
Outline

- Introduction
- Problem and study objectives
- Methodology
  - *Define the studied scenarios*
  - *LCA Approach*
  - *Systems boundaries*
- Results
- Conclusion

Wastewater Services Coverage in Egypt

Population Distribution

- About 57 % of Egyptian population live in rural areas where about 43% live in urban areas



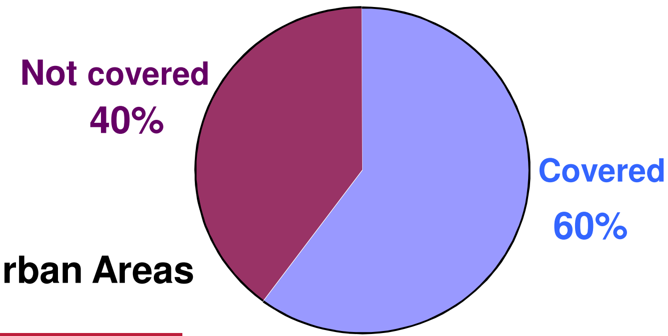
Population distribution

Rural Areas

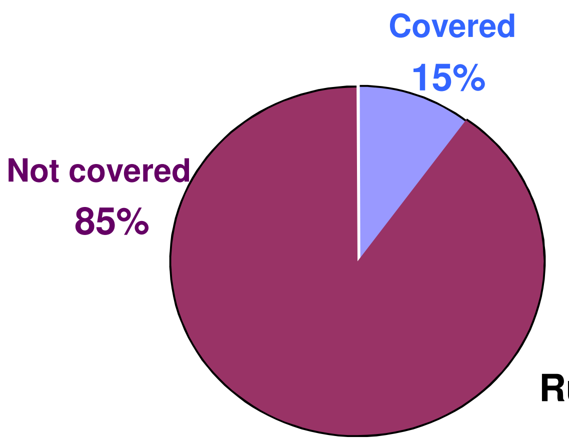
- Only 15 % are covered by wastewater collection and treatment facilities

Urban Areas

- About 60 % are covered by wastewater services and it is planned to be 100 % by 2017

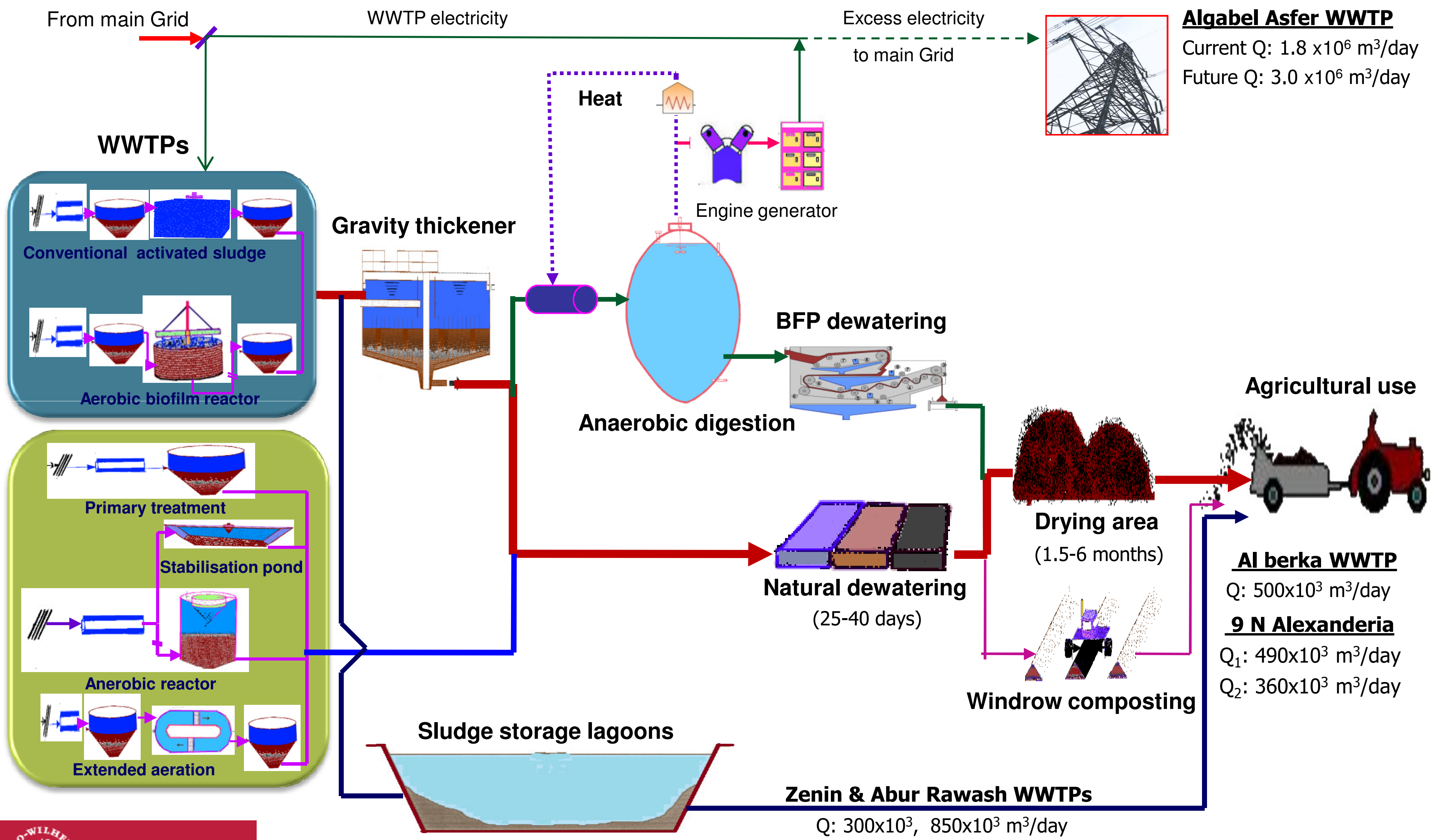


Urban Areas

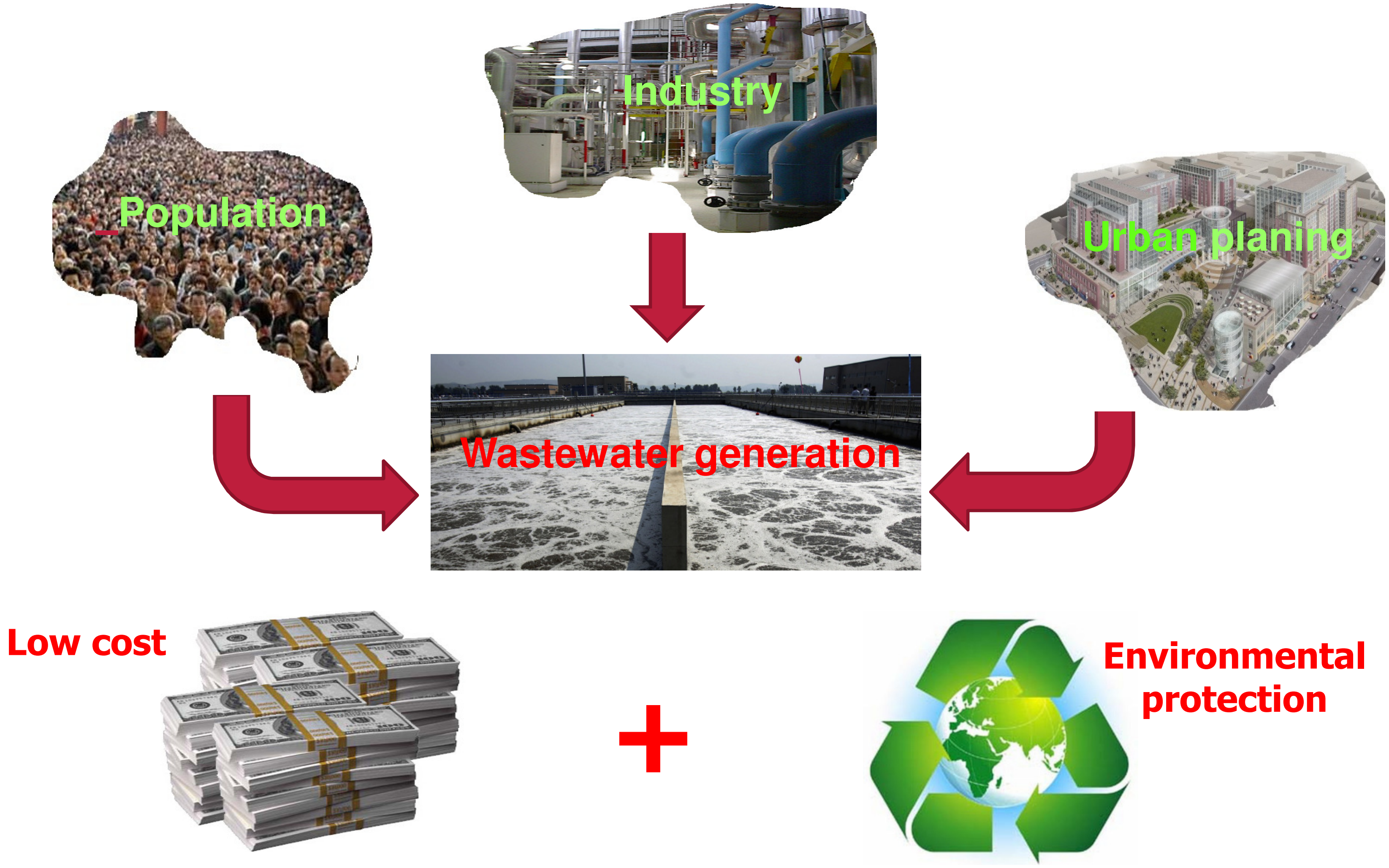


Rural Areas

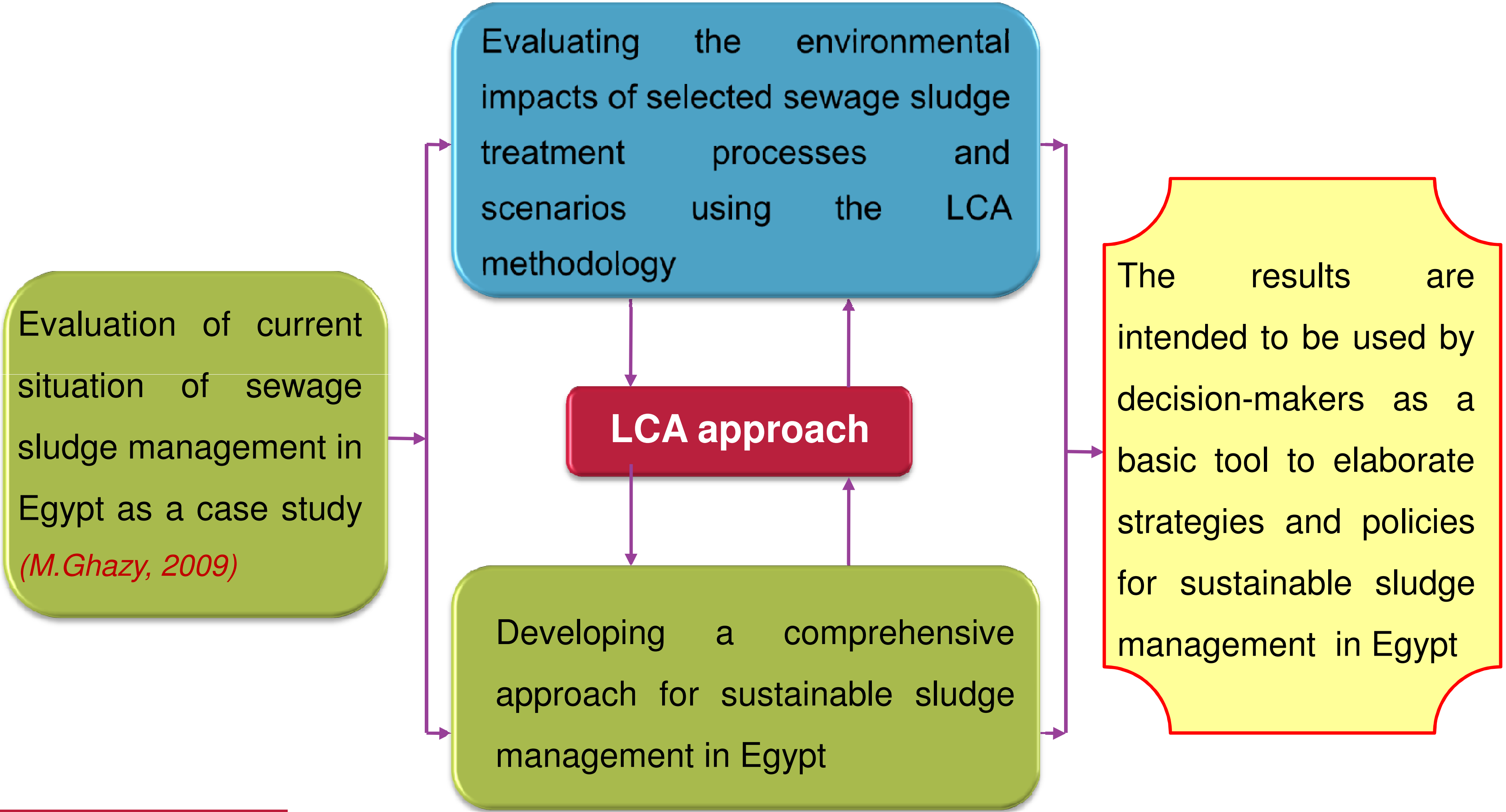
Current Sewage Sludge Treatment Options



Problem and Challenges



Study Objectives



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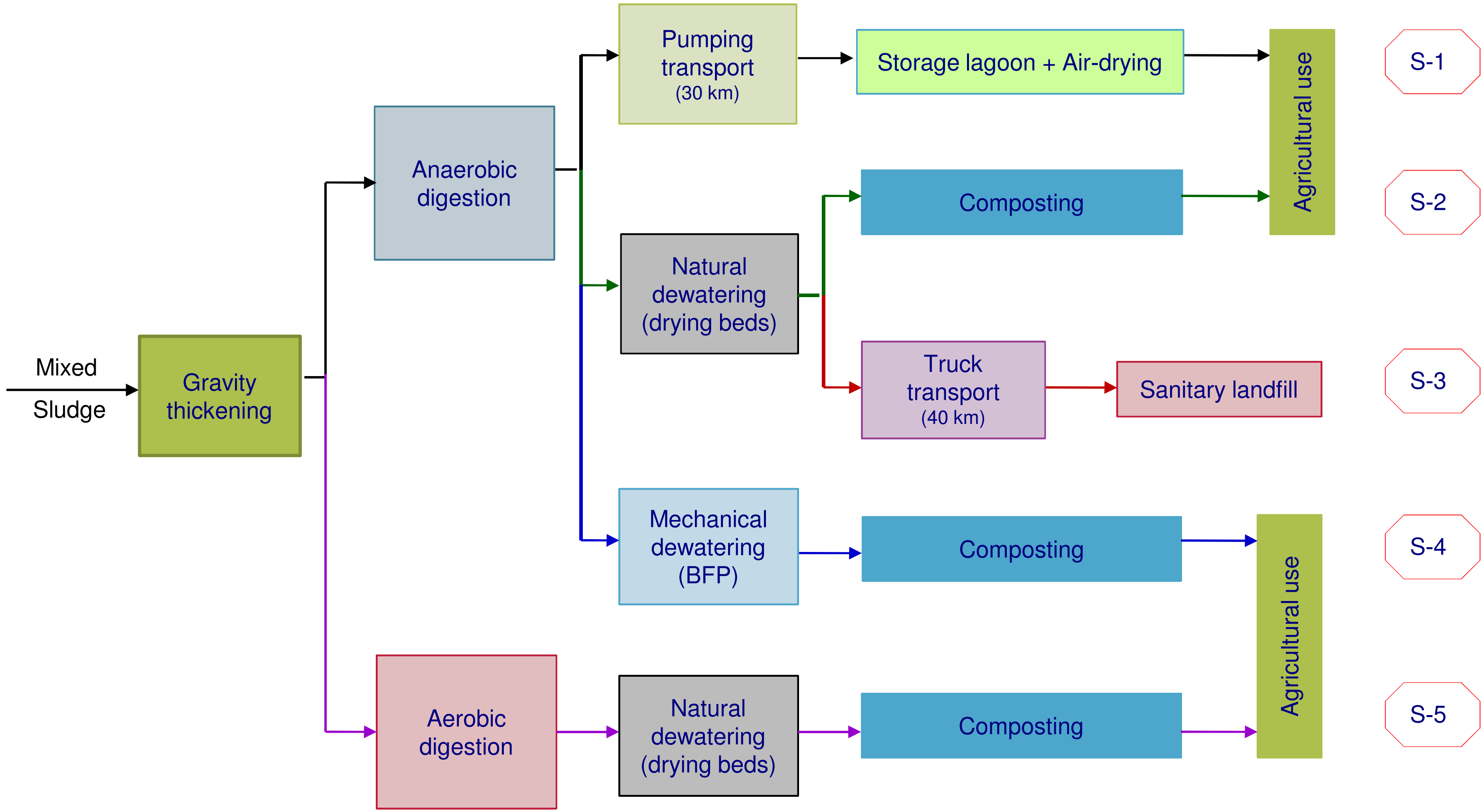
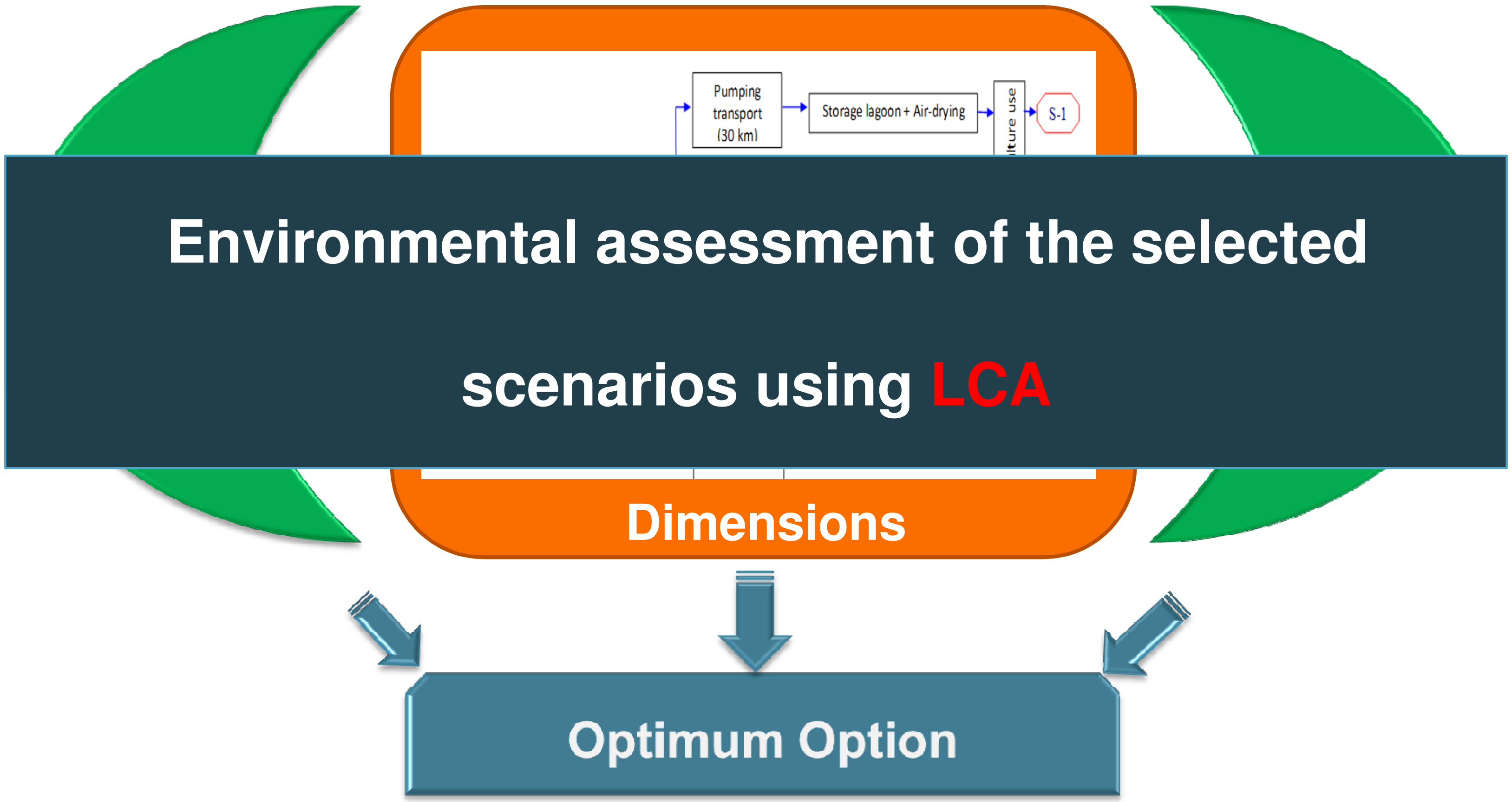
Studied Scenarios

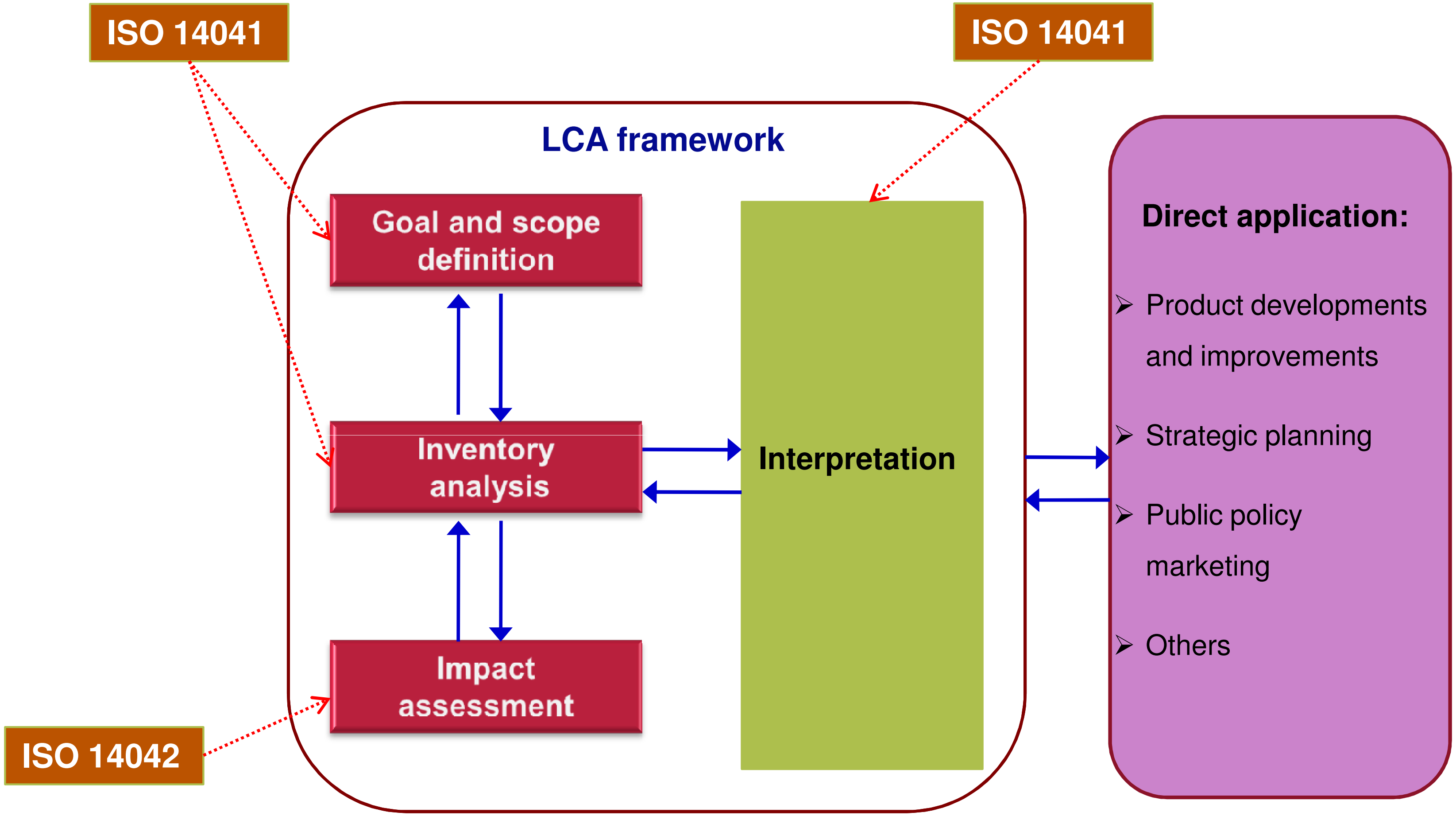


Study Methodology



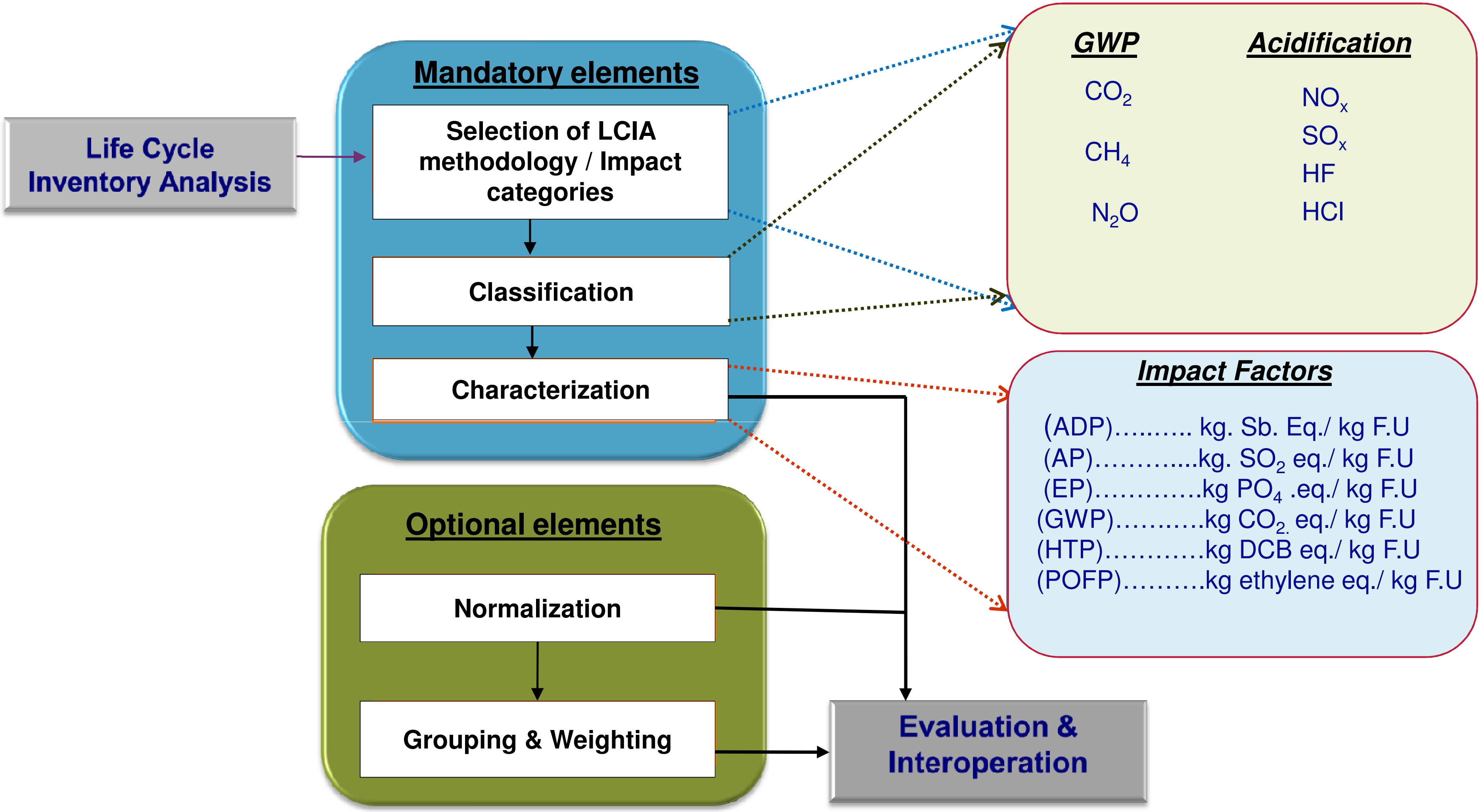
Low cost, more sustainable and less environmental impacts

LCA Origin and Structure



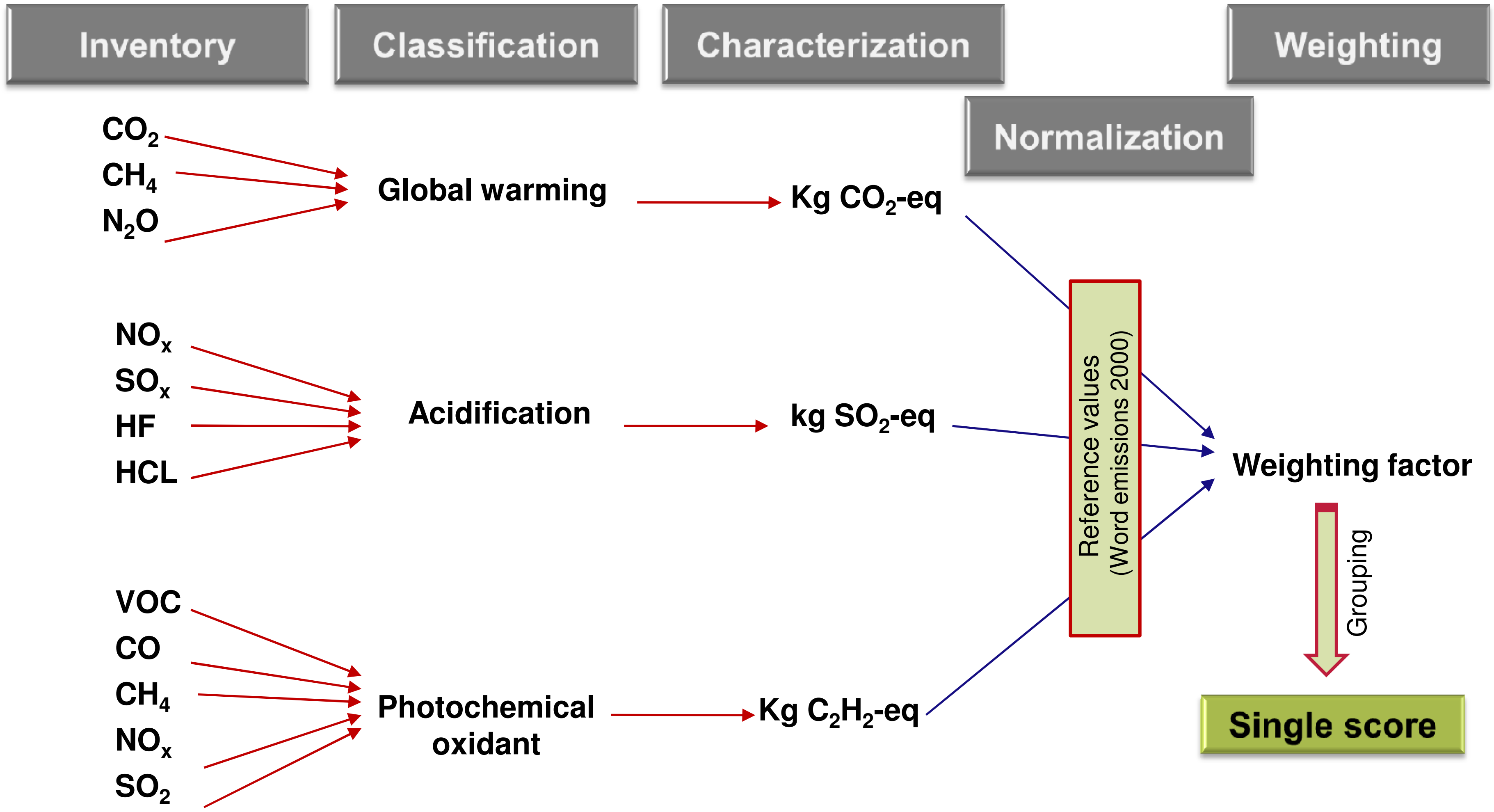
Phases and applications of LCA (based on ISO 14040)

Life Cycle Impact Assessment (LCIA)



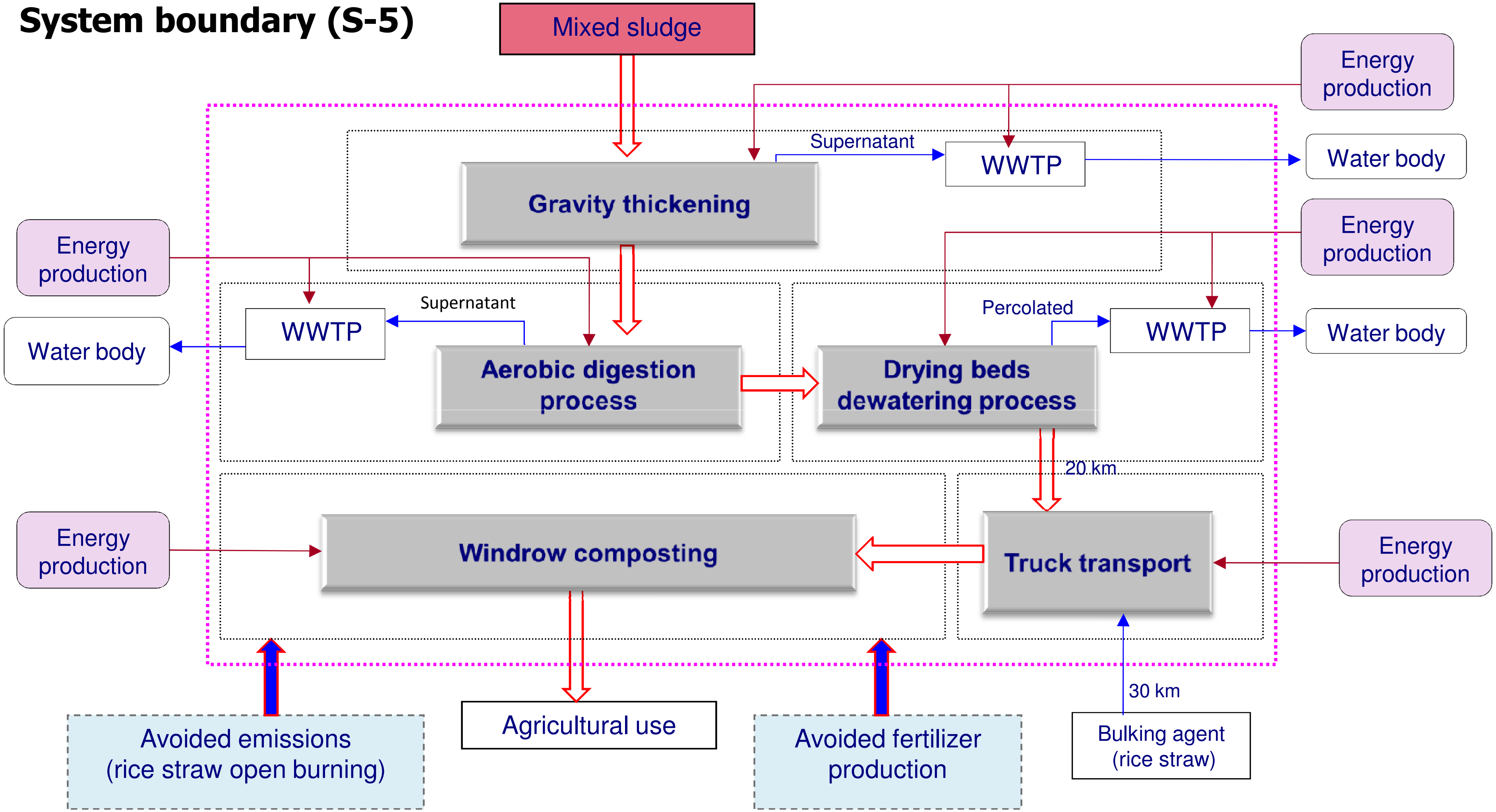
Elements of LCIA (based on ISO 14042, 2000)

Applying of LCA Approach

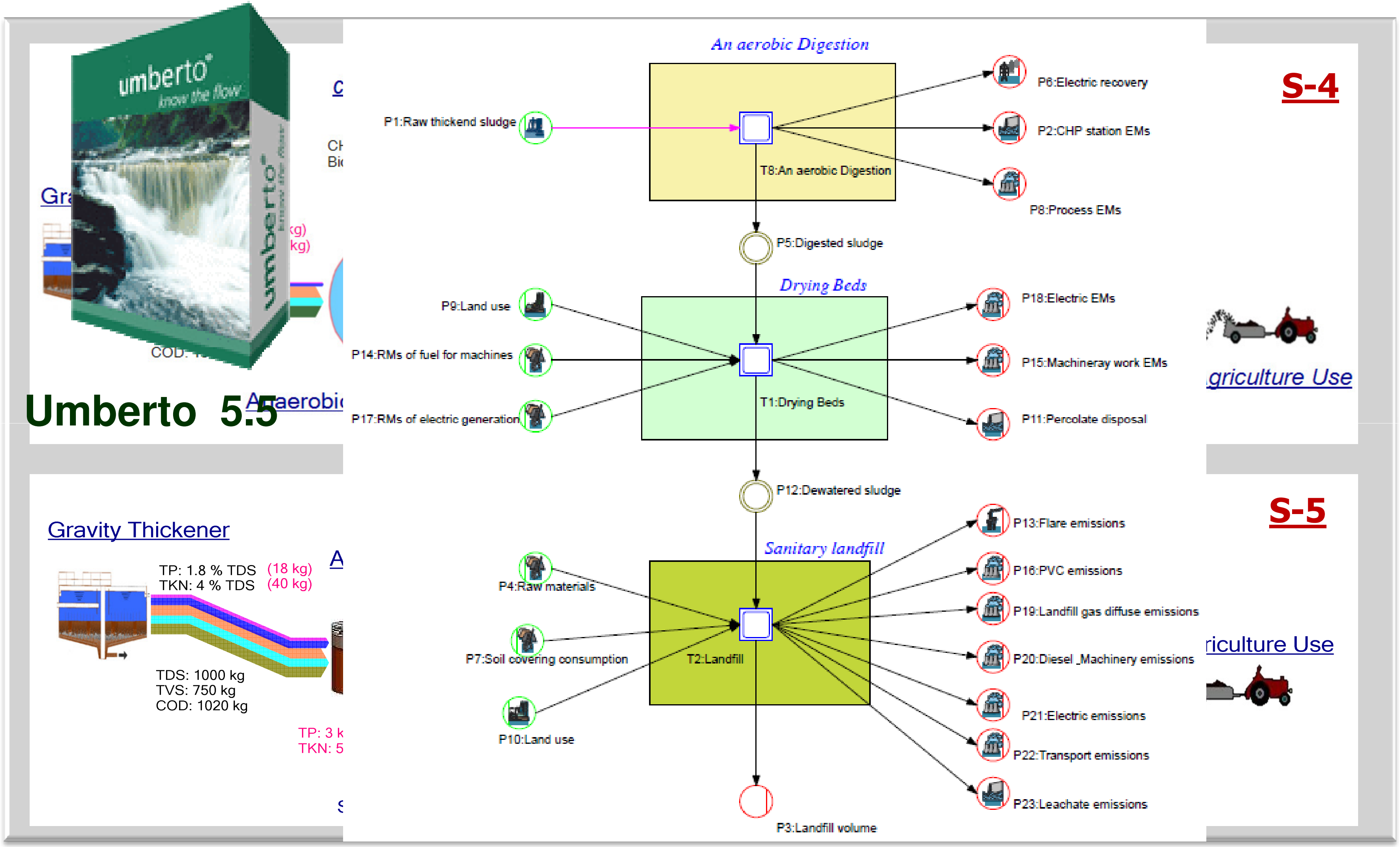


System Boundaries

System boundary (S-5)



Material and Energy Mass Balance



Main transitions (S-3)

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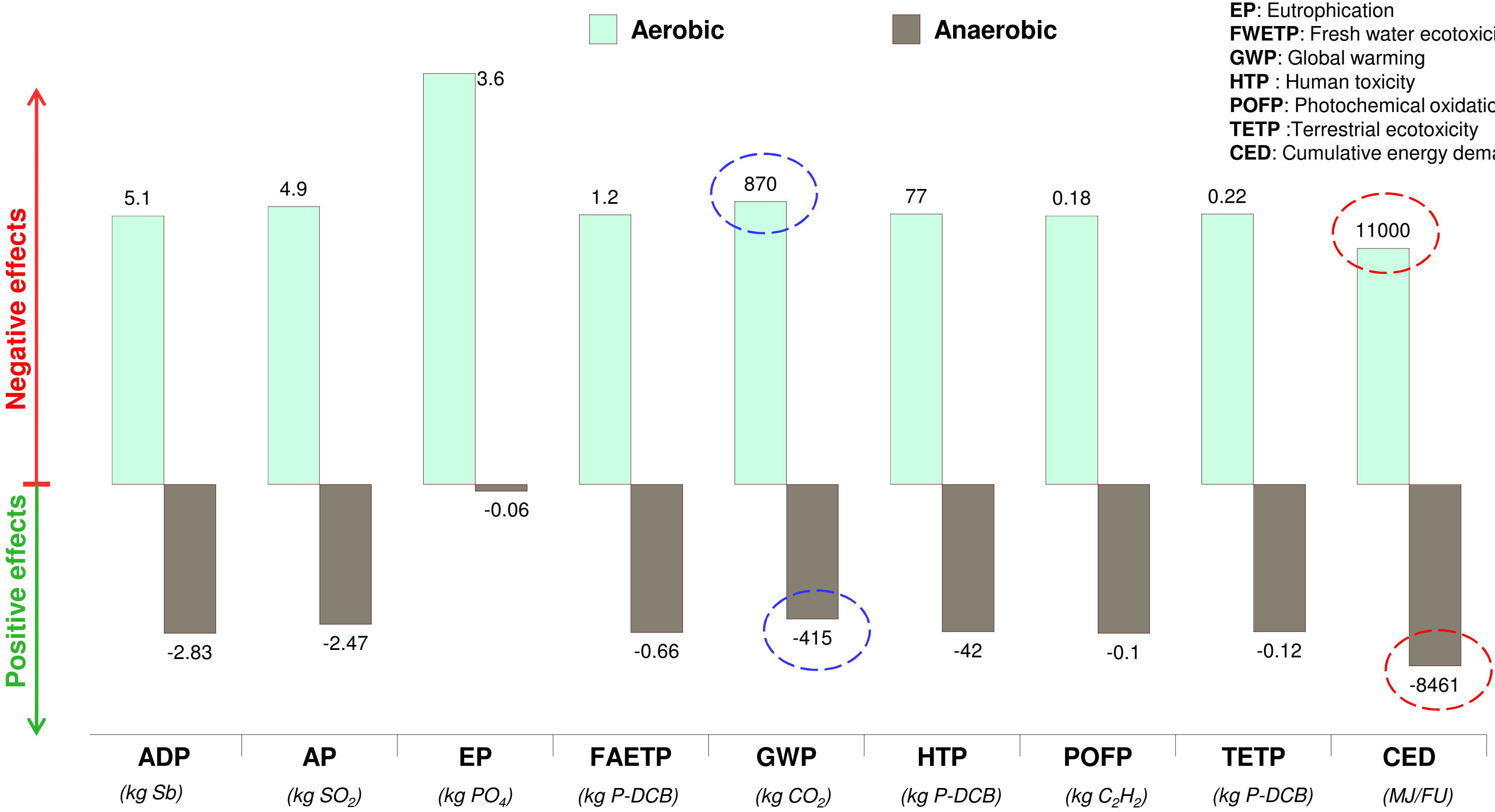
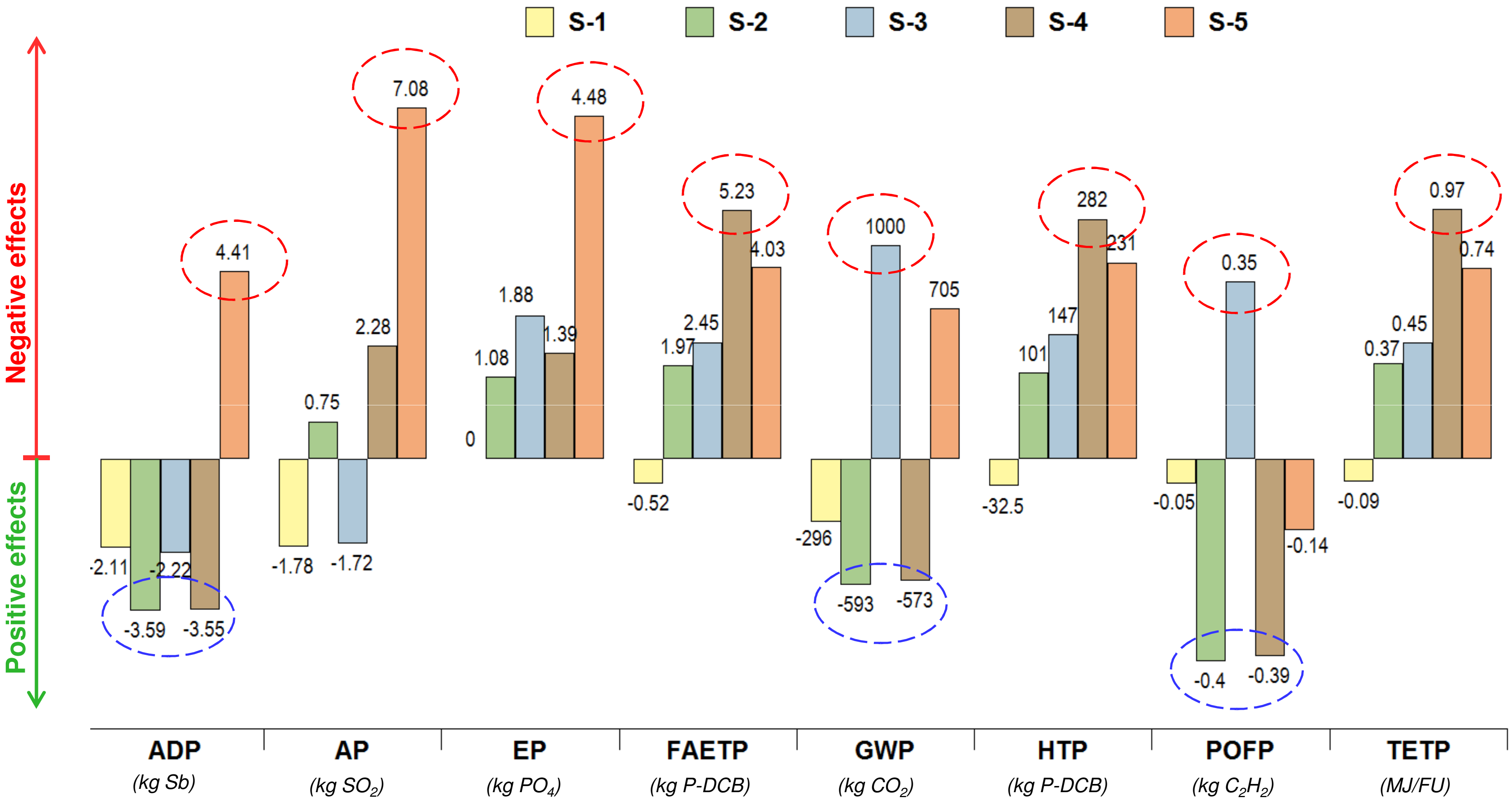
Environmental Impacts of Aerobic/Anaerobic Digestion



ADP: Abiotic depletion
AP: Acidification
EP: Eutrophication
FWETP: Fresh water ecotoxicity
GWP: Global warming
HTP : Human toxicity
POFP: Photochemical oxidation
TETP :Terrestrial ecotoxicity
CED: Cumulative energy demand

With considering the effect of the avoided emissions

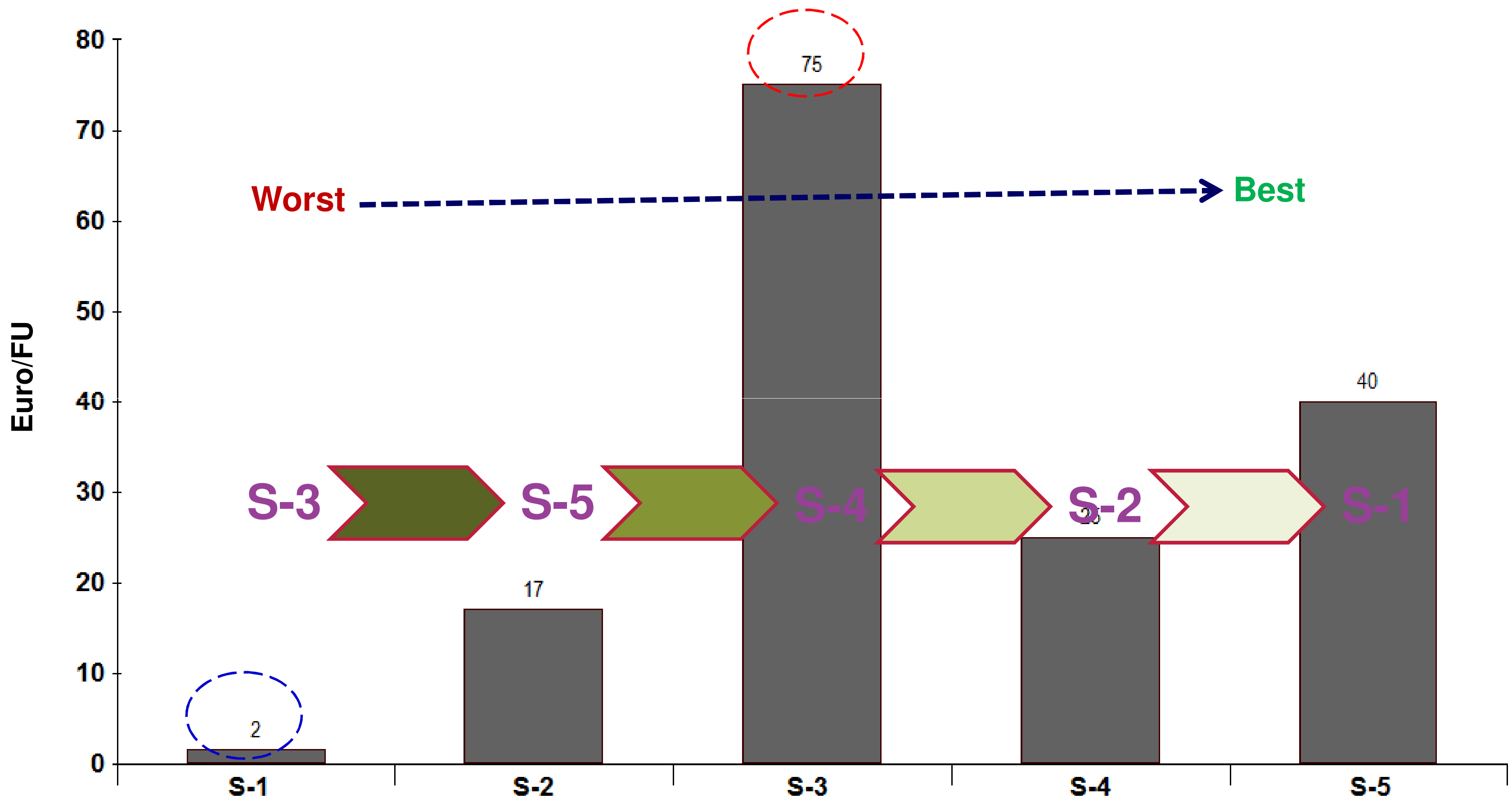
Environmental Impacts of Studied Scenarios



Characterization results of all compared scenarios

Weighting / Grouping Methods

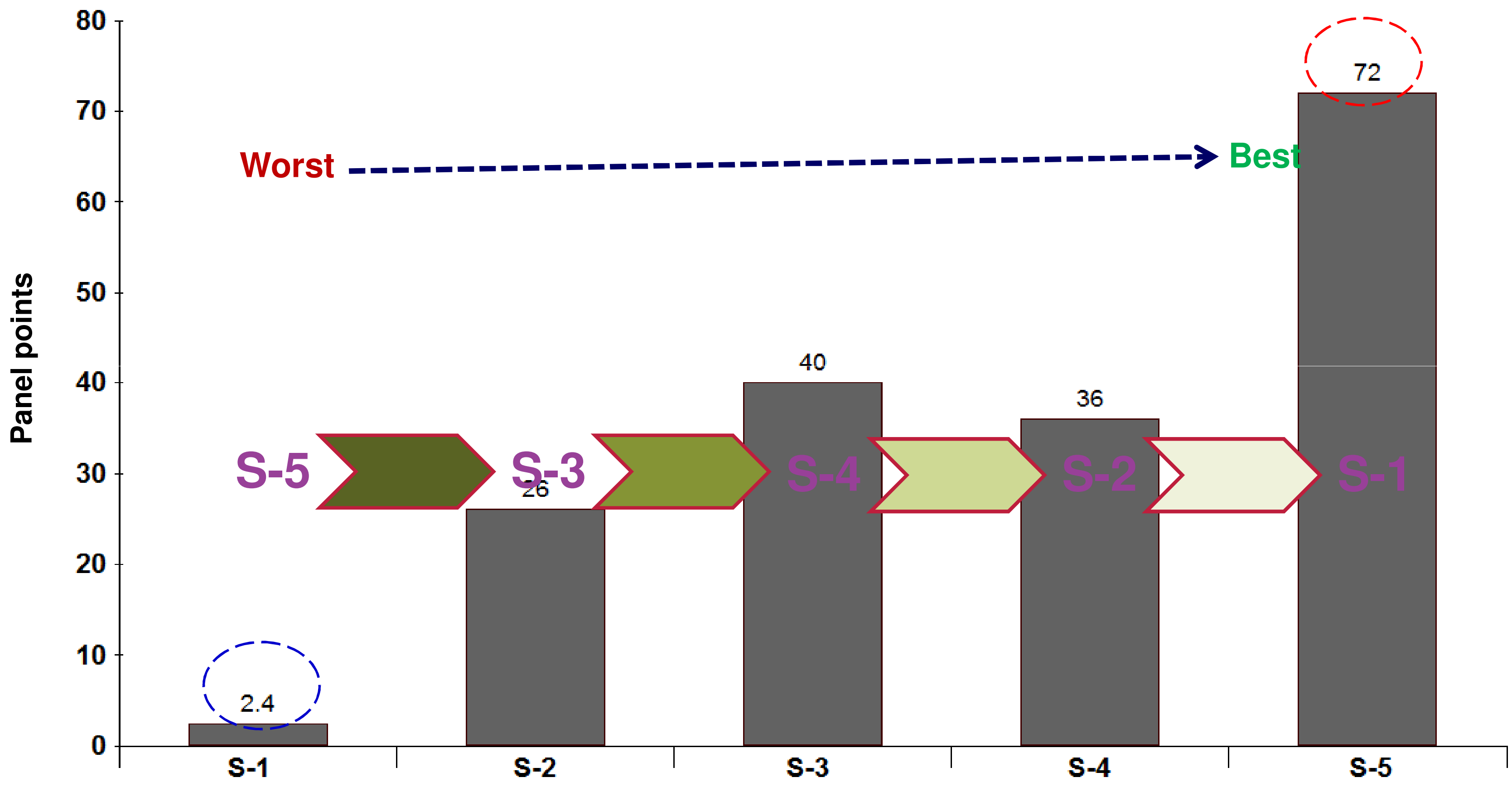
❑ Monterey method (Ecotax)



Weighting profiles of the studied scenarios using the Ecotax2002

Weighting / Grouping Methods

❑ **Panel method**



Weighting profiles of the studied scenarios using Canadian panel method

Summary of the Weighting Methods Results

	Ecotax2002	Panel Method	Characterization Factors	Overall Ranking	
Worst	S-3	S-5	S-5	S-3	*Sanitary landfill*
	S-5	S-3	S-3/S-4	S-5	*Aerobic/Drying beds*
	S-4	S-4	S-4/S-3	S-4	*Anaerobic/BFP*
	S-2	S-2	S-2	S-2	*Anaerobic/Drying beds*
Best	S-1	S-1	S-1	S-1	*Storage lagoon*

Conclusion

- The application of aerobic digestion shows a highly negative environmental impacts, while the application of anaerobic digestion shows a significant improvement.

- The application of composting process using rice straw as a bulking agent has a significant improvement in many environmental categories.

- The first scenario is the highest environmentally preferable alternative, while the third scenario turned out to be the worst.

Thank You

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DAAD
Deutscher Akedemischer Austausch Dienst
German Academic Exchange Service

Classification

Classification of environmental intervention to their related impact category

Impact category	Relevant Interventions		Indicator
Depletion of abiotic resources (ADP)	**Resources:**	lignite, hard coal, natural gas, crude oil, uranium, raw phosphate, lead, iron, copper, nickel, chromium ore, zinc, bauxite, sulphur, potash ......etc	kg Sb-eq
Climate change (GWP)	**Air:**	CO_2, CH_4, N_2O , Halocarbons	kg CO_2-eq
Acidification (AP)	**Air:**	NH_3, NO_x, SO_2, HCl, HF	kg SO_2-eq
Eutrophication (EP)	**Water:**	P species, N species, COD/TOC	kg PO_4-eq
	Air:	NH_3, NO_x	
Human toxicity (HTP)	**Air:**	Cd, Cr, Cu, Hg, Ni, Pb, Zn, NH_3, NOx, SO_2, HCl, HF, PM_{10}, benzene, CH_2O, PAH, PCDD/PCDF, etc	kg DCB-eq
	Water:	Cd, Cr , Cu, Hg, Ni, Pb, Zn, etc	
	Soil:	Cd, Cr, Cu, Hg, Ni, Pb, Zn , etc	
Freshwater ecotoxicity (FATP) Terrestrial ecotoxicity (TATP)	**Air:**	Cd, Cr, Cu, Hg, Ni, Pb, Zn, HF, benzene, PAH, PCDD/PCDF , etc	
	Water:	Cd, Cr, Cu, Hg, Ni, Pb, Zn, F, etc	
	Soil:	Cd, Cr, Cu, Hg, Ni, Pb, Zn , etc	
Photochemical oxidation (POFP)	**Air:**	CO,NO_x, VOCs,CH_4,, C_2H_2, etc	kg ethylene
Stratospheric ozone depletion (ODP)	**Air:**	1,1,1-trichloroethane, tetrachloroethene, trichlorofluoromethane, halons, etc	Kg CFC-11- eq

(R: resources, W: emission to water, A: emission to air, S: emission to soil)

Impact Categories and Method of Assessment

Impact category	Units	LCIA method
Abiotic depletion (ADP)	kg Sb eq	CML 2001
Acidification (AP)	kg SO_2 eq	"
Eutrophication (EP)	kg PO_4 eq	"
Global warming (GWP)	kg CO_2 eq	"
Fresh water aquatic ecotoxicity (FWETP)	kg p-DCB	"
Terrestrial ecotoxicity (TETP)	kg p-DCB	"
Human toxicity (HTP)	kg p-DCB	"
Stratospheric ozone depletion (ODP)	Kg CFC-11 eq	"
Photochemical oxidation (POFP)	kg ethylene	"
Cumulative energy demand (CED)	MJ	

Normalization Data

$$N_c = \frac{IR_c}{R_c}$$

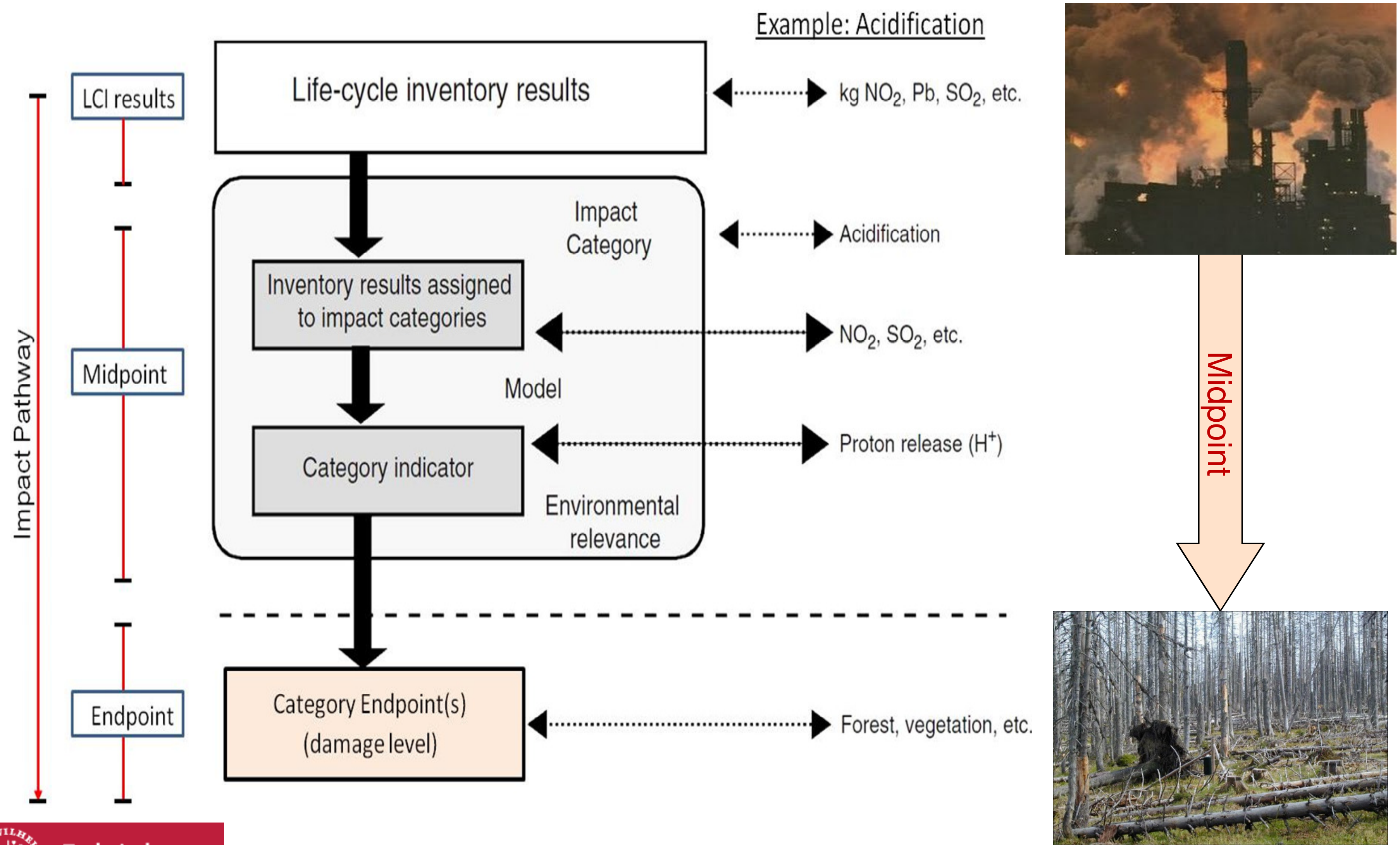
IR_c : score of characterization indicator of category c

R_c: reference value of category c

Impact category	World 2000	World 1995	Germany 2004	Units
Climate change (GWP_{100})	**6,864**	7,280	12,202	kg CO_2-eq/(pe·a)
Acidification (AP_{100})	**52**	57	14	kg SO_2-eq/(pe·a)
Eutrophication (EP)	**10**	23	6.50	kg PO_4-eq/(pe·a)
Human toxicity ($HTP_{infinite}$)	**1,455**	10,017	7,266	kg DCB-eq/(pe·a)
Freshwater ecotoxicity (FATP)	**5.04**	358	89	kg DCB-eq/(pe·a)
Terrestrial ecotoxicity (TETP)	**8.36**	47.2	70	kg DCB-eq/(pe·a)
Depletion of abiotic resources (DAP)	**1,278**	28	33	kg Sb-eq/(pe·a)
Photochemical oxidation (POFP)	**58**	16.8	-	kg C_2H_2-eq/(pe·a)
Stratospheric ozone depletion (ODP)	**0.03**	0.09	-	kg CFC-11-eq/(pe·a)

GWP emissions in Egypt have been changed from 2,124 kg CO_2-eq/(pe·a) in 1990 to 2,976 kg CO_2-eq/(pe·a) in 2000

Principle of Characterisation



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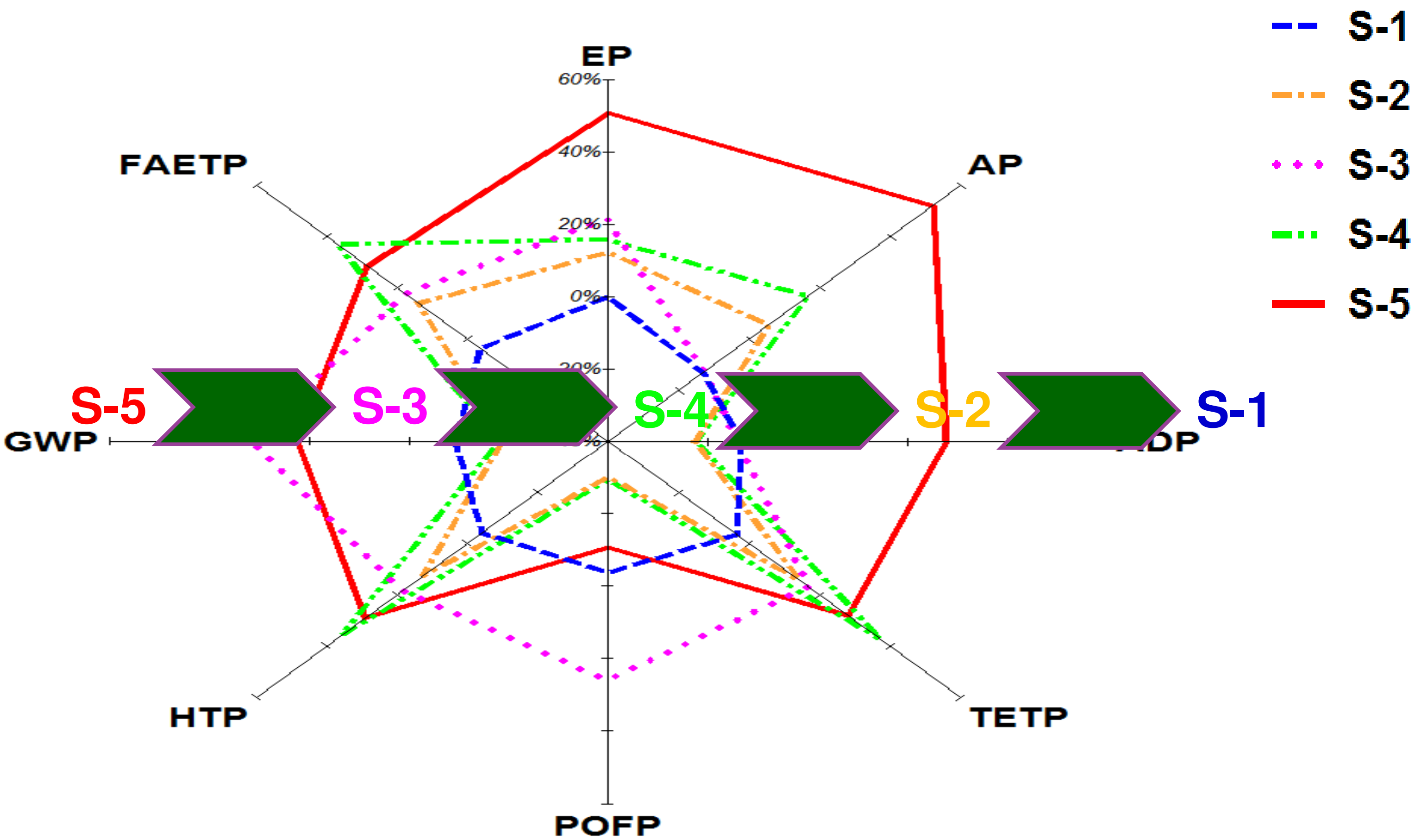
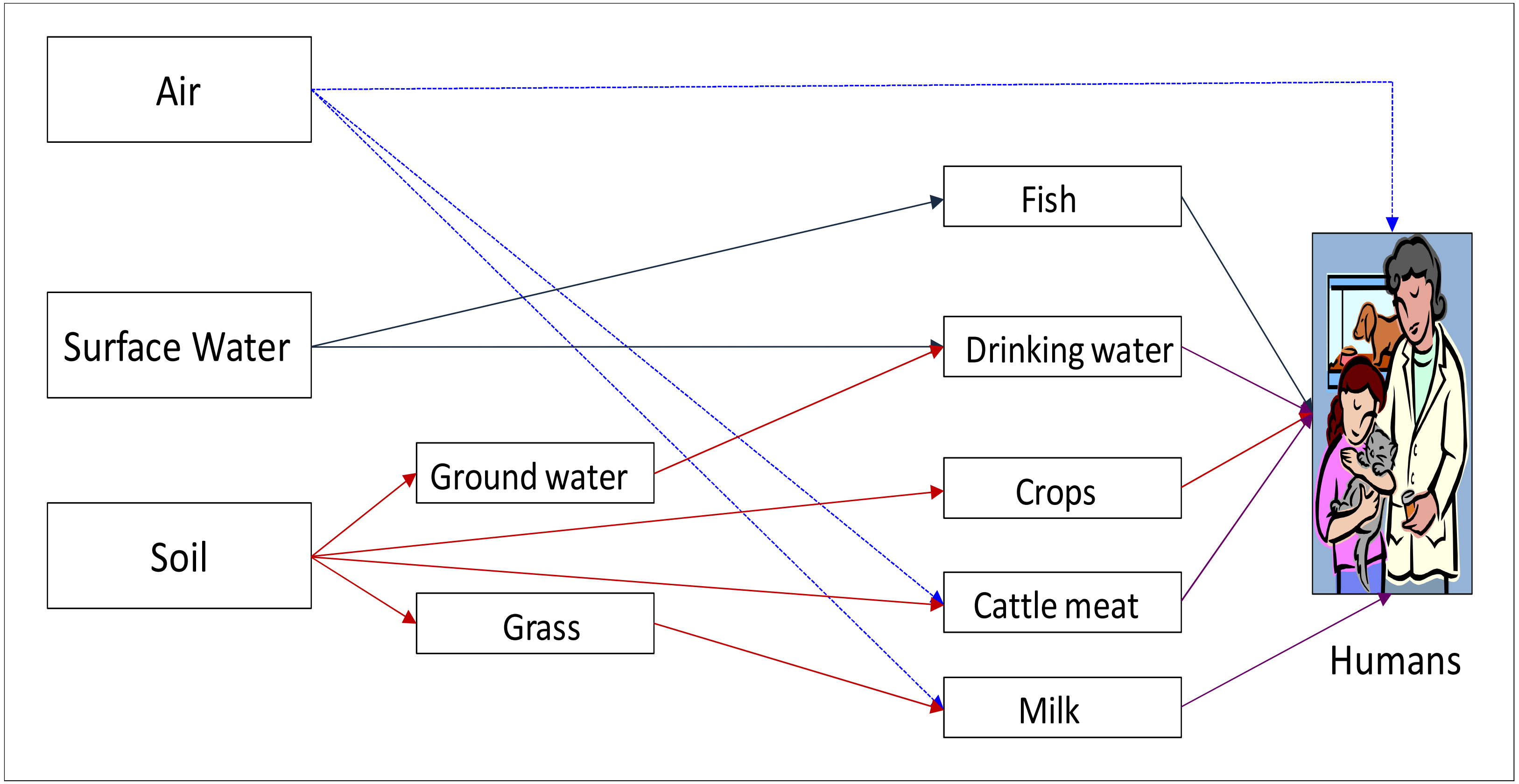
Environmental Impacts of Studied Senarios



Characterization results of all compared scenarios

Human Toxicity Potential (HTP)



Human exposure routes identified in USES

Weighting / Grouping Methods

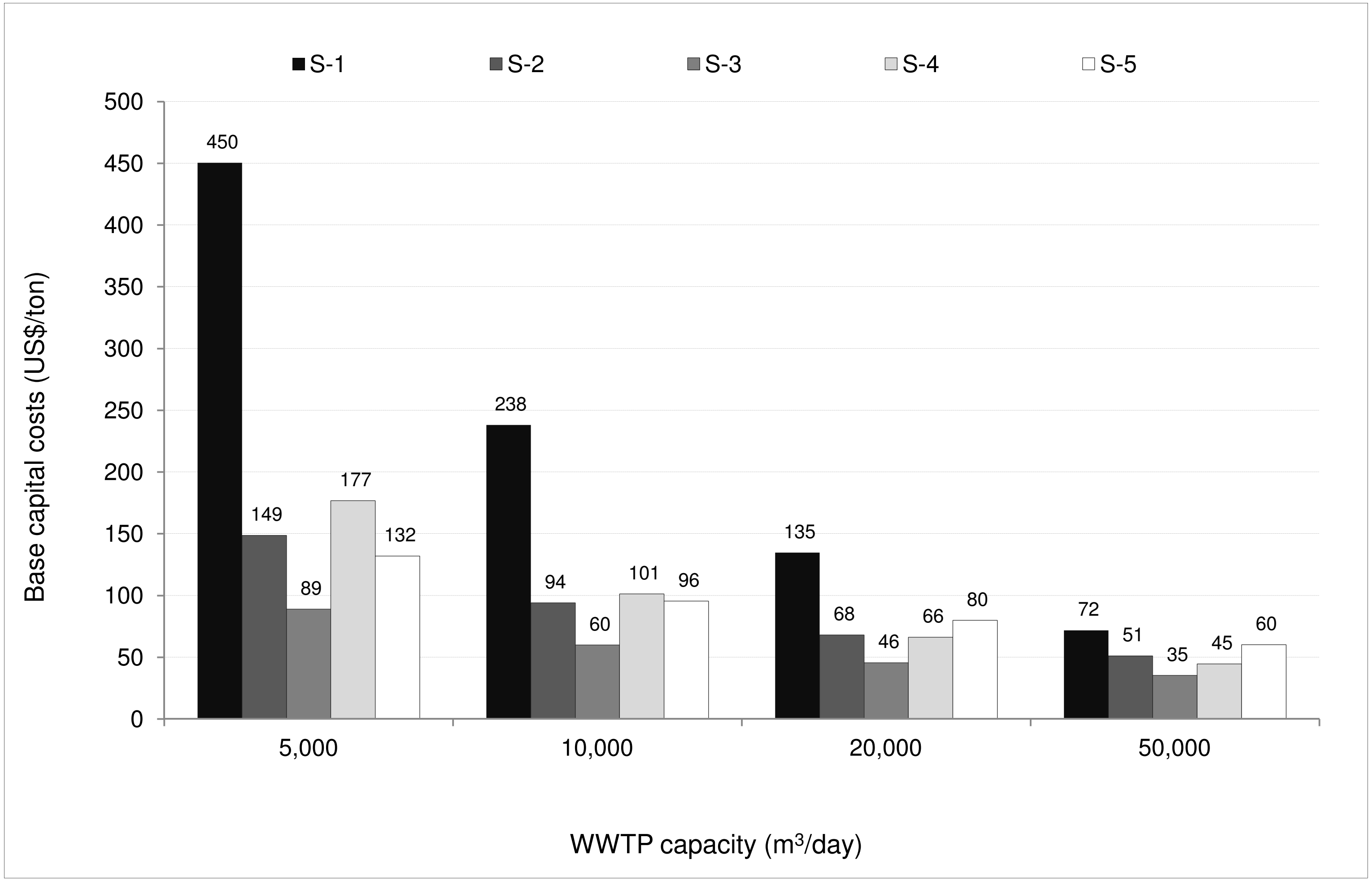
- Ecotax 2002 method

Impact category	Reference unit	Weight of reference
Abiotic depletion (ADP)	MJ eq	0.015 Euro/MJ
Acidification (AP)	kg SO_2 eq	1.5 Euro/kg
Eutrophication (EP)	kg PO_4 eq	2.85 Euro/kg
Global warming (GWP)	**kg CO_2 eq**	**0.063 Euro/kg**
Fresh water aquatic ecotoxicity (FWETP)	kg p-DCB	12.4 Euro/kg
Terrestrial ecotoxicity (TETP)	kg p-DCB	17.6 Euro/kg
Human toxicity (HTP)	kg p-DCB	17.6 Euro/kg
Stratospheric ozone depletion (ODP)	Kg CFC-11 eq	120 Euro/kg
Photochemical oxidation (POFP)	kg C_2H_2 eq	48 Euro/kg

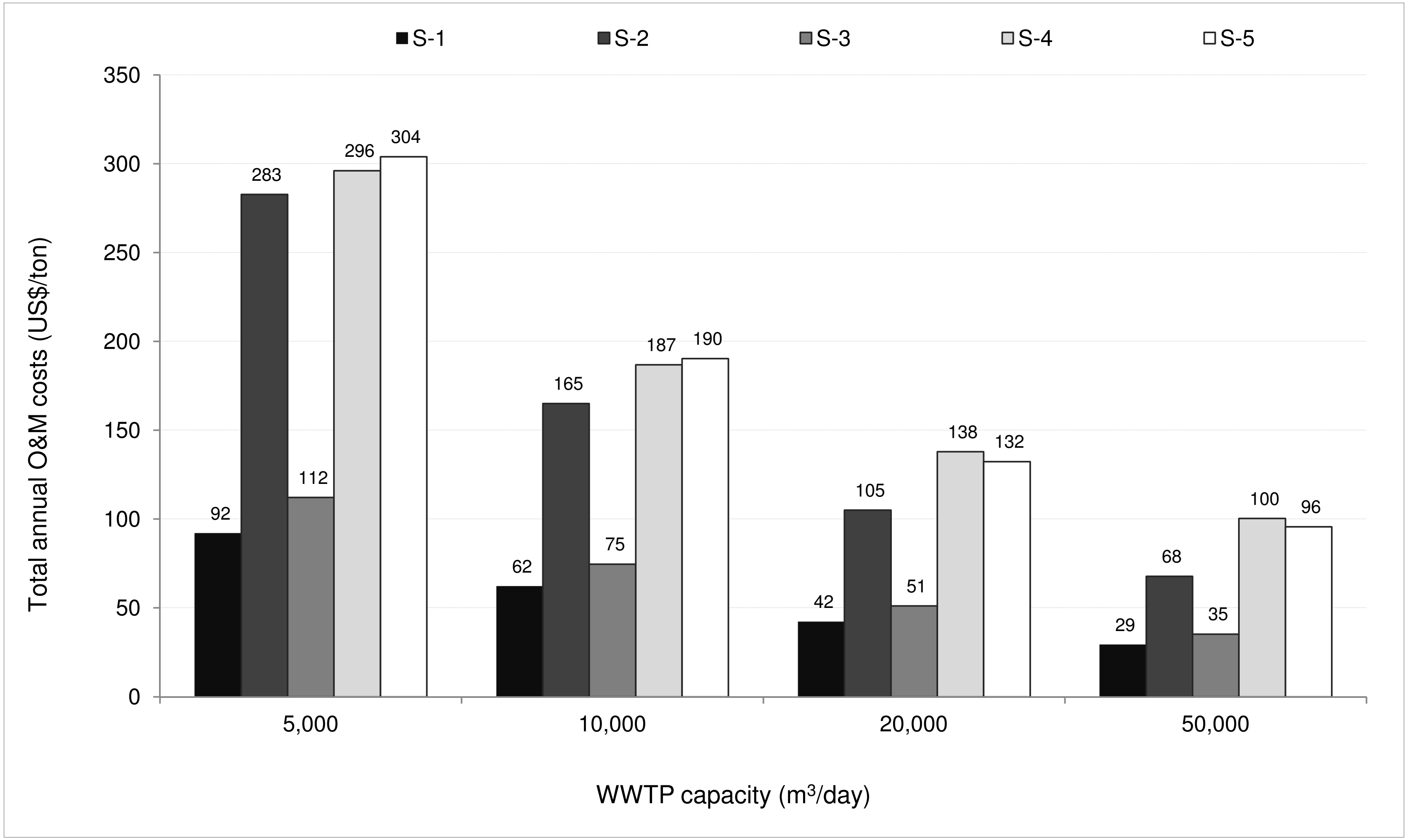
- Canadian citizens panel

Impact category	Weight (%)
Abiotic depletion (ADP)	12.9
Acidification (AP)	9.2
Eutrophication (EP)	7.9
Global warming (GWP)	**18.2**
Fresh water aquatic ecotoxicity (FWETP)	6.6
Terrestrial ecotoxicity (TETP)	6.6
Human toxicity (HTP)	8.5
Stratospheric ozone depletion (ODP)	13.1
Photochemical oxidation (POFP)	6.8
Land use	10.6

Base capital costs of the studied scenarios



Total annual O&M costs of studied scenarios



Area of Application of Studied Scenarios