



TRansition paths to sUustainable
legume-based systems in EEurope

Sustainable Development Indicators: ENVIRONMENT

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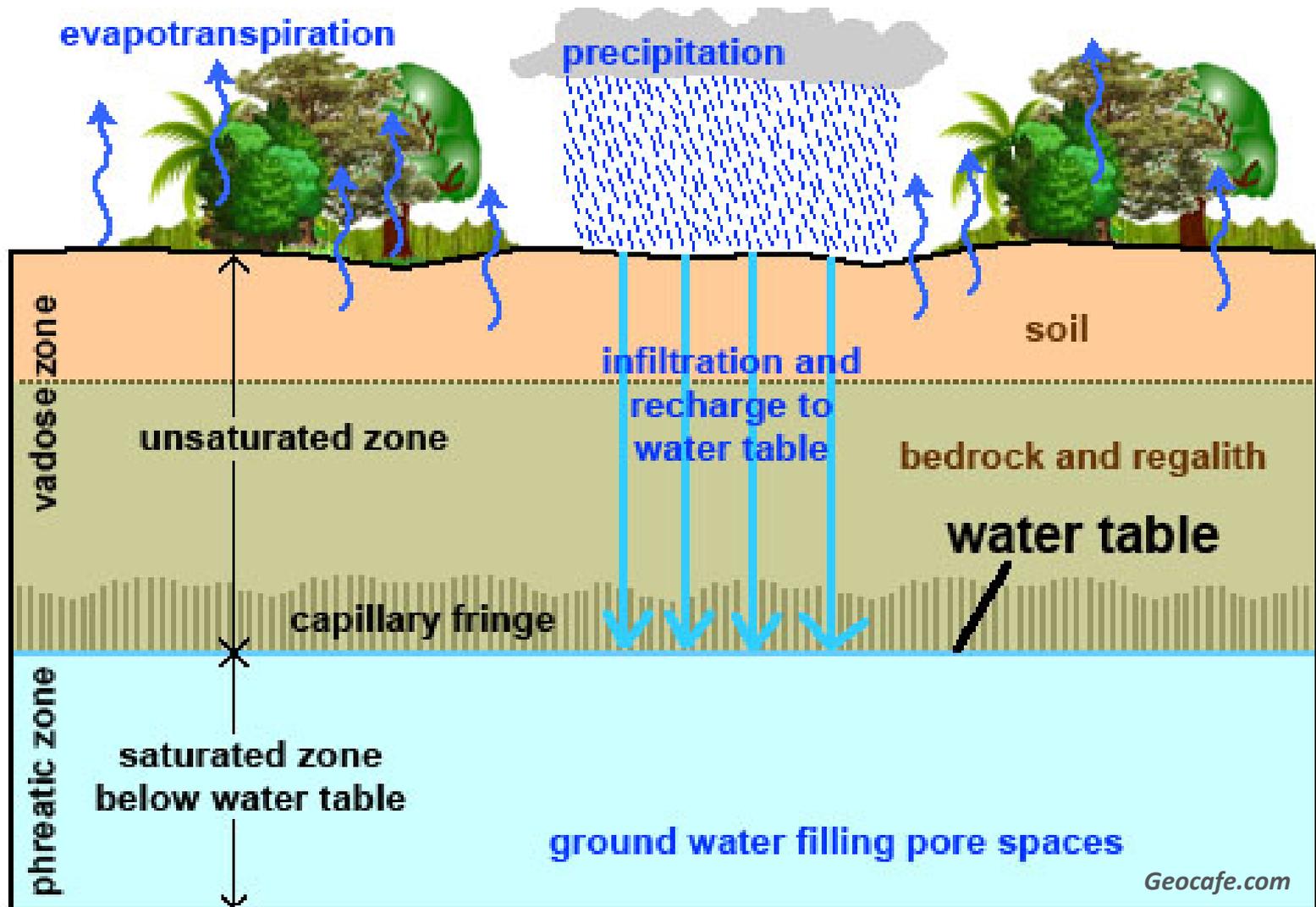
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**The James Hutton Institute,
Scotland, UK**

Monday 16th September, Ljubljana

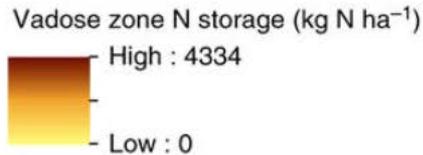
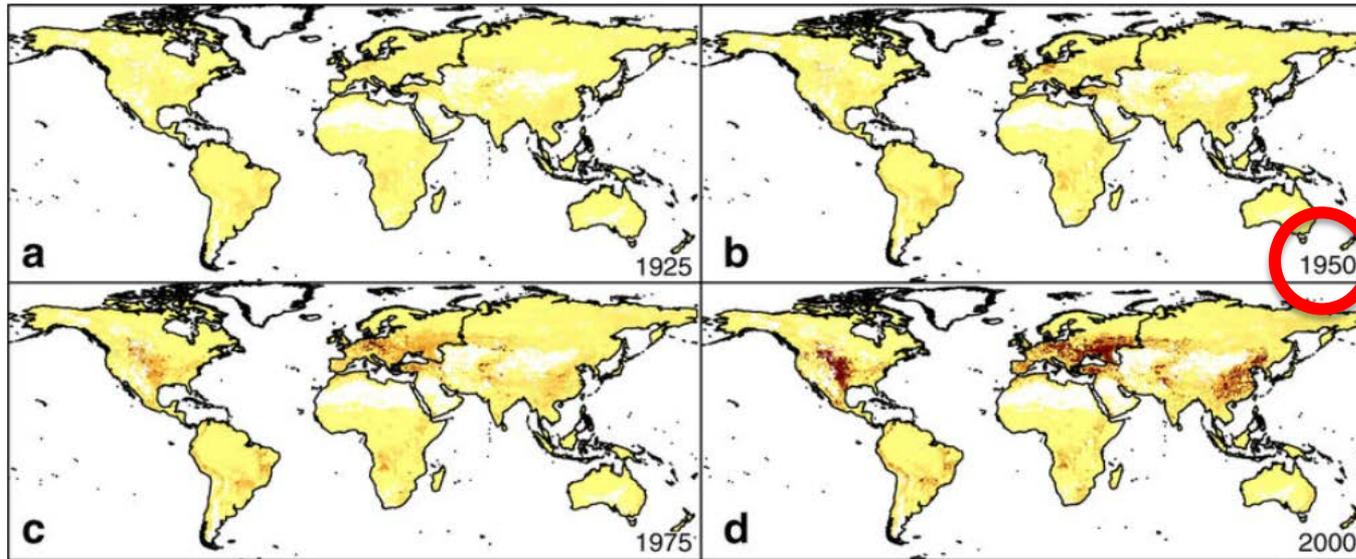


“The nitrate time-bomb”



“The nitrate time-bomb”

From: Global patterns of nitrate storage in the vadose zone



Since synthetic nitrogen fertilisers were introduced (ca 1950) levels of nitrate in the vadose layer have increased dramatically to levels over 4.3 t ha^{-1}

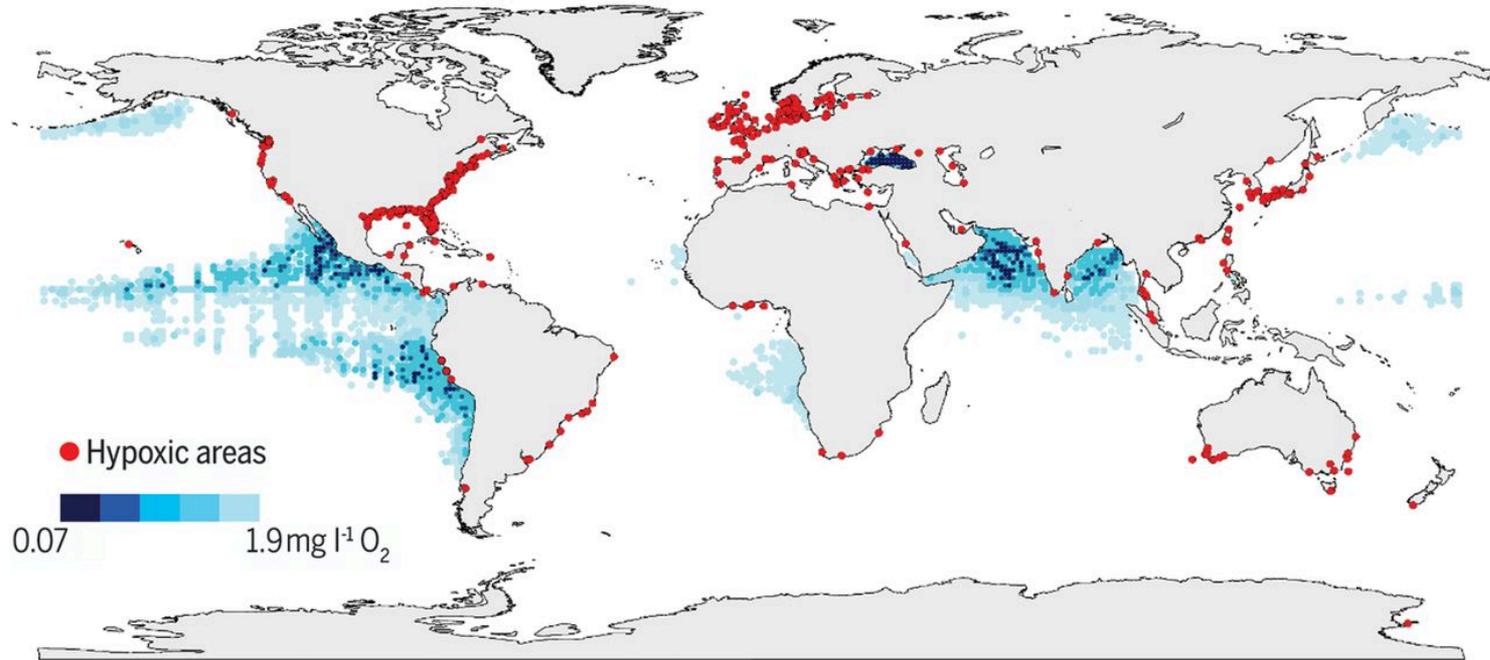
Spatial distribution of nitrate stored in the vadose zone. Global vadose zone N storage (in kg N ha^{-1}) is shown for 1925 (a), 1950 (b), 1975 (c) and 2000 (d)



Such eutrophication helps deoxygenate open ocean and coastal waters



Severe and negative impacts on biodiversity, biogeochemistry, food security



- blue shaded regions; oxygen-minimum zones at 300 m depth
- Red (dots): O₂ declines to <2 mg L⁻¹ (<63 μmol L⁻¹)

[Source: data and map by R. Diaz and GO2NE Network (respectively), available from World Ocean Atlas, 2009]

See also: Breitburg et al., (2018) Declining oxygen in the global ocean and coastal waters. *Science* 359(6371), DOI: 10.1126/science.aam7240



Habitat loss & pesticide use = biodiversity loss



Warning of 'ecological Armageddon' after dramatic plunge in insect numbers

Three-quarters of flying insects in nature reserves across Germany have vanished in 25 years, with serious implications for all life on Earth, scientists say



▲ Flying insects caught in a malaise trap, used by entomologists to collect samples. Photograph: Courtesy of Entomologischer Verein Krefeld

- German reserves (“protected areas”)
 - **over 75 % decline in 27 y**
- The main factors are suggested as:
 - **habitat conversion (loss)**
 - **pesticides**
 - *perhaps* also climate change

[Hallmann et al., \(2017\) PloS One, 12](#)

The Guardian (UK newspaper) Oct 18th '17





Q: Why not aspire to 'neutral-nitrogen' farming?

NEWS AGRICULTURE, CLIMATE, POLLUTION

Fertilizer produces far more greenhouse gas than expected

Farmers' overuse of nitrogenous additives may explain puzzling emissions

BY BETH MOLE 5:31PM, JUNE 9, 2014

Excess fertiliser can exponentially boost the emissions of microbes

[Shcherbak *et al.*, \(2014\). Global meta-analysis of the nonlinear response of soil nitrous oxide \(N₂O\) emissions to fertilizer nitrogen. *Proceedings National Academy Sciences* **111**, 9199.](#)



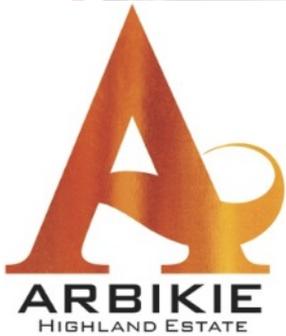
We can do the same things differently



Kirsty Black, master distiller and distillery manager at Arbikie Highland Estate



Alcohol from 100% beans
(peas, faba & lentils)



Distilling 'pot-ale' co-product

- Protein isolated for human food with www.horizonproteins.com

CoolBeans™ registered

40% whole bean beer



Spent barley/bean grains

- Until now brewers pay for uplift (used as fuel)
- Now trialled as animal feed
- Developed as human food (in Canada)



GHG Emission Inventories: Scope-1, -2 & -3



Scope 1 - sources owned or controlled by the company;

Scope 2 - associated with purchased energy; and,

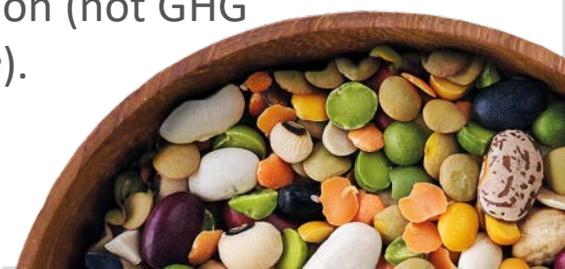
Scope 3 - sources not *directly* controlled by the company.

CO ₂ e breakdown by "Scope"		
Scope	Brewing Corporations	
	Belgian	Canadian
1	7	15
2	8	39
3	85	46

Mainly accounted for by:

- agriculture;
- synthetic fertiliser use;
- transportation; and,
- malting barley.

Yet, global brewers & distiller member of the *Sustainable Agriculture Initiative* www.saiplatform.org and appear focused on more-efficient alcohol production (not GHG reduction *per se*).



One approach to impact assessment is :

Life Cycle Analysis

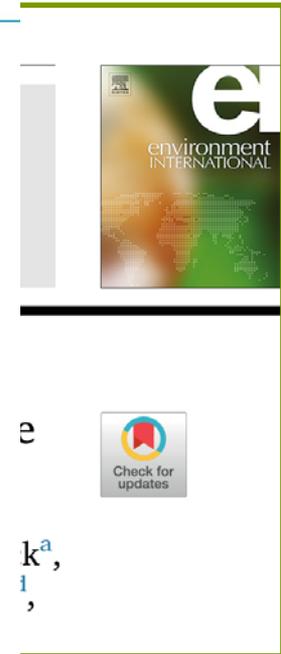
research highlights



Just the tonic! Legume biorefining for Europe's protein deficit and mitigate

Theophile Lienhardt^{a,b}, Kirsty Black^{c,d,e,f}, Sophie Robert M. Rees^h, Michael Williams^g, Charles S. David Styles^{a,b,*}

AGRICULTURAL EMISSIONS
Benefits of a pea and tonic
Environ. Int. **130**, 104870 (2019)



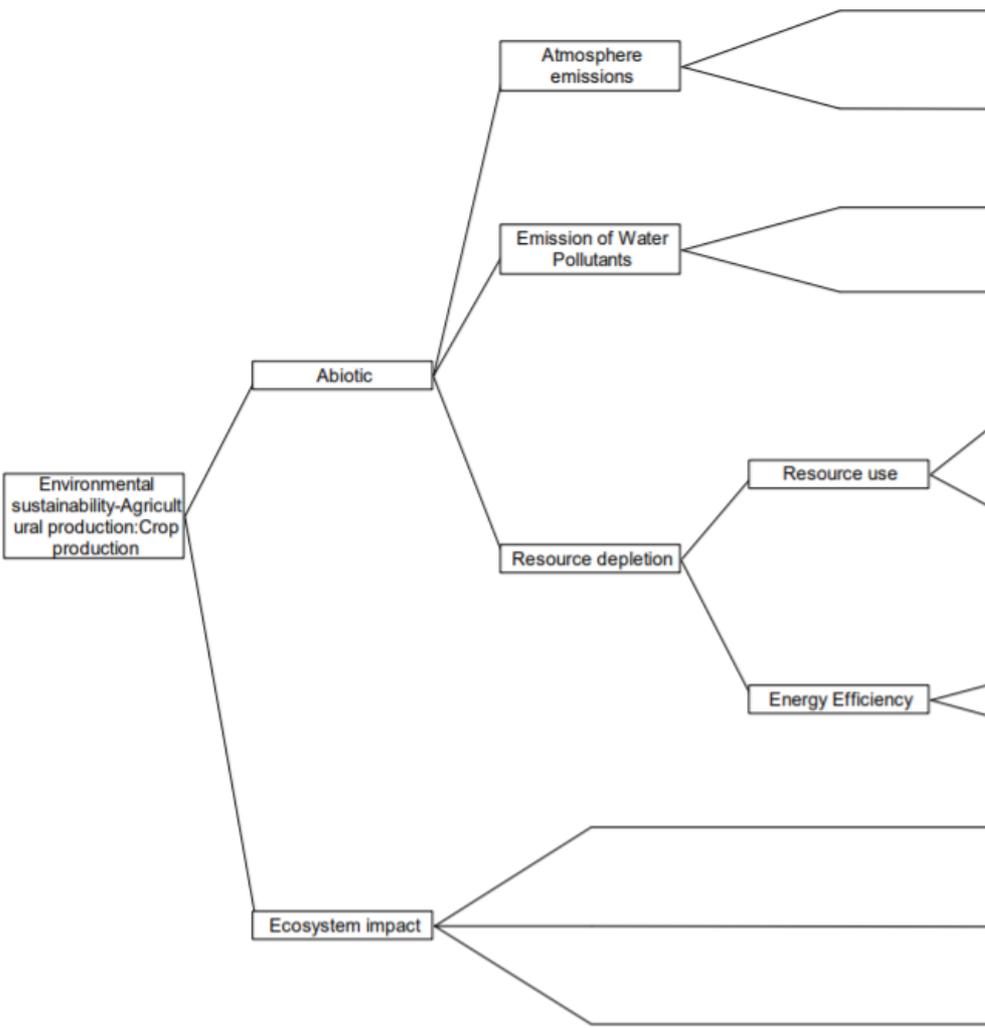


The TRUE ‘Decision Support System’:

- is not simply single-product focused but considers **the whole-system**
- **Must define sustainable development indicators**
 - within each of the **three pillars**
 - Across the value-chain broken down in **5 nodes**



1- Crop Production



Atmospheric emissions (GHG)

CO₂ - CH₄ - N₂O - NO_x

- kg CO₂e Mg product DW⁻¹

Other air pollutants

- kg Mg product DW⁻¹

Nitrogen & phosphorous fertiliser Use

- kg (total) Mg product DW⁻¹

- kg synthetic Mg product DW⁻¹

- % surplus N & P

- % from renewable source

Ground and surface water extraction

- Irrigation req. / type (no, med., high)

Fuel consumption / type

- L Mg product DW⁻¹

- % renewable

Land use-efficiency & -type

- m² y⁻¹ Mg product DW⁻¹

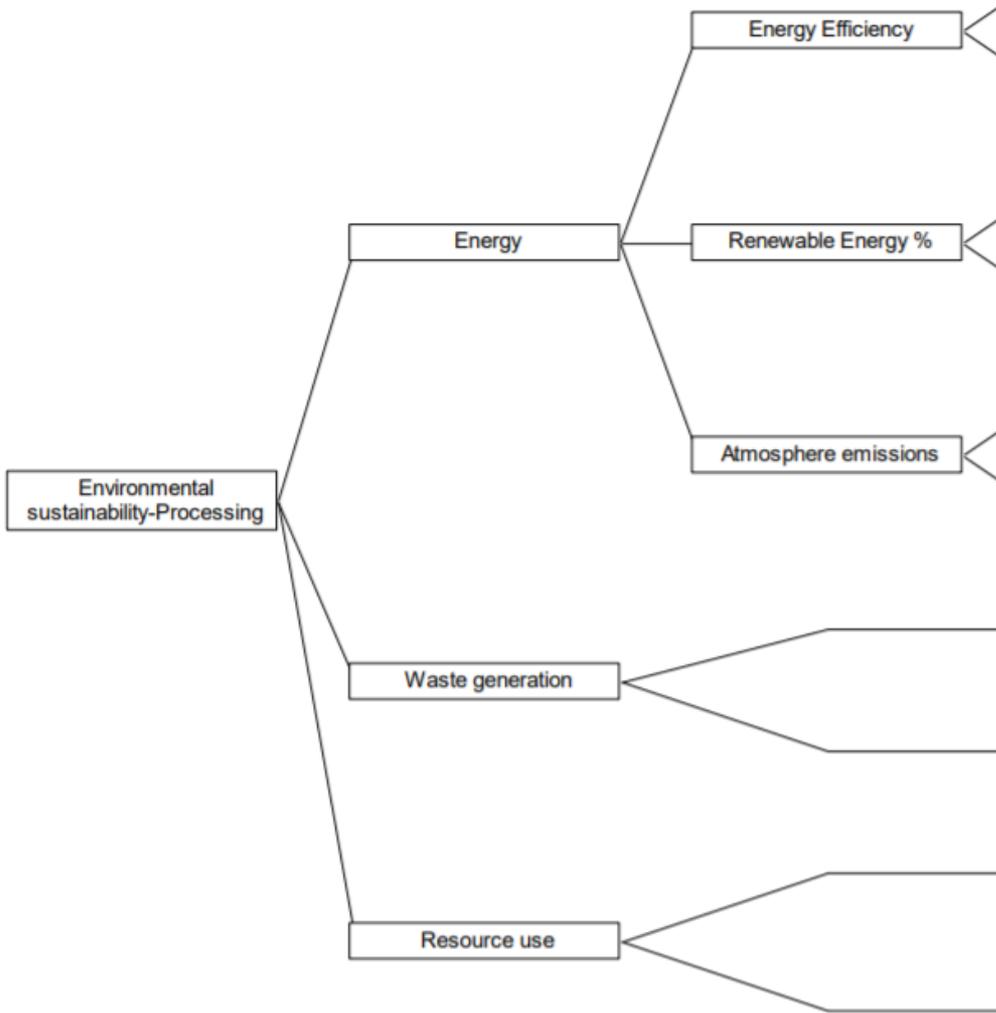
- Structural diversity (low, med, high)

Soil

- % organic matter



2 - Processing



Electricity Use

- kWh (total) Mg product DW⁻¹
- % renewable

Fuel consumption / type

- MJ (total) Mg product DW⁻¹
- % renewable

Atmospheric emissions

CO₂ - CH₄ - N₂O - NO_x

- kg CO₂e Mg product DW⁻¹

Other air pollutants

- kg CO₂e Mg product DW⁻¹

Waste generation & handling

- % product loss
- % of loss recycled

Packaging

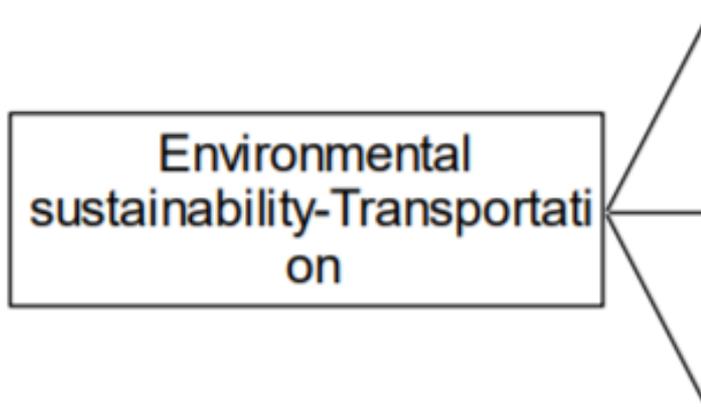
- % from renewables or recyclable

Ground and surface water extraction

- L Mg product DW⁻¹



3 – Transport & Distribution



Freight intensity

- Type (global air, oceanic, EU, regional)
- kg CO₂e Mg product DW⁻¹

Atmospheric emissions

CO₂ - CH₄ - N₂O - NO_x

- kg CO₂e Mg product DW⁻¹

Other air pollutants

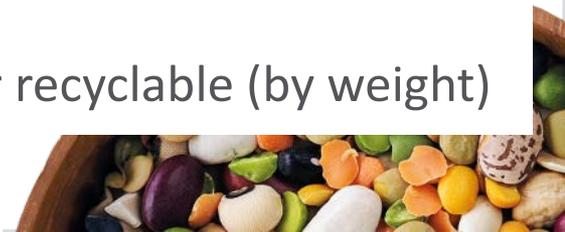
- kg CO₂e Mg product DW⁻¹

Losses/waste

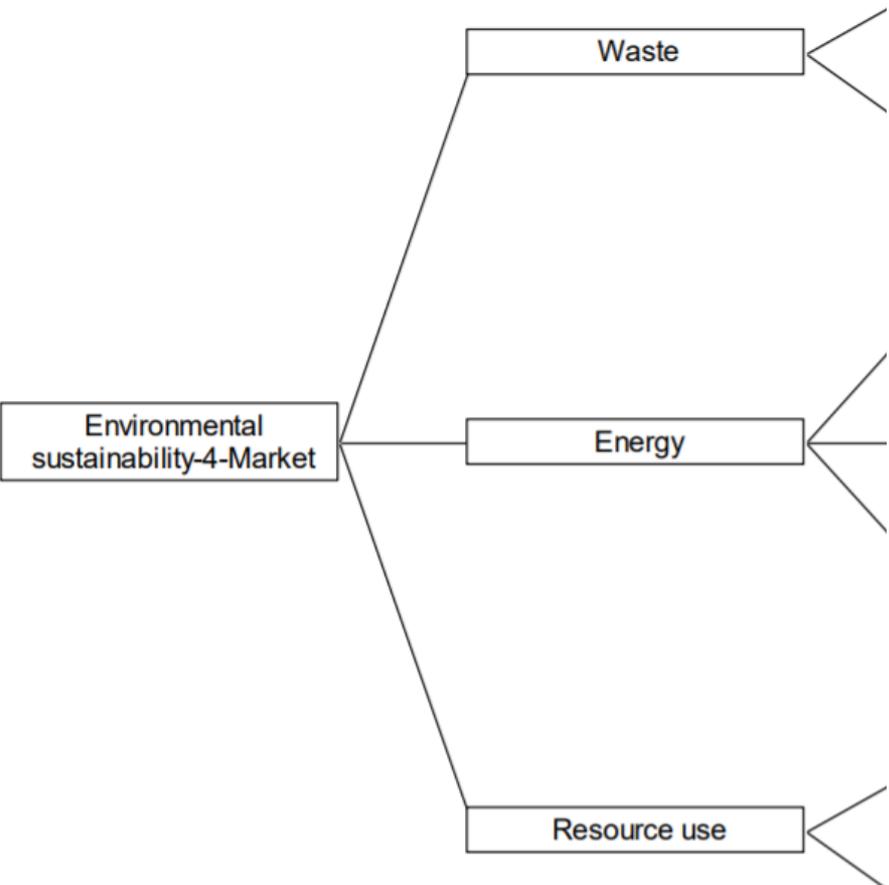
- % product loss
- % recycled

(Packaging)

- % from renewables or recyclable (by weight)



4 - Markets & Retailers



Losses/waste

- % product loss
- % recycled

Energy Efficiency

- Storage type (energy use indicator)
- kg CO₂e Mg product DW⁻¹
- % from renewables

Atmospheric emissions

CO₂ - CH₄ - N₂O - NO_x

- kg CO₂e Mg product DW⁻¹

Other air pollutants

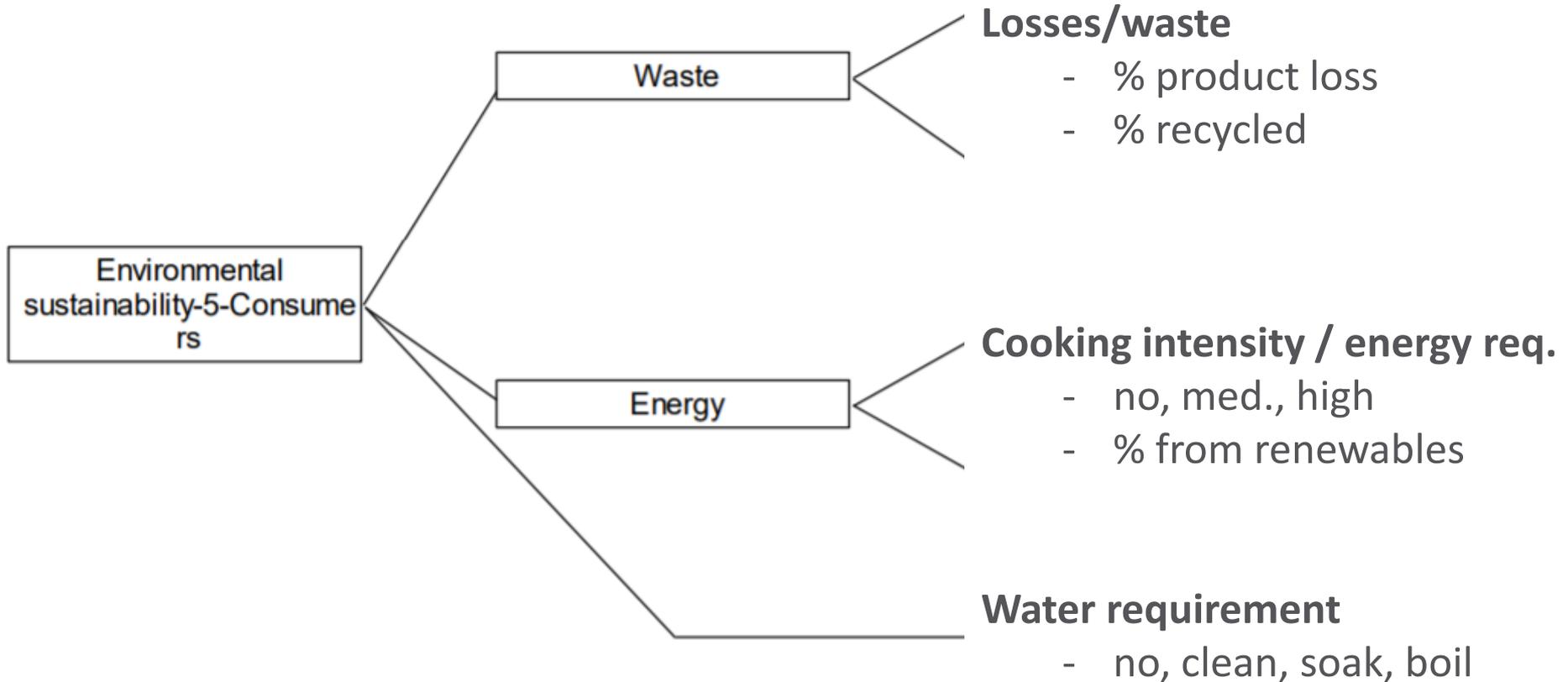
- kg CO₂e Mg product DW⁻¹

Packaging

- Layers of packaging (number, 0, 1, >1)
- % from renewables or recyclable (by weight)



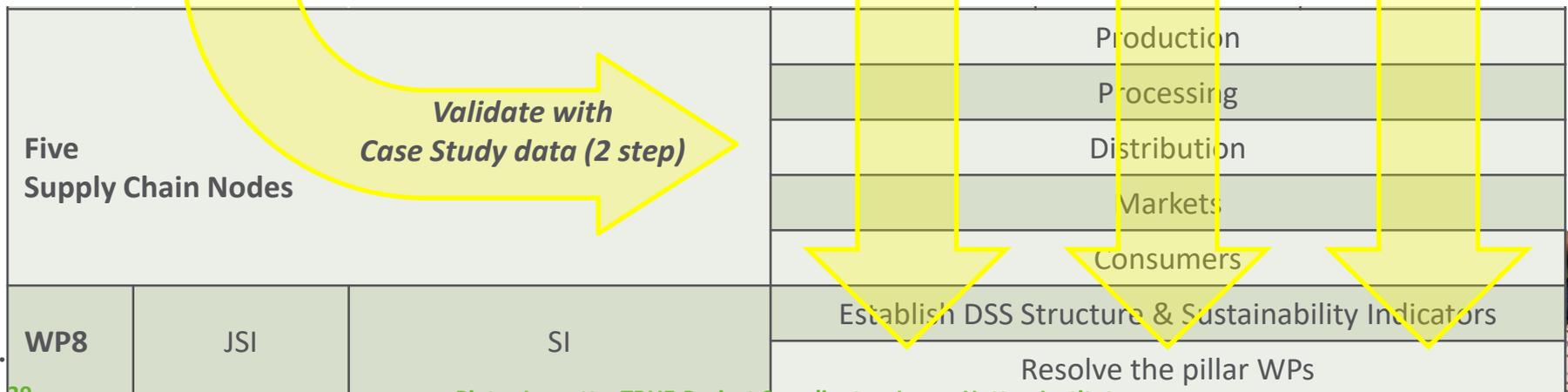
5 - Consumers



Decision Support System, Jožef Stefan Institute



Pillar Work Packages		
5 (Environment)	6 (Economics)	7 (Policy & Gov.)

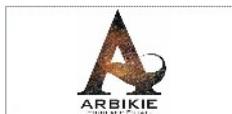


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