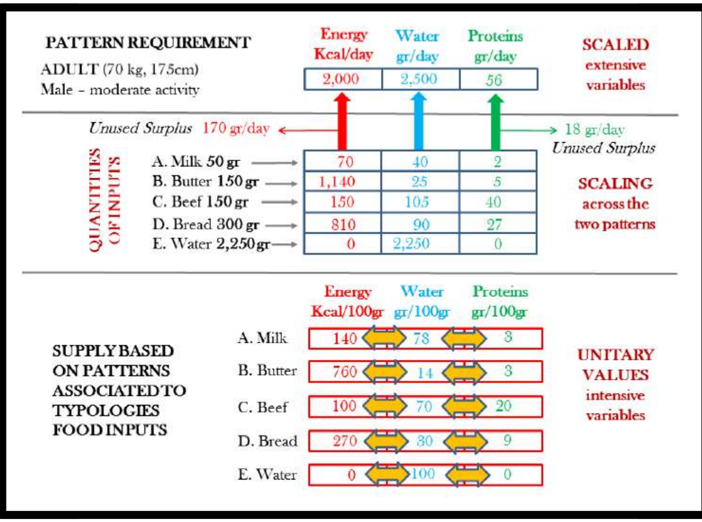
A new perspective on Water-Energy-Food Systems, in support of Sustainable Development Goal 2.

MAGIC Seminar, Brussels, 21st November 2019



The James Hutton Institute

MAGIC NEXUS

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 689669.

Welcome

- Aims
  - Introduce MAGIC project & its ‘societal metabolism’ approach
  - Demonstrate application to sustainable agriculture and SDG2
  - Discuss implications for understanding & governing interconnected systems

Keith Kerry Alba

- Housekeeping
  - Refreshments
  - Facilities
  - No fire alarm planned
  - Consent – photos and discussion notes

Agenda

12:45 – 13:15	**Welcome & Introductions** Overview of MAGIC project Introduction to Societal Metabolism approach Queries about method
13:15 – 13:45	**A new perspective on SDG2 via Societal Metabolism Analysis** Analysing agricultural sustainability in terms of environmental flows within EU Analysing agricultural sustainability in terms of consequences beyond the EU Considering nutrition, food security & hunger
13:45 – 14:15	**Discussion** Queries and discussion on method and its application to SDG2 Implications for understanding and governing agri-food systems

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Introducing MAGIC

- Moving Towards Adaptive Governance in Complexity: Informing Nexus Security”

  H2020, 2016-2020, www.magic-nexus.eu

- A Nexus Cluster project (water-energy-food systems)

- Objectives – EU policy focused

  “Increased understanding of how

  - *water management,*
  - *food and*
  - *biodiversity*

  policies are linked together and

  - *to climate*
  - *and sustainability goals”.*

Why consider a new method?

Appreciate that problems – and responses – are part of complex socio-ecological systems

Policy coherence key to sustainable development[1]

- e.g. agriculture underpins SDG2, also 13, 15,etc…

Resulting challenges

- Need to assess implications of any decision across multiple domains
- Need consistency - approaches that can operationalise sustainability assessment for a variety of systems
- Need to reflect on assumptions or implicit framings (e.g. efficiency as a solution)
- Need to offer & explore ideas for improving sustainability


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Science

World faces 'perfect storm' of problems by 2030, chief scientist to warn

Food, water and energy shortages will unleash public unrest and international conflict, Professor John Beddington will tell a conference tomorrow

Food and water shortages as a result of climate change and growing populations are likely to trigger mass

Must avoid resorting to partial views or "useful fictions"[2] in order to cope with "overwhelming systems"[3]

1. European Commission (2019). SWD(2019) 20 final. Commission staff working document. *2019 EU report on Policy Coherence for Development*. https://ec.europa.eu/europeaid/sites/devco/files/swd_2019_20_pcdreport.pdf

2. *Thinking fast and slow.* D. Kahneman (2011), Penguin

3. *Wickedness and the anatomy of complexity*. C. Andersson & P. Tornberg (2018), Futures, 95, 117-138

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Societal metabolism analysis – what can it offer?

- Builds holistic view
  - Connect across topics, disciplines and data
  - Recognise both biophysical and socio-technical limits
  - Zoom across scales – local to global, without losing interconnections
  - Look across systems – production, supply, consumption

- Insights
  - Characterise "Metabolic patterns" of society and systems – help flag where societal processes may be unsustainable in long-term
  - Compare different aspects of system – geographically *(e.g. regions)* or functionally *(e.g. different farm types within a country)*
  - Explore effect of hypothetical changes e.g. *"what if we ate less dairy"*

- Can help test policy framings, options, evidence or assumptions

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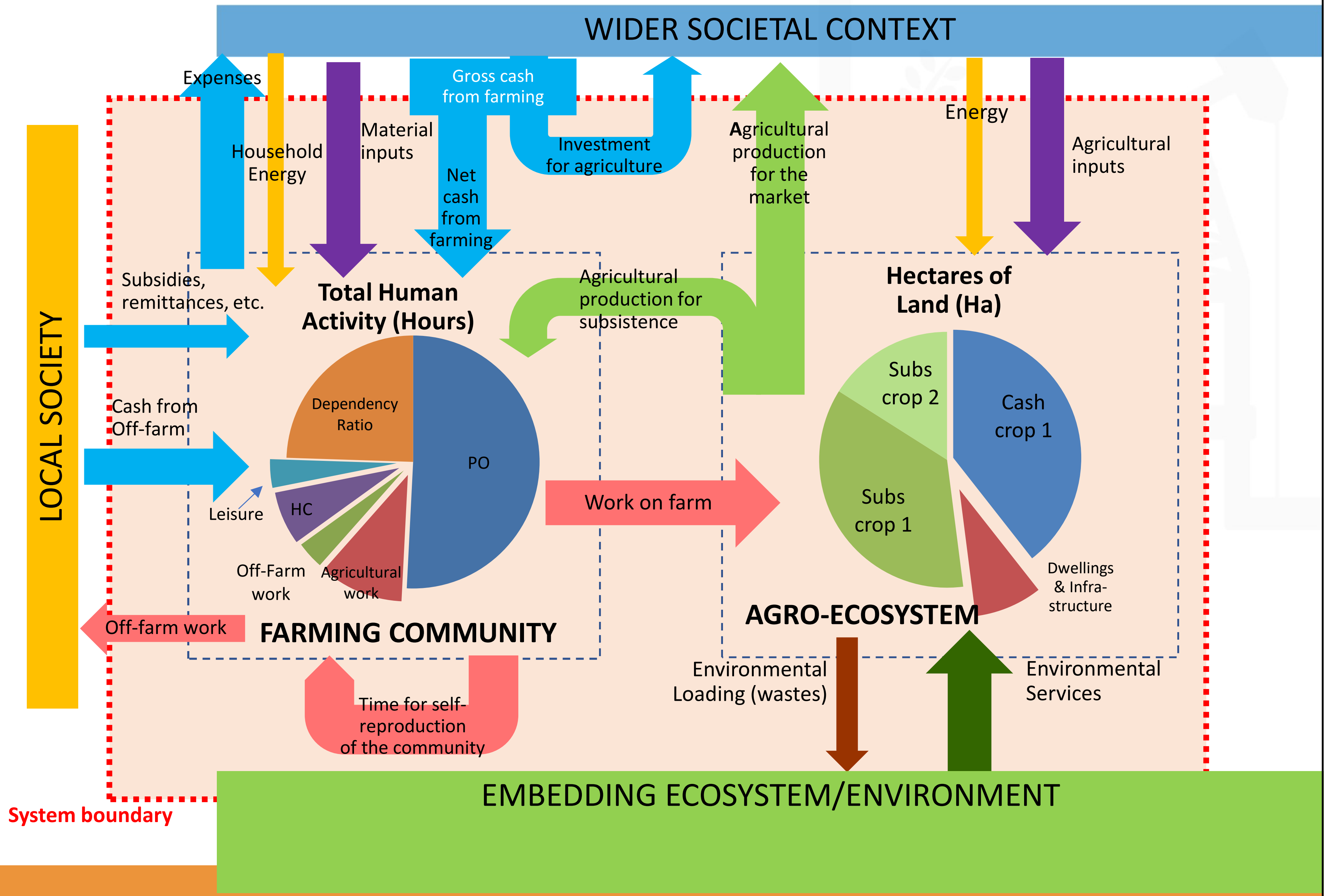
“Simple” example of a societal metabolism…



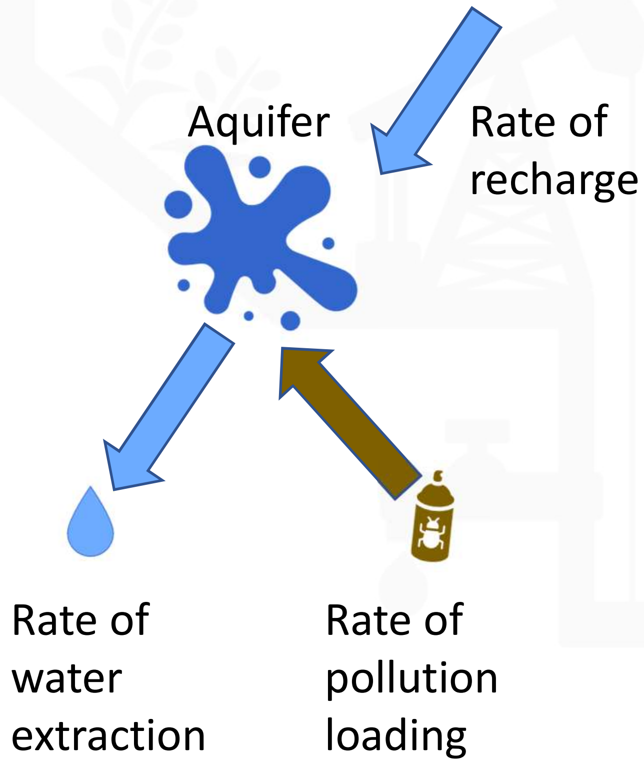
Key concepts – "Funds and Flows"

Funds

- Remain within the system (define its identity, need to be maintained)
- Examples – from environment and society
  - Land
  - People's time
  - Infrastructures
- Special case of funds when non-renewable – **Stocks**

Flows

- Resources entering or leaving system
- Examples – from environment and society
  - Nutrients
  - Energy carriers
  - Money
- Special case of flows when lacking utility – **Wastes** (account for to check circularity)



Organising the funds and flows

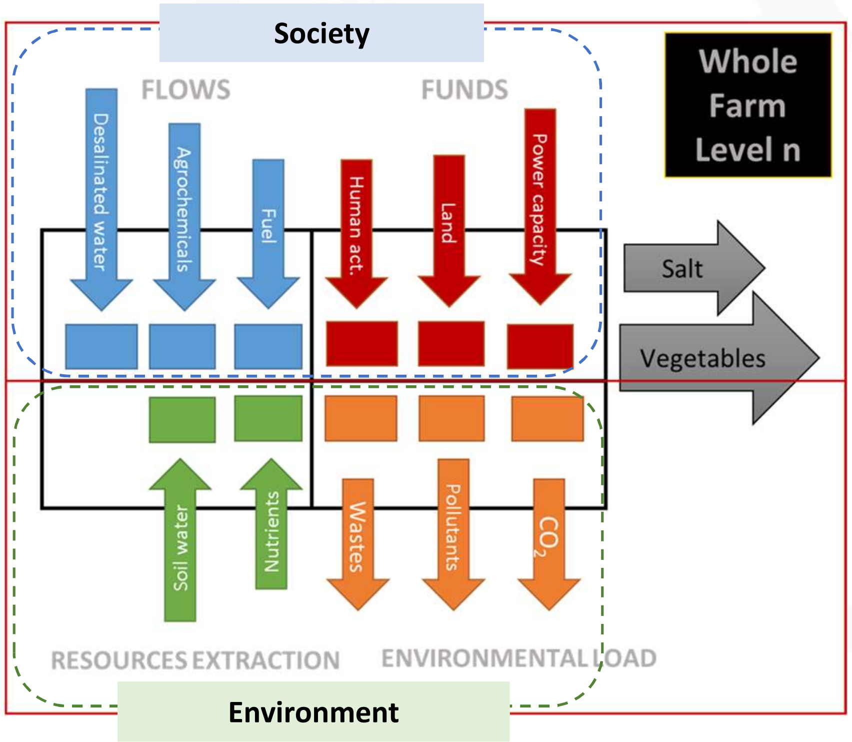
The "Processor"

An accounting framework
for 1 system (e.g. tomato farm)

Choices & challenges

1. What to represent: Focal issues, key resource types, connection of funds and flows

2. How to populate: Categorisation & combination of data sources

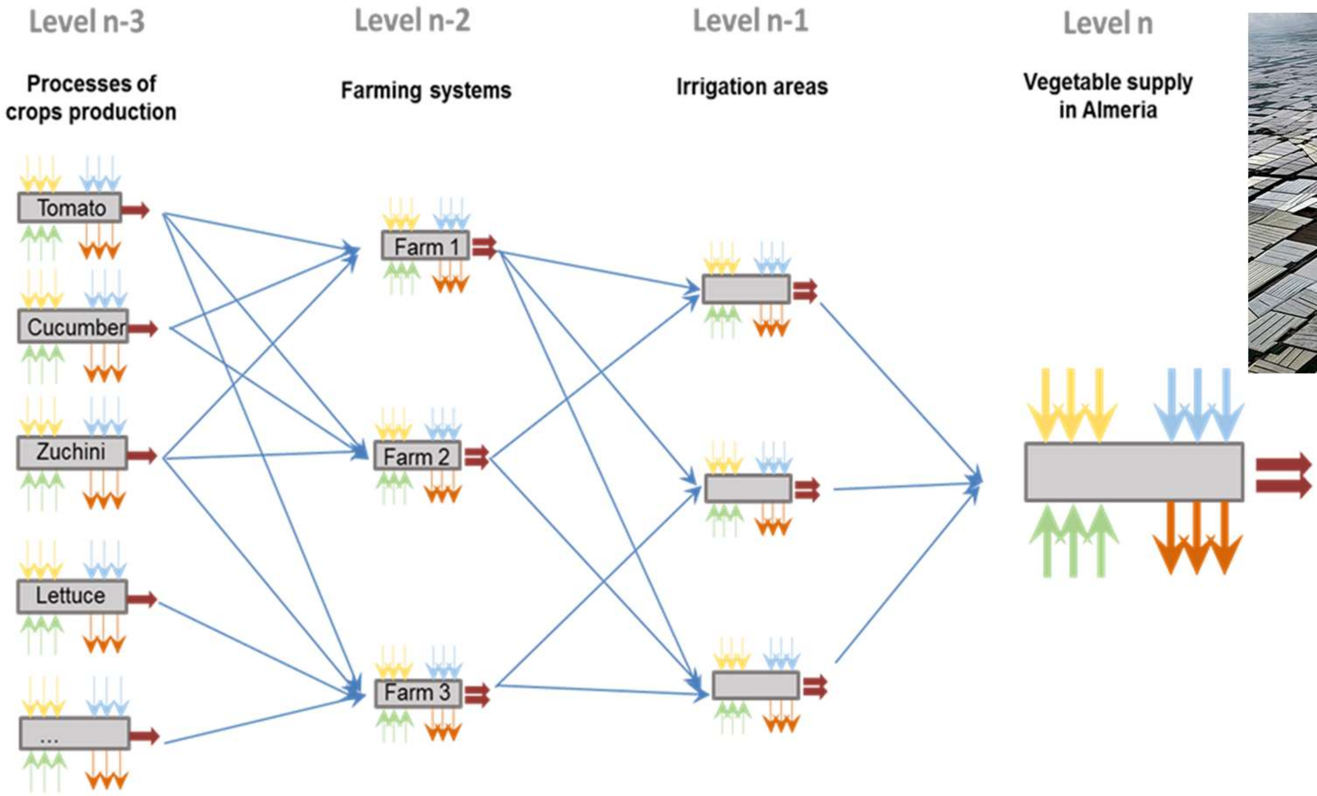


Simplified example 'processor' for high value cropping using desalinated water derived from wind energy in Canary Islands

*The accounting framework used in MAGIC is MuSIASEM (Multi-scale Integrated Analysis of Societal and Ecosystem Metabolism) – see Giampietro, M., Aspinall, R.J., Ramos-Martin, J., Bukkens, S., 2014. *Resource Accounting for Sustainability Assessment: The Nexus between Energy, Food, Water and Land use*. Routledge

Study systems across scales – processor networks

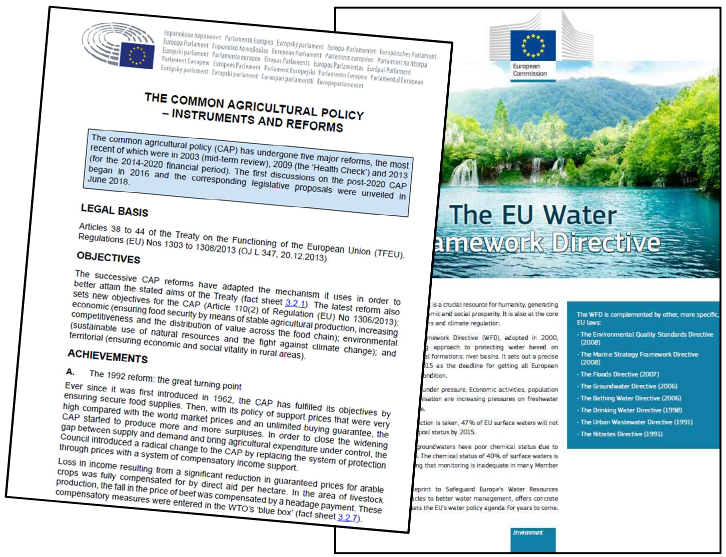
- Connect processors in ‘sequential pathways’
- Mix activities in entities (farms or farm systems) or geographical zones (basins, regions)



Bottom-up: Determined by lower level characteristics (per unit of land or output) ⇨ ⇦ *Top-down: Determined by the compatibility between bottom-up scaling of farming typologies and boundary conditions provided by the socio-economic (viability) and the environmental contexts (feasibility)*

Framing matters

- Systems are different depending on the level of analysis (functions, language, metrics etc)
- Potential interventions ALSO differ e.g. current agri-food policies
  - CAP & WFD mostly relate to sequential pathways & production systems.
  - No EU policy relating to societal demand (food policy?)



THE COMMON AGRICULTURAL POLICY – INSTRUMENTS AND REFORMS

The common agricultural policy (CAP) has undergone five major reforms, the most recent of which were in 2003 (mid-term review), 2009 (the 'Health Check') and 2013 (for the 2014-2020 financial period). The first discussions on the post-2020 CAP began in 2016 and the corresponding legislative proposals were unveiled in June 2018.

LEGAL BASIS

Articles 38 to 44 of the Treaty on the Functioning of the European Union (TFEU). Regulations (EU) Nos 1303 to 1308/2013 (OJ L 347, 20.12.2013).

OBJECTIVES

The successive CAP reforms have adapted the mechanism it uses in order to better attain the stated aims of the Treaty (fact sheet 3.2.1). The latest reform also sets new objectives for the CAP (Article 110(2) of Regulation (EU) No 1306/2013): economic (ensuring food security by means of stable agricultural production, increasing competitiveness and the distribution of value across the food chain); environmental (sustainable use of natural resources and the fight against climate change); and territorial (ensuring economic and social vitality in rural areas).

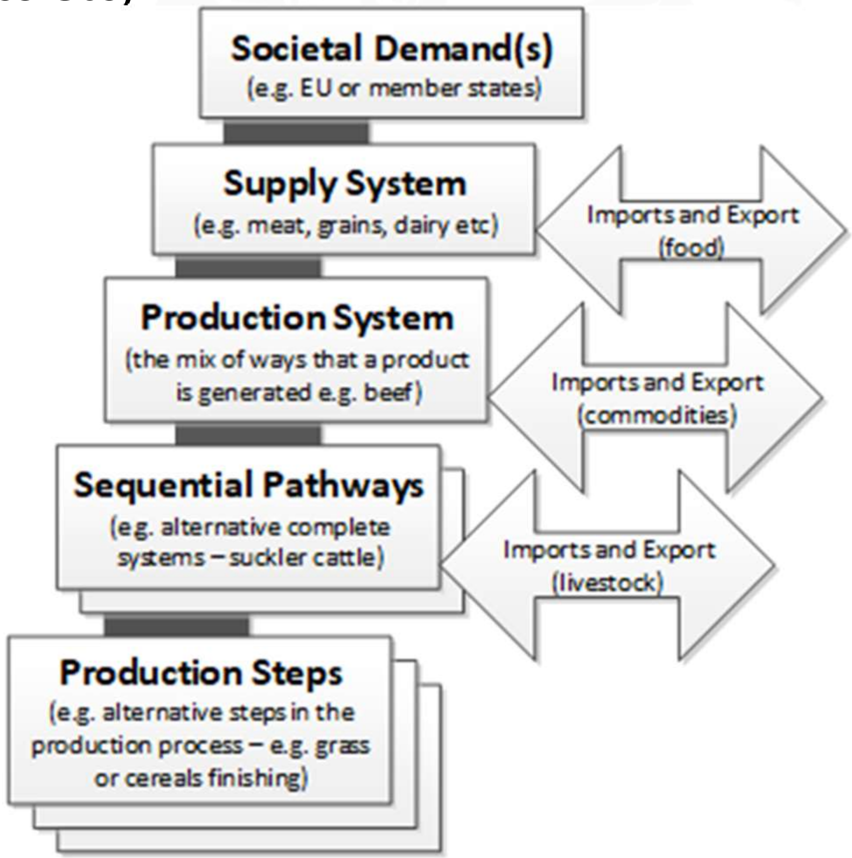
ACHIEVEMENTS

A. The 1992 reform: the great turning point

Ever since it was first introduced in 1962, the CAP has fulfilled its objectives by ensuring secure food supplies. Then, with its policy of support prices that were very high compared with the world market prices and an unlimited buying guarantee, the CAP started to produce more and more surpluses. In order to close the widening gap between supply and demand and bring agricultural expenditure under control, the Council introduced a radical change to the CAP by replacing the system of protection through prices with a system of compensatory income support.

Loss in income resulting from a significant reduction in guaranteed prices for arable crops was fully compensated for by direct aid per hectare. In the area of livestock production, the fall in the price of beef was compensated by a headage payment. These compensatory measures were entered in the WTO's 'blue box' (fact sheet 3.2.7).

The EU Water
amework Directive



How we look at system openness

Only possible to understand system sustainability by also considering the resources crossing a system boundary

- Dependencies have implications for security
- Imports – flows in
  - Kinds of imports – livestock feed
  - Virtual land, water, GHG emissions etc.
- Exports – flows out
  - Exported agricultural goods
  - Pollution and wastes

We can strengthen understanding of consequences beyond a system (e.g. externalisation beyond EU), in two ways

- By analogy – if we were to re-internalise current inputs
  e.g. if EU were to grow all its own livestock feed,

or

- Use local data to assess actual impacts
  e.g. footprint of imported Brazilian soya

Metrics arising from processors

- Extent
  Absolute size (physical or financial)
  e.g. area of land used to produce tomatoes
- Intensity
  Rate of flow /fund (per area, per capita, per hour, per €)
  e.g. rate of water extraction per hectare of land used for tomato growing

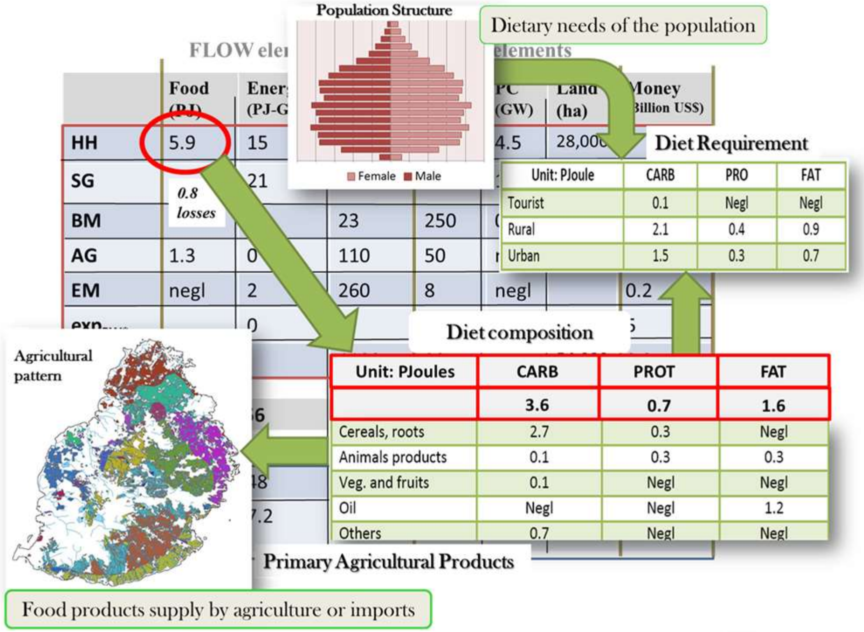
Must consider individually <u>and</u> together

- Problem that matter: both ‘concentration’ (i.e. local soil contamination) and ‘magnitude’ (i.e. low-level but widescale GHG emissions)
- Checks on potential solutions: i.e. Improved efficiency may not lead to an overall decrease in resource use*

*Polimeni, J.M., Mayumi, K., Giampietro, M., 2010. *Jevons' Paradox and the Myth of Resource Efficiency Improvements*. Earthscan Publications Ltd.

Insights from the approach

Metrics organised into technical matrices – coherent and consistent way to organise.



Allows us to debate

- Footprint of activities
- Interdependency with other systems
- Biophysically feasible, in long-term?
- Technologically and economically viable, in long-term?
- Desirable?

Lots of visual options - but try to highlight both intensity and extent metrics.

Need contextualisation to understand how pressures create impacts in different settings.

e.g. Maximum sustainable rate of water extraction depends on particular aquifer

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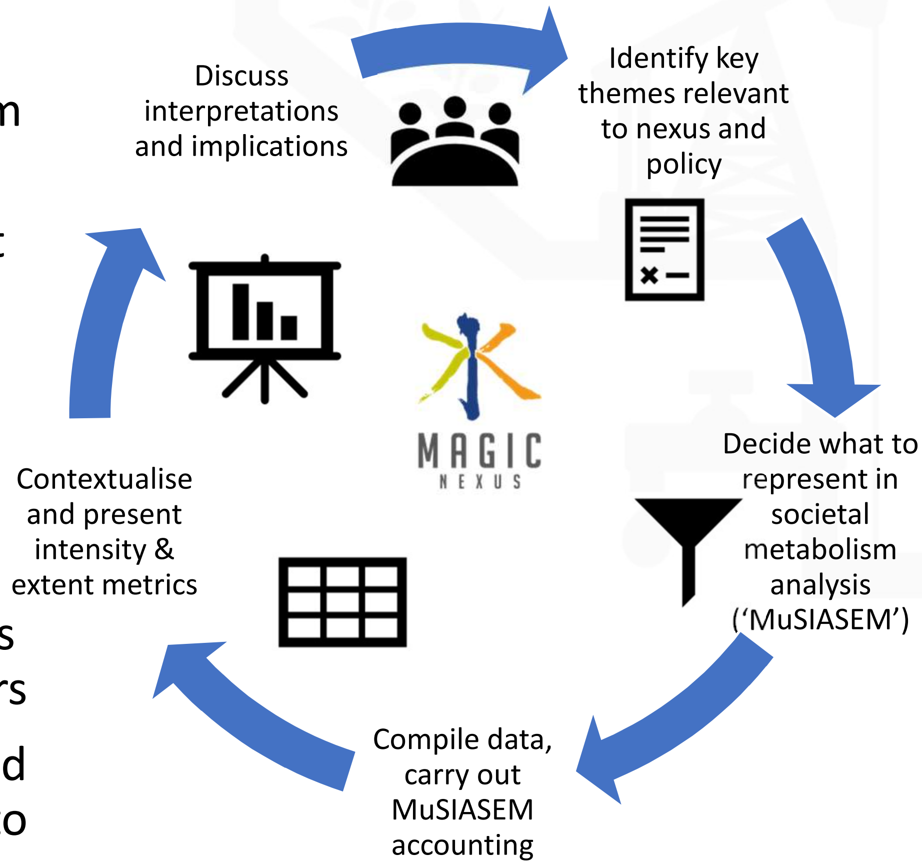
Working with policy & stakeholders

Value of method depends on how its application is focused & framed

- What is the problem? How does system function?
- What our objectives and options, what are the consequences of changing objectives and constraints?

MAGIC responds to policy-relevant themes, claims and issues*

- SDG2 focus today reflects prior analysis and interaction with policy stakeholders
- Keen to discuss more: sustainability and desirability of agri-food systems, how to understand, how to achieve



*This is what we call 'Quantitative Story Telling' – the overall transdisciplinary process of deciding who to work with, how to focus application of MuSIASEM and with whom to discuss the implications. See https://magic-nexus.eu/content/what-quantitative-story-telling for more information

Summary

Societal Metabolism Accounting ('MuSIASEM')

- Helps understand metabolism of societal processes, and interconnections between systems.
- Can be used to understand sustainability of current systems and consider 'what if' questions
- Value depends on how its application is focused & framed

More information on methodology & examples

- See 2-page briefings available today
- Examples of applications across a range of policy domains in the MAGIC document repository including policy case studies

Questions for clarification of method?

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A new perspective on SDG2 via Societal Metabolism Analysis

K.B. Matthews[a], K.L. Blackstock[a], K.A. Waylen[a], A. Juárez-Bourke[a], D.G. Miller[a], D. Wardell-Johnson[a], M. Rivington[a], A. Renner[b], J. Cadillo, M. Ripa[b] and M. Giampietro[b,c]

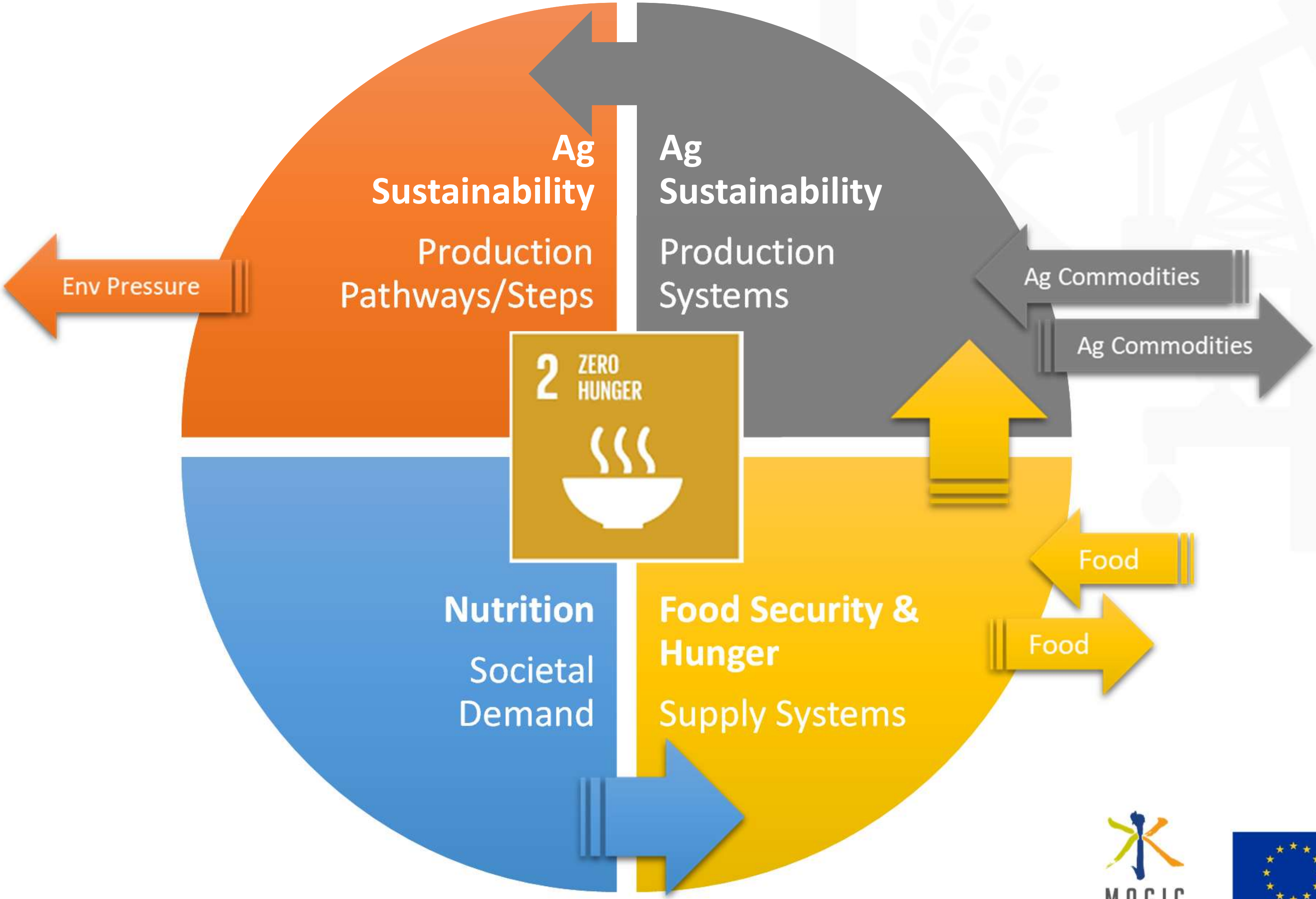
[a] The James Hutton Institute, Aberdeen, Scotland, [b] Institut de Ciència i Tecnologia Ambientals, Universitat Autonoma de Barcelona, Catalunya, [c]Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona, Catalunya

SDG2 ambitions

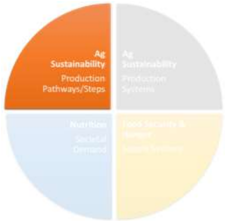
- Shared policy ambitions – EU and SDGs
- Most clearly with CAP post 2020 objectives
- Not only about CAP – other policies goals' and instruments
  - Water Framework, Natura 2000
  - Energy, Circular Economy, Climate Change

- The SDG as a whole arguably needs coherent approaches to consumption as well as production – a systemic agri-food policy

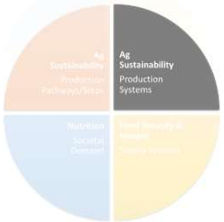
SDG2 and Societal Metabolism Analysis



SDG2 – Overview of results slides

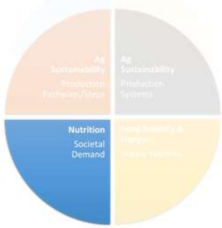


- How data shapes the analysis
- Pressures and impacts on European environment associated with agricultural production pathways.
  - Focus on soils
  - Focus on waters/biodiversity



- Pressures and impacts associated with imported inputs and commodities (e.g. soya feed) supporting Europe's agriculture

- Supply systems
  - Embodied Energy
  - Social Consequences



- Nutrition
  - Connecting commodities and diets

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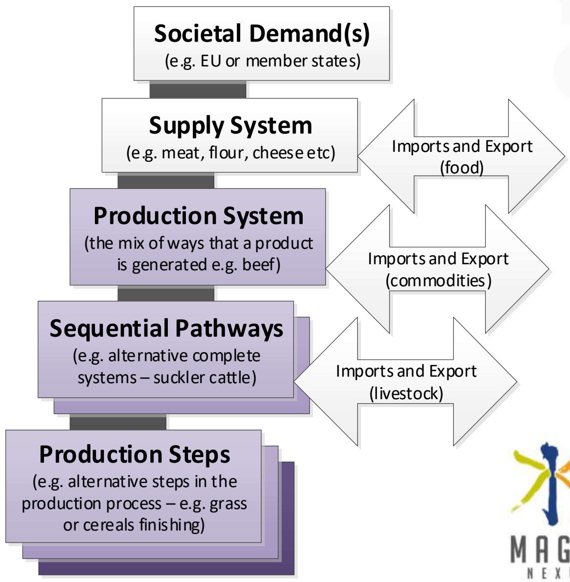
How data shapes the analysis

- Exploitation of data from Farm Accounts Data Network (FADN)
  - detailed variables (4800+) physical quantities and €-based **Steps/Pathways** ➲
  - Farm Types (FT 14) as **Production Systems**
    - Mix of activities – flows
    - Mix of land, labour, capital – funds
    - Metabolism
  - FT and Regions (FADN) combined
    - Mix of sequential pathways/steps ➲
  - Time series – 2013 "discontinuity"

Barley Total area under production	in ha
Barley Production	in tonnes
Barley Sales quantity	in tonnes
Barley Total output	in EUR
Barley Farm consumption	in EUR
Barley Farm use	in EUR
Barley Sales value	in EUR
Barley Opening value	in EUR
Barley Closing value	in EUR

Barley GMO	in ha
Barley. Irrigated crop total area under production	in ha
Barley Energy crop total area under production	in ha



Renner A., Cadillo Benalcazar J.J., Benini L., and Giampietro M.
Environmental pressure of the European agricultural system: An exercise in biophysical anticipation Submitted to Ecosystems Services
Cadillo Benalcazar J.J., Renner A., and Giampietro M.
An accounting framework for characterizing the sustainability of the European agricultural system

Characterising systems and their pressures

Member State	Farms No. (000')	UAA (ha)	Time (000' h)	Arable %	Pasture %	Live-stock Nos.	Stocking Rate LU/ha	N kg/ha	P kg/ha	CProt €/ha	Energy €/ha	Mach €/hr	Extent All Subs (€ '000)	Intensity All Subs €/ha	All Subs €/h
Austria	143	34	3.8	69%	26%	28	0.8	54	14	81	155	23	20	593	5
Belgium	58	50	5.1	61%	36%	139	2.8	110	11	187	268	16	20	408	4
Bulgaria	126	52	6.7	83%	11%	59	1.1	77	14	67	138	7	20	381	3
Croatia	162	16	3.3	49%	42%	11	0.7	55	24	64	102	12	8	478	2
Cyprus	21	10	2.9	83%	1%	5	0.5	58	35	105	272	19	5	555	2
Czech Republic	35	155	12.1	71%	26%	154	1.0	89	18	98	209	9	84	546	7
Denmark	57	91	4.8	90%	7%	136	1.5	84	31	117	242	37	34	371	7
Estonia	15	96	4.2	68%	29%	65	0.7	43	12	26	109	16	24	253	6
Finland	73	64	3.3	92%	8%	42	0.7	55	8	31	395	26	61	964	18
France	603	87	3.6	67%	30%	74	0.9	85	18	111	128	20	32	365	9
Germany	375	170	7.3	77%	23%	117	0.7	99	16	98	184	26	68	398	9
Greece	687	10	2.6	59%	21%	6	0.6	79	34	110	226	8	7	652	3
Hungary	205	43	4.3	75%	19%	29	0.7	67	22	92	182	9	19	455	5
Ireland	173	58	2.5	29%	71%	58	1.0	102	12	62	70	18	21	363	8
Italy	1,065	23	3.3	59%	29%	43	1.9	47	26	84	223	6	9	400	3
Latvia	49	56	3.2	68%	29%	14	0.2	49	19	37	85	8	14	259	4
Lithuania	122	42	4.1	74%	21%	37	0.9	76	24	44	100	9	10	241	2
Luxembourg	3	74	3.9	49%	49%	87	1.2	107	8	79	114	43	47	636	12
Malta	6	3	3.4	90%	0%	35	12.1	30	5	162	1596	11	4	1,489	1
Netherlands	99	33	5.8	65%	31%	135	4.1	103	7	333	622	24	15	452	3
Poland	1,477	20	4.0	77%	18%	21	1.1	94	33	66	179	7	6	310	2
Portugal	191	26	3.0	45%	35%	11	0.4	25	13	68	100	5	9	346	3
Romania	2,268	10	3.3	83%	11%	11	1.1	80	50	62	144	3	3	281	1
Slovakia	7	551	24.8	64%	36%	159	0.3	56	12	66	123	8	182	330	7
Slovenia	87	10	2.2	43%	45%	13	1.4	49	19	76	280	13	8	882	4
Spain	837	54	3.7	45%	39%	61	1.1	31	18	53	106	5	14	265	4
Sweden	56	115	4.2	88%	12%	131	1.1	65	18	52	213	47	50	436	12
United Kingdom	195	142	8.1	43%	56%	160	1.1	79	17	81	140	17	35	248	4
Grand Total	**9,195**	**63**	**4.4**	**66%**	**30%**	**61**	**1.0**	**75**	**18**	**87**	**163**	**14**	**24**	**375**	**5**

Legend - Individual lines are average businesses, Farm nos. are the number of businesses represented, UAA is the utilised agricultural area, N is nitrogen fertiliser, P is phosphorous fertiliser, Cprot is crop protection, Mach is machinery, Subs are subsidies.

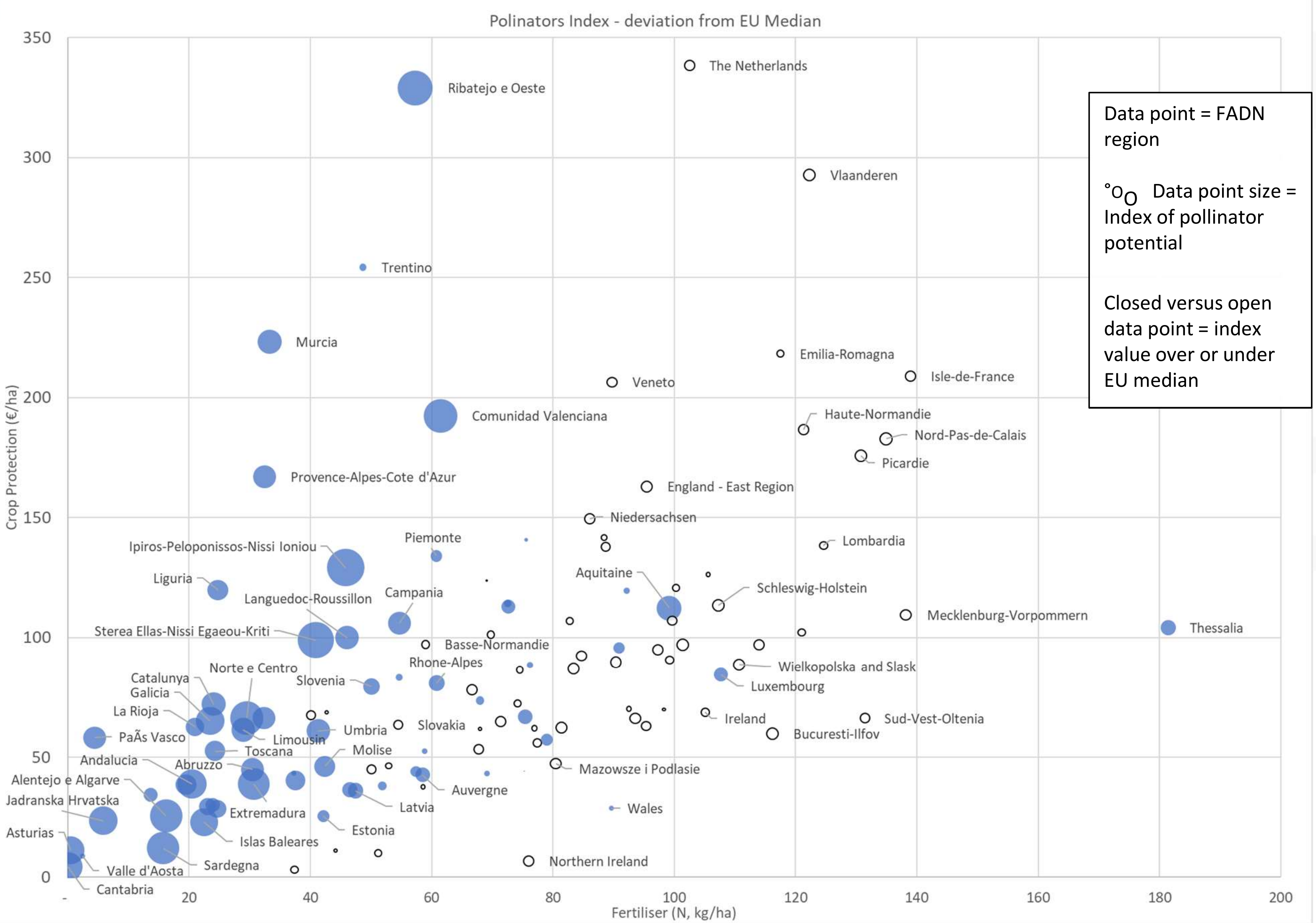
Sectoral comparisons

- Highlight contrasts in the mix of Production Systems
    - Balance of labour and machinery
    - Balance of inputs (and outputs)
    - Mix of land uses – diversity vs. specialisation
    - Extents of pathways – geographic, production
    - Intensity of pathways – per ha or per kg of product
- Farmtypes ⇨ Member States ⇨ Regions (FADN) ⇨ ...
    - Comparisons of Production Systems, Pathways or Steps used at progressively finer levels of detail
    - Balance of level of detail against the breadth of view
- Working with mixes – necessary but remains challenging

Geographical Analysis

- Concern with Impacts on the Biosphere
- Member State ⇨ Region (FADN) ⇨ Farmtype Mix ⇨ Farmtype
  - How pressures get translated into consequences for biosphere
  - How to operate at region/landscape scale
  - Issues of attribution, causality, uncertainty etc – but still need to make policy
- Discuss pressures arising from mix of Farmtypes
  - Trade-offs and their long term viability
  - Discussion through a boundary object
  - Experimental…
- Adding geography into the social metabolism analysis

Environmental pressure and biodiversity

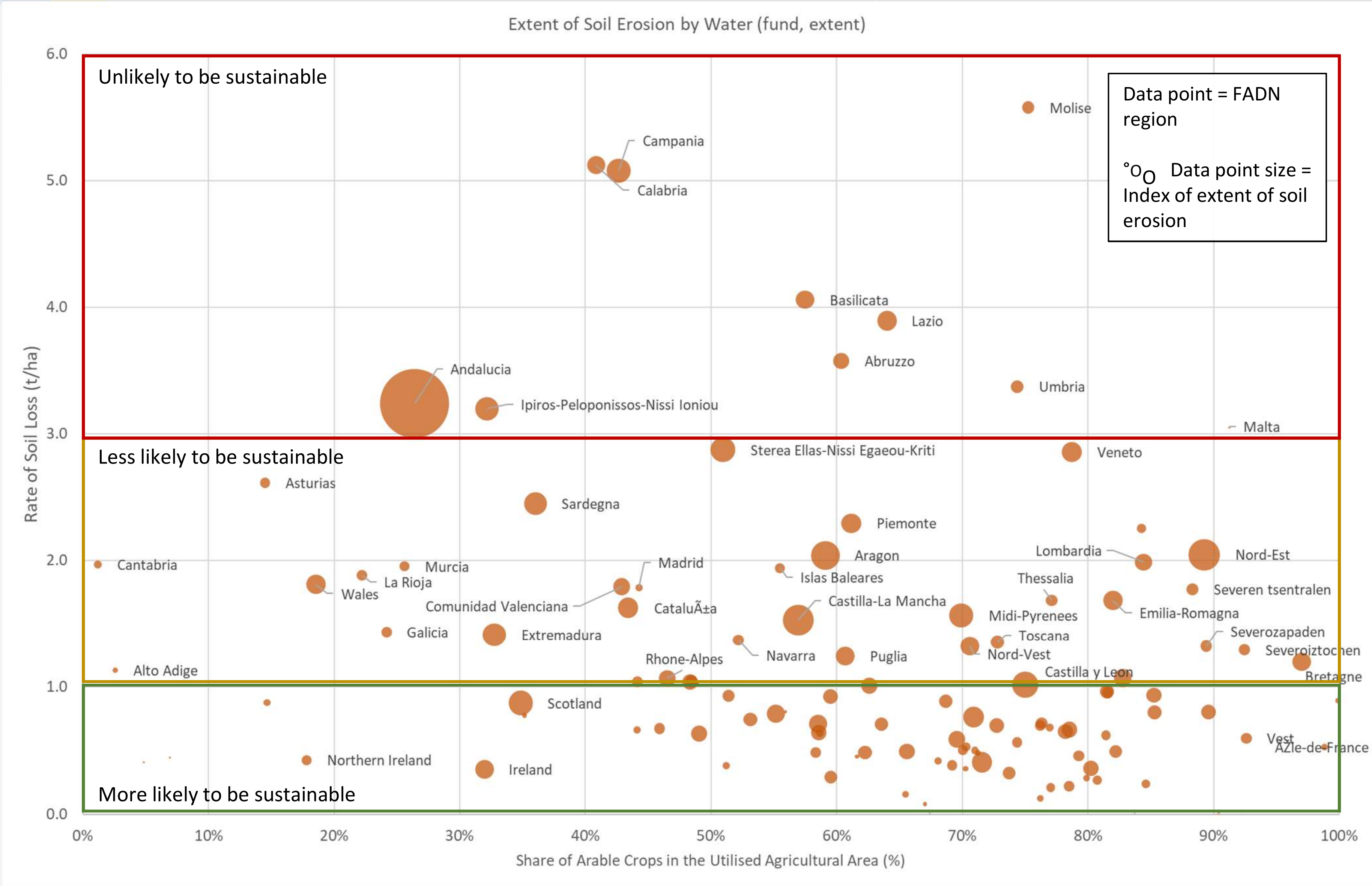


Data point = FADN region

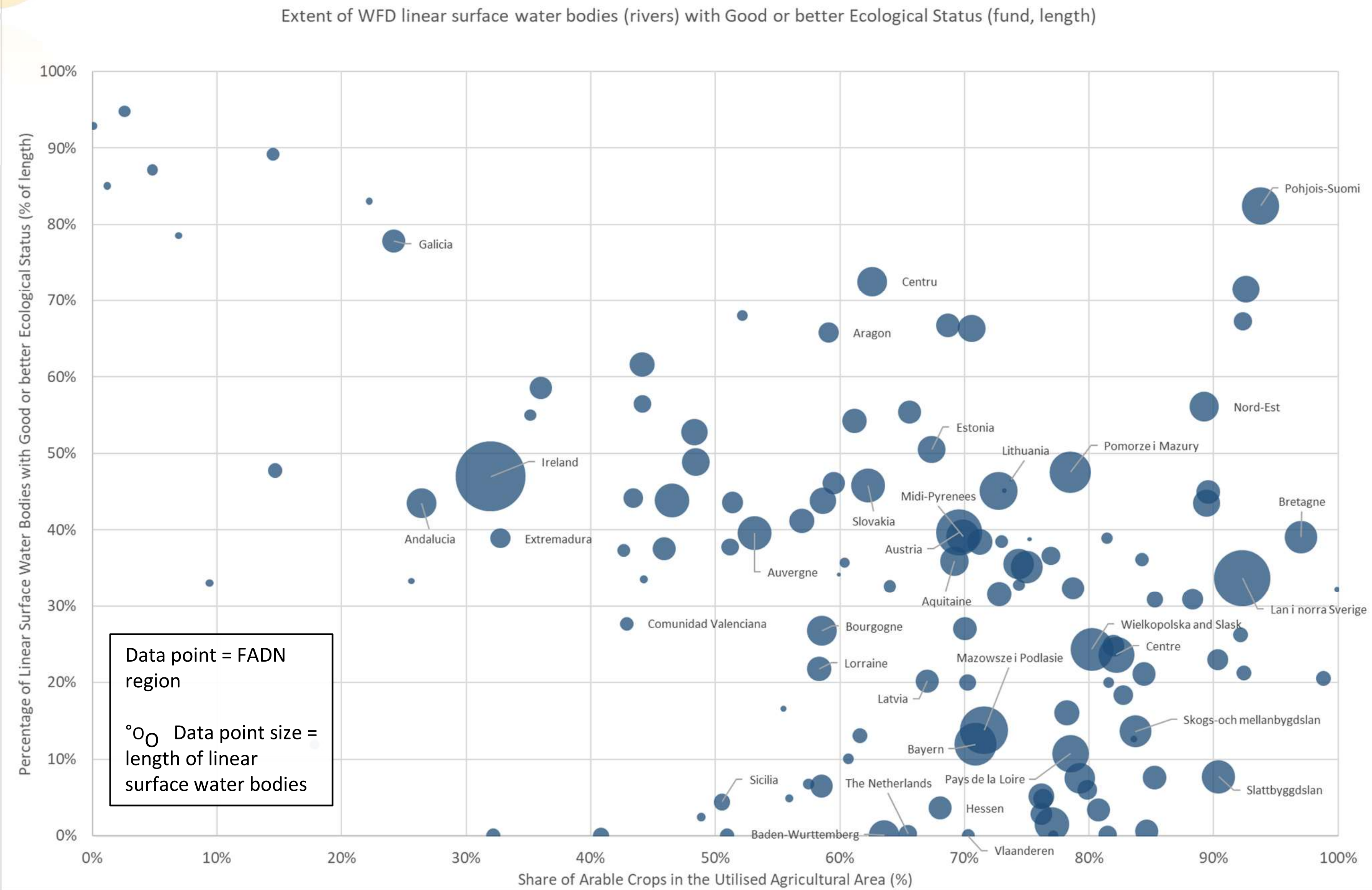
°o O Data point size = Index of pollinator potential

Closed versus open data point = index value over or under EU median

Environmental pressure and soils



Environmental pressures and rivers



Data point = FADN region

°o O Data point size = length of linear surface water bodies

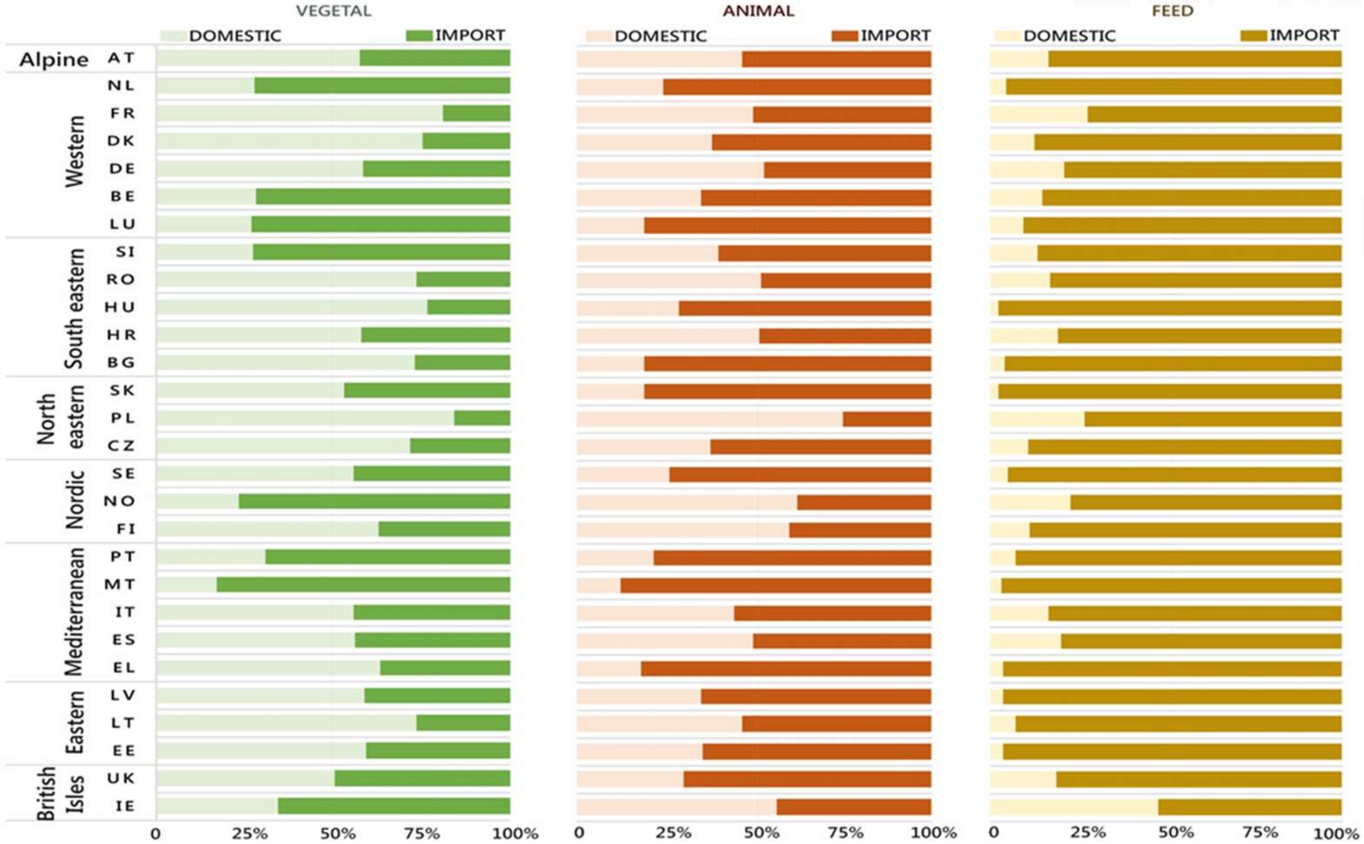
Water – final users and uses

- Balance of use between and within regions
- Contrasts in the nature of the water being used (amount and ratios)
- Greater dependence of some systems on blue water
- Not feasible to undertake activities in some regions without the embodied water in feeds

Water Use (cubic metres)	Green Water (all)	Green Water (local Agric)	Green Water (imported feed)	Blue Water (all)	Blue Water (local Agric)	Blue Water (imported feed)
(BEL) Belgium	**27,772,665**	**9,253,478**	**18,519,188**	**1,909,651**	**472,318**	**1,437,332**
(0341) Vlaanderen	**15,732,566**	**5,424,953**	**10,307,613**	**1,079,849**	**278,432**	**801,417**
(15) Specialist COP	-	-	-	-	-	-
(16) Specialist other fieldcrops	2,887,706	2,447,226	440,480	134,836	100,616	34,220
(20) Specialist horticulture	157,748	104,037	53,711	14,905	10,735	4,171
(36) Specialist orchards - fruits	392,907	392,907	-	25,567	25,567	-
(38) Permanent crops combined	-	-	-	-	-	-
(45) Specialist milk	2,976,743	214,645	2,762,098	226,165	11,690	214,475
(48) Specialist sheep and goats	-	-	-	-	-	-
(49) Specialist cattle	2,551,641	169,233	2,382,408	196,817	11,821	184,996
(50) Specialist granivores	706,157	325,270	380,887	59,019	28,807	30,211
(60) Mixed crops	-	-	-	-	-	-
(70) Mixed livestock	2,845,015	555,139	2,289,876	204,292	26,126	178,167
(80) Mixed crops and livestock	3,214,649	1,216,495	1,998,153	218,248	63,070	155,177
(0343) Wallonie	**12,040,100**	**3,828,525**	**8,211,575**	**829,801**	**193,886**	**635,915**
(ESP) Spain	**110,424,848**	**30,483,965**	**79,940,883**	**15,929,642**	**4,143,865**	**11,785,776**
(0575) Andalucia	**14,013,329**	**3,090,310**	**10,923,020**	**2,000,067**	**390,367**	**1,609,700**
(15) Specialist COP	462,008	461,283	725	75,789	75,685	104
(16) Specialist other fieldcrops	1,059,590	1,056,981	2,609	116,871	116,495	375
(20) Specialist horticulture	145,162	145,017	145	21,166	21,145	21
(35) Specialist wine	322,655	322,655	-	61,646	61,646	-
(36) Specialist orchards - fruits	473,586	473,586	-	39,862	39,862	-
(37) Specialist olives	19,518	11,663	7,855	2,490	1,337	1,153
(38) Permanent crops combined	214,760	214,760	-	30,753	30,753	-
(45) Specialist milk	4,037,594	9,729	4,027,865	597,282	1,316	595,966
(48) Specialist sheep and goats	1,099,837	28,841	1,070,995	157,375	3,071	154,303
(49) Specialist cattle	3,228,191	51,986	3,176,205	474,581	4,599	469,982
(50) Specialist granivores	66,094	4,228	61,866	10,477	393	10,084
(60) Mixed crops	163,216	163,216	-	19,145	19,145	-
(70) Mixed livestock	2,031,905	59,846	1,972,059	295,323	5,448	289,875
(80) Mixed crops and livestock	689,214	86,520	602,694	97,308	9,473	87,836

Externalisation – linking to trade

- The balance of domestic and imported materials for three categories of agricultural commodities (2012) ➊



- Use of non-EU funds "Virtual" or "Embodied"
- Allows for greater concentration of resources per ha / per person, in EU livestock systems.

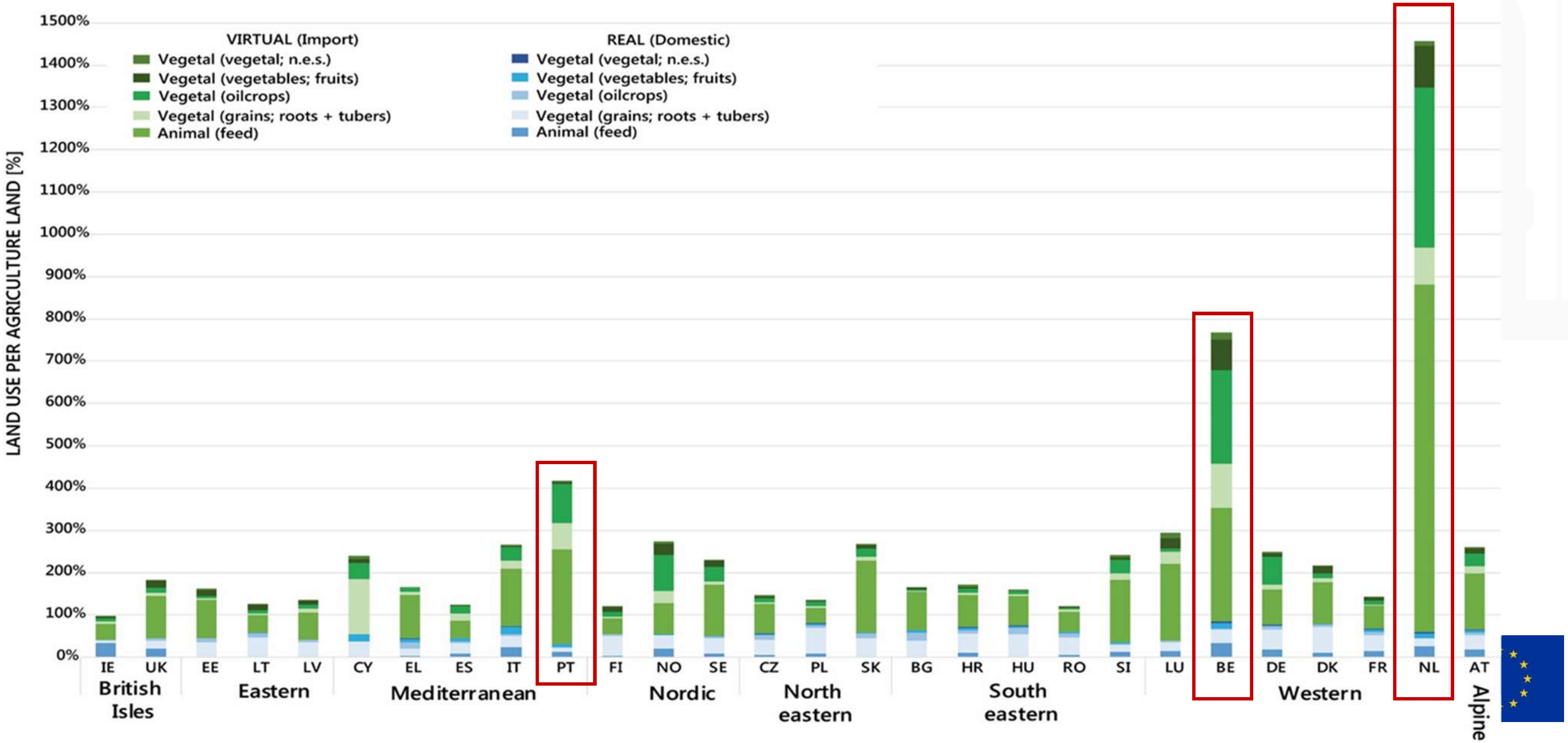
- Trade active between EU member states but also with rest-of-the-world. Dependence on external sources of livestock feeds.

Externalisation - environmental pressure

What if we were to re-internalize current imports – implications for land

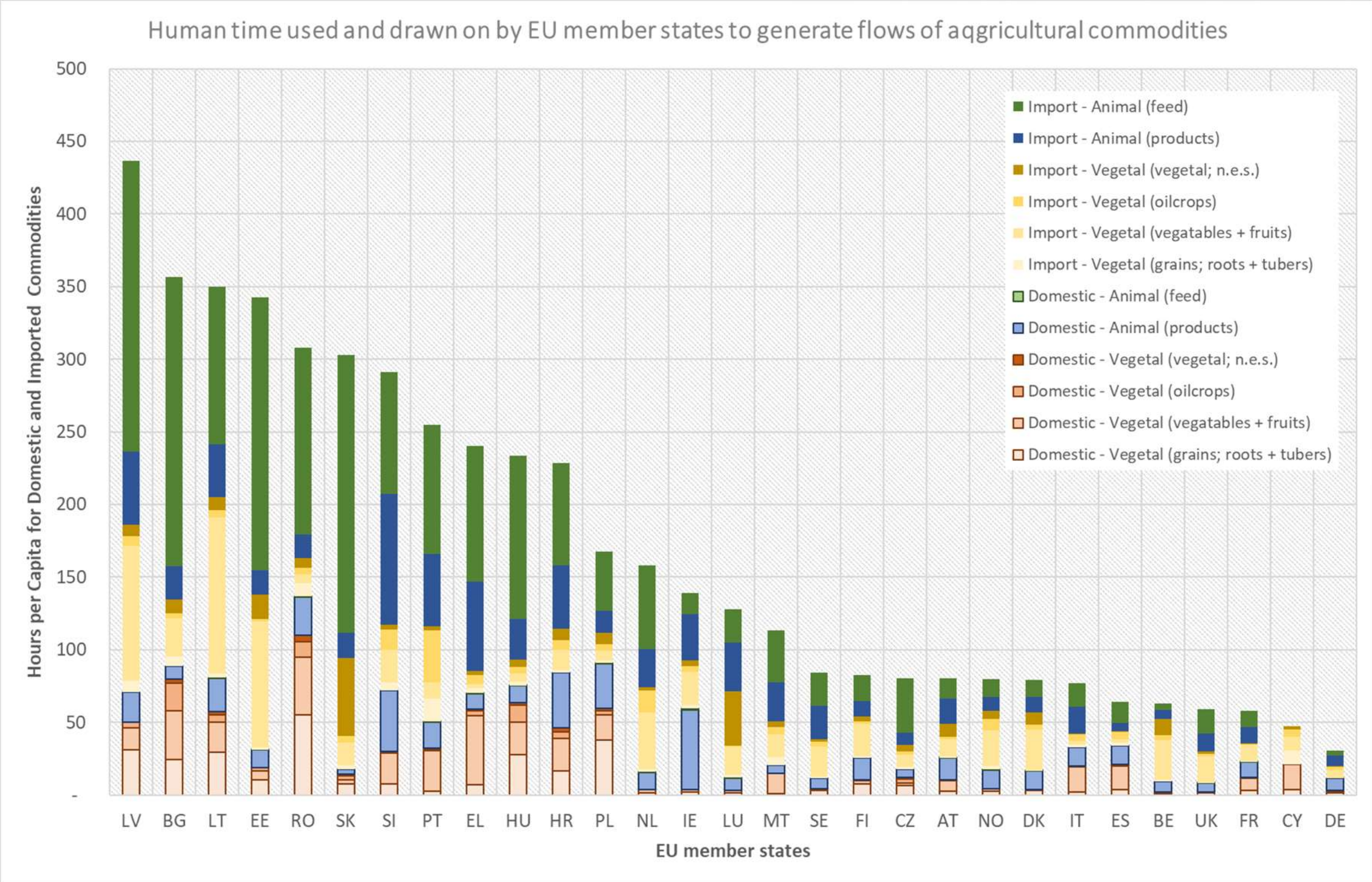
- Implications for feasibility, food security, economic security

But also real impacts where produced – local environment, welfare etc



Externalisation - social pressures (working time)

Reinternalization raises questions of how much time (labour) would be needed
Mass of imports not only factor – mediated by nature of production systems in place ➲



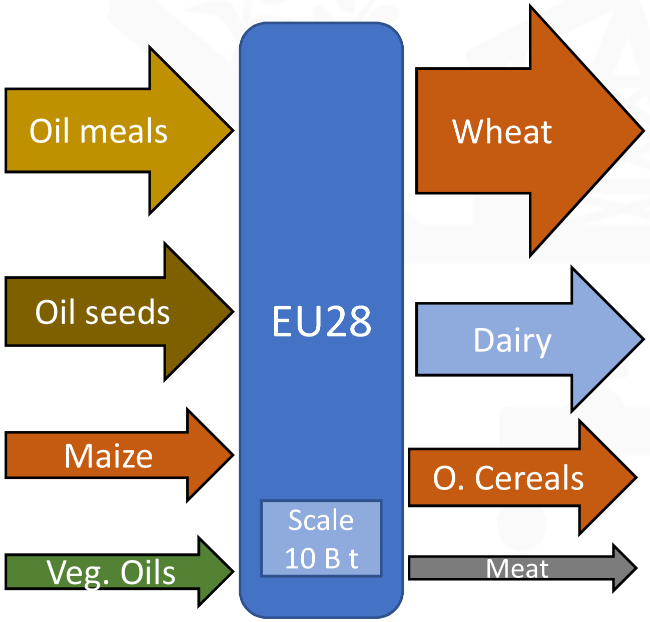
Food Security and Hunger

Supply Systems

End use of outputs

Importance of trade

- Within EU transfers – MS level – granularity challenge (scenarios)
- Beyond EU - imports and exports – role in food availability ➲
- Citizens access to affordable food? In EU and beyond?
- Embodied energy in processing, transport, retail (80%) – sectoral linkages*
- Use of land to provide non-food materials (C storage, energy, plastics, building materials etc)



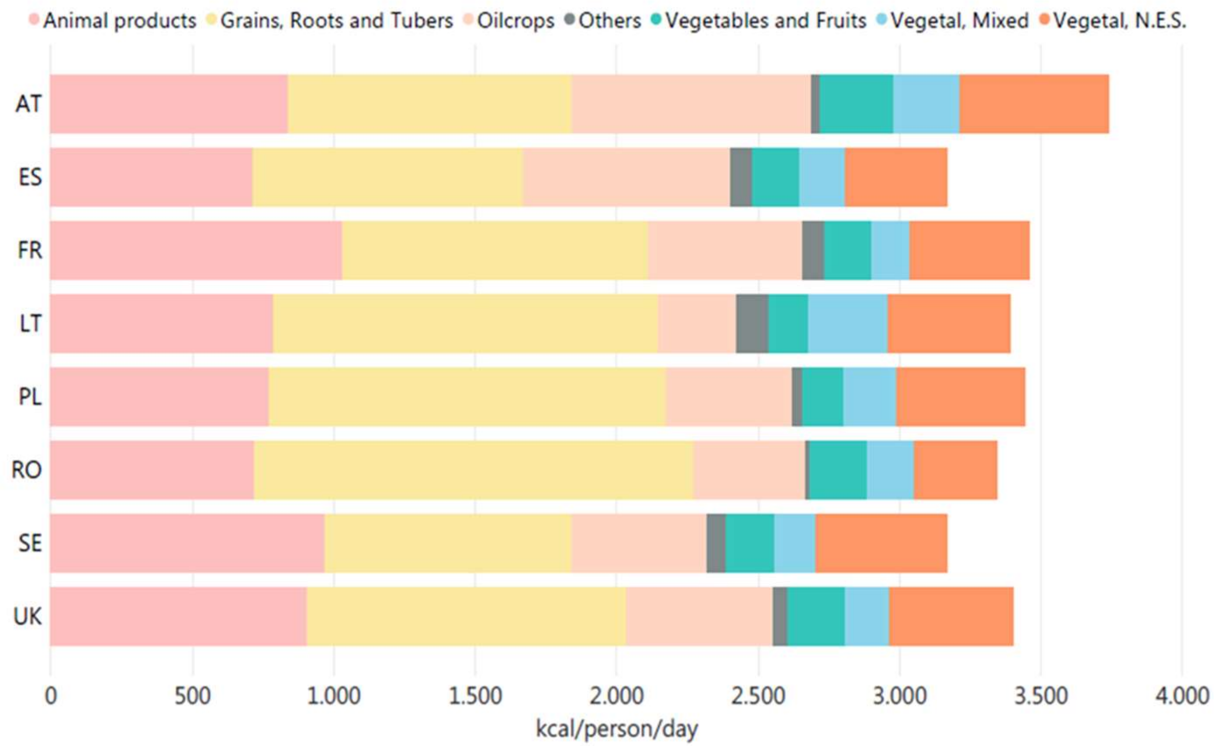
*links to other parts of MAGIC http://magic-nexus.eu/policy-case-studies
European Futures for Energy Efficiency (EUFORIE) https://sites.utu.fi/euforie/

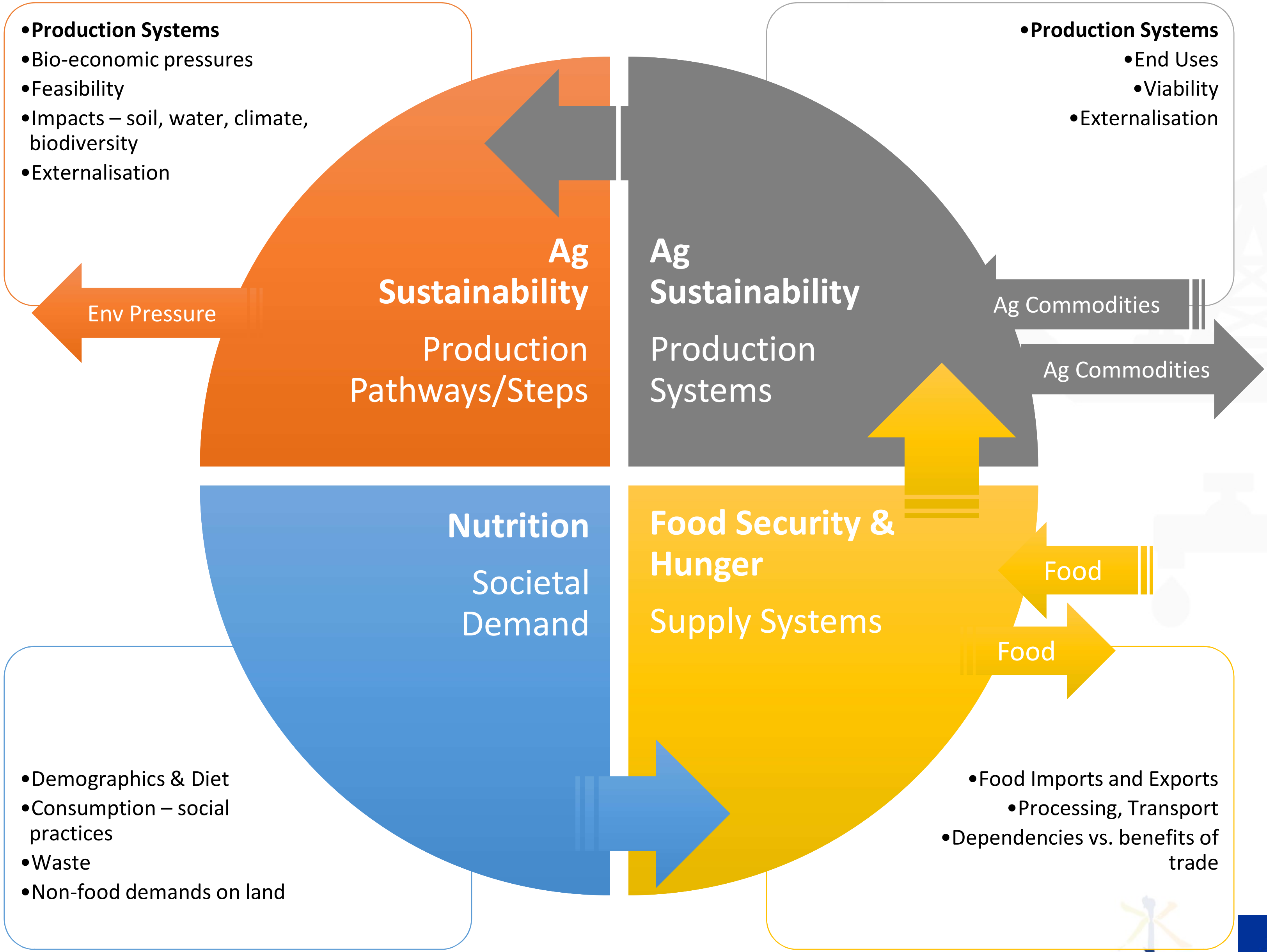
Nutrition - Societal Demand

Nutrition

Demographics and Diet choices - size and composition of demand ➲

- Mediation of biophysical need by the social and cultural – e.g. time on shopping and cooking
- Waste – linking to circular economy (and households)
- Over consumption





•Production Systems
•Bio-economic pressures
•Feasibility
•Impacts – soil, water, climate, biodiversity
•Externalisation
•Production Systems
•End Uses
•Viability
•Externalisation
Env Pressure
Ag Sustainability
Production Pathways/Steps
Ag Sustainability
Production Systems
Ag Commodities
Ag Commodities
Nutrition
Societal Demand
Food Security & Hunger
Supply Systems
Food
Food
•Demographics & Diet
•Consumption – social practices
•Waste
•Non-food demands on land
•Food Imports and Exports
•Processing, Transport
•Dependencies vs. benefits of trade

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Our view of implications

- European agri-food system needs to change to be sustainable
  - Environmental pressures unlikely to be sustainable within and beyond EU
  - Are these justified by social outcomes of agri-food system?
- Need new methods such MuSIASEM complement existing metrics
  - Understanding *extent* as well as *intensity* is useful
  - Connecting production and consumption
- Policy may need to change to better support SDGs – not yet truly coherent
  - CAP as primary influence at present
  - Confirms importance of policy coherence[1] e.g. CAP in support of WFD
  - Missing policy(s)? Supports idea of food policy?
- Others have suggested change is needed: what is stopping us?

1. European Commission (2019). SWD(2019) 20 final. Commission staff working document. *2019 EU report on Policy Coherence for Development*. https://ec.europa.eu/europeaid/sites/devco/files/swd_2019_20_pcdreport.pdf

Your view of implications

- European agri-food system sustainable?
- What is desirable about the current agri-food system?

- What needs to change (incl. Policy or policy gaps)?
- What impedes change?

- Is MuSIASEM an interesting method?
- Want to see new applications?

Our next steps and outputs

- Workshop report, Dec 2019
- MAGIC Deliverable 5.1 – this analysis in full, and more, March 2020
- Conferences including potentially Green Week 2020
- Open to suggestions...

Thank you!

- Don't forget a feedback & consent form – really helps us.

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Thank you – Don't forget a feedback form