

“Soil futures - emerging drivers and needs of soil management and soil services”

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EJP Soil Science Days 2024



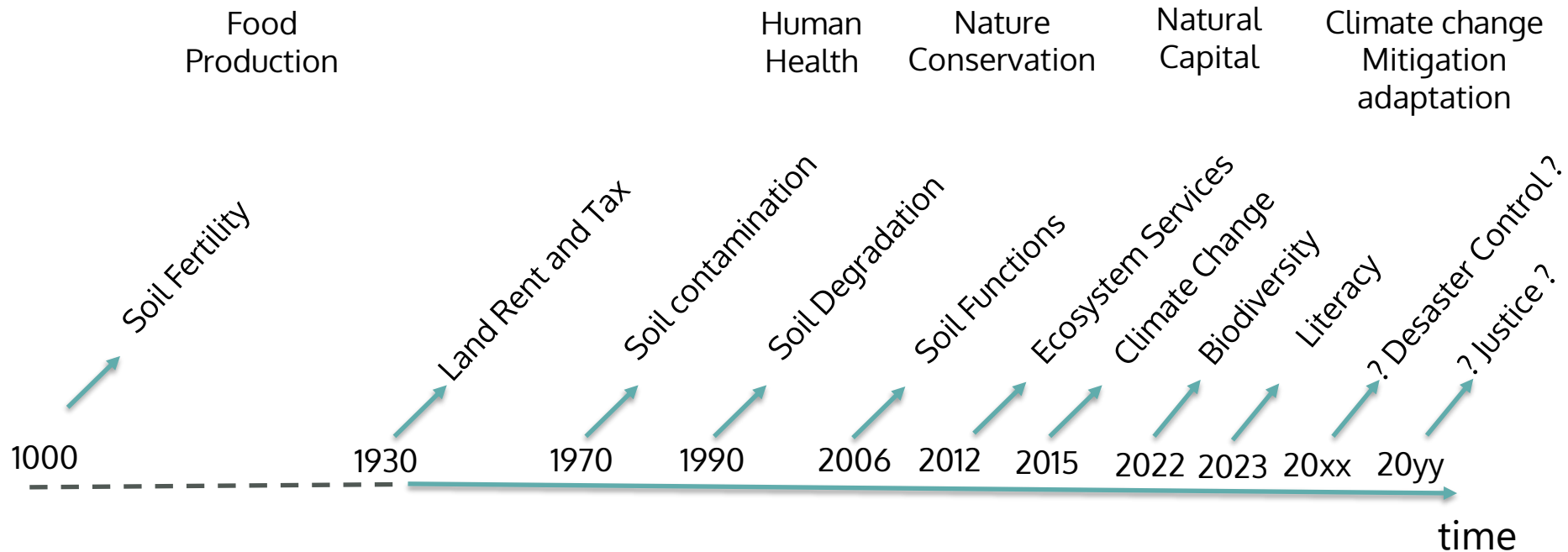
EJP soil – biggest achievements from AB perspective

So much, and:

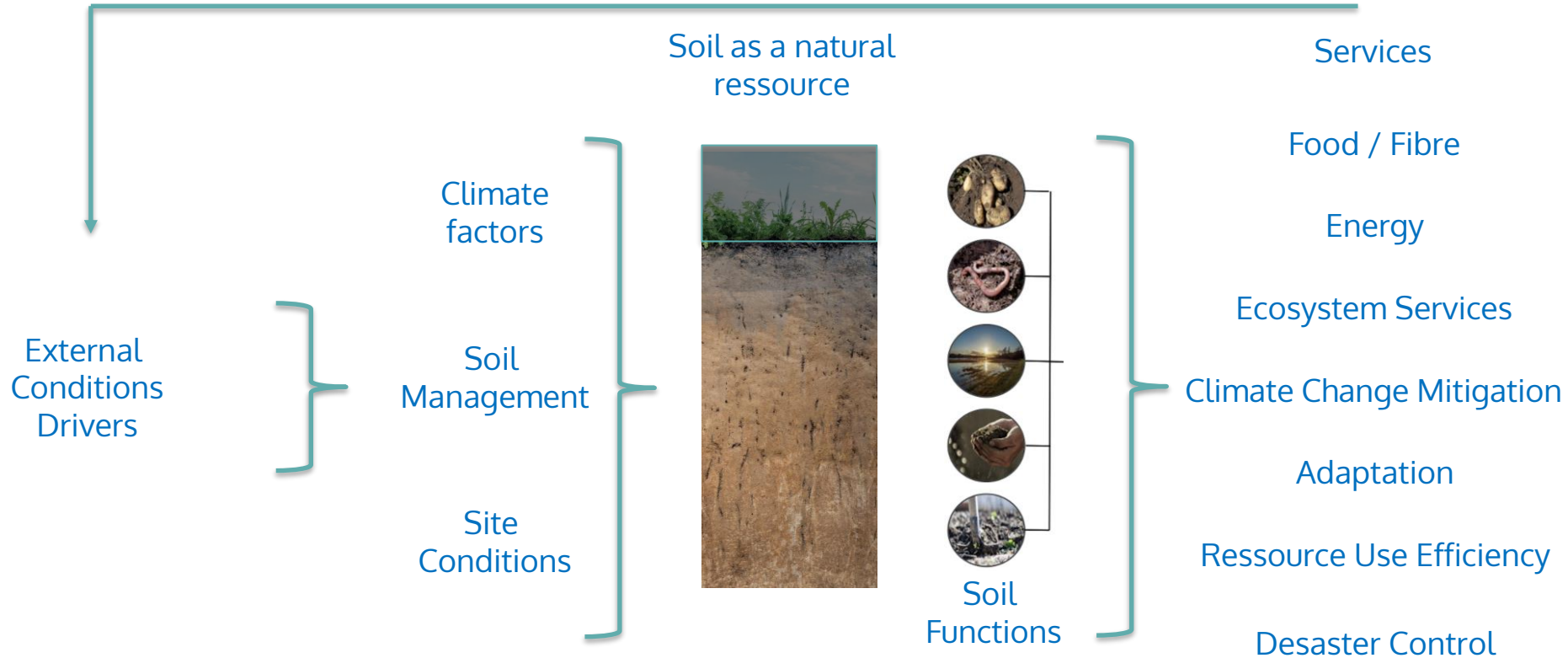
- Agricultural management – soil interaction
- Socio-economic perspectives; stakeholder involvement
- Ontology – common language – harmonisation of concepts and methods
- Data management – shared knowledge network
- Early career network
- Soil enthusiasm

.... and much more

Why is soil perceived as relevant?



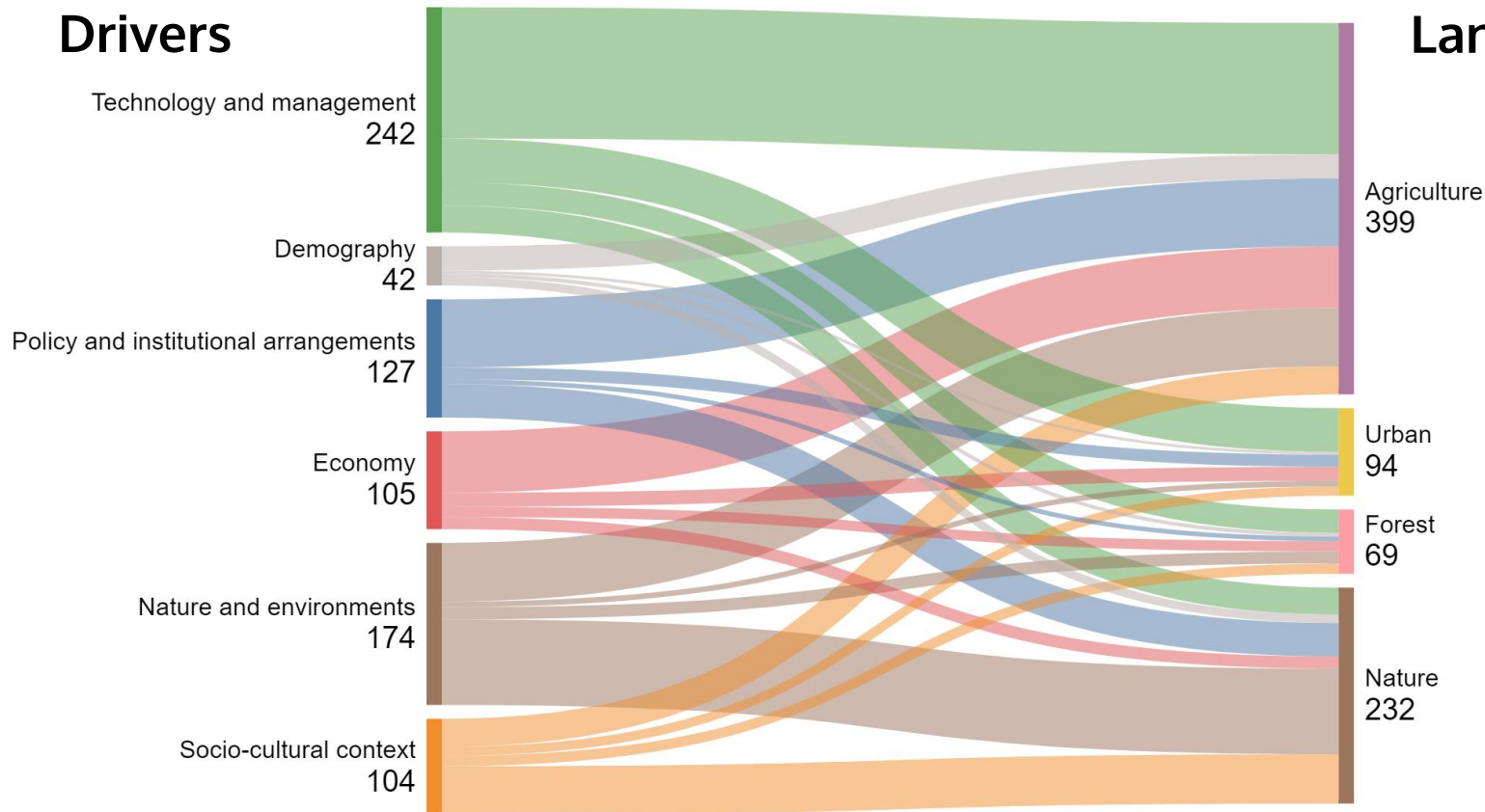
Soil in socio-economic system



Europe: external drivers for agricultural, urban, forest, nature land use

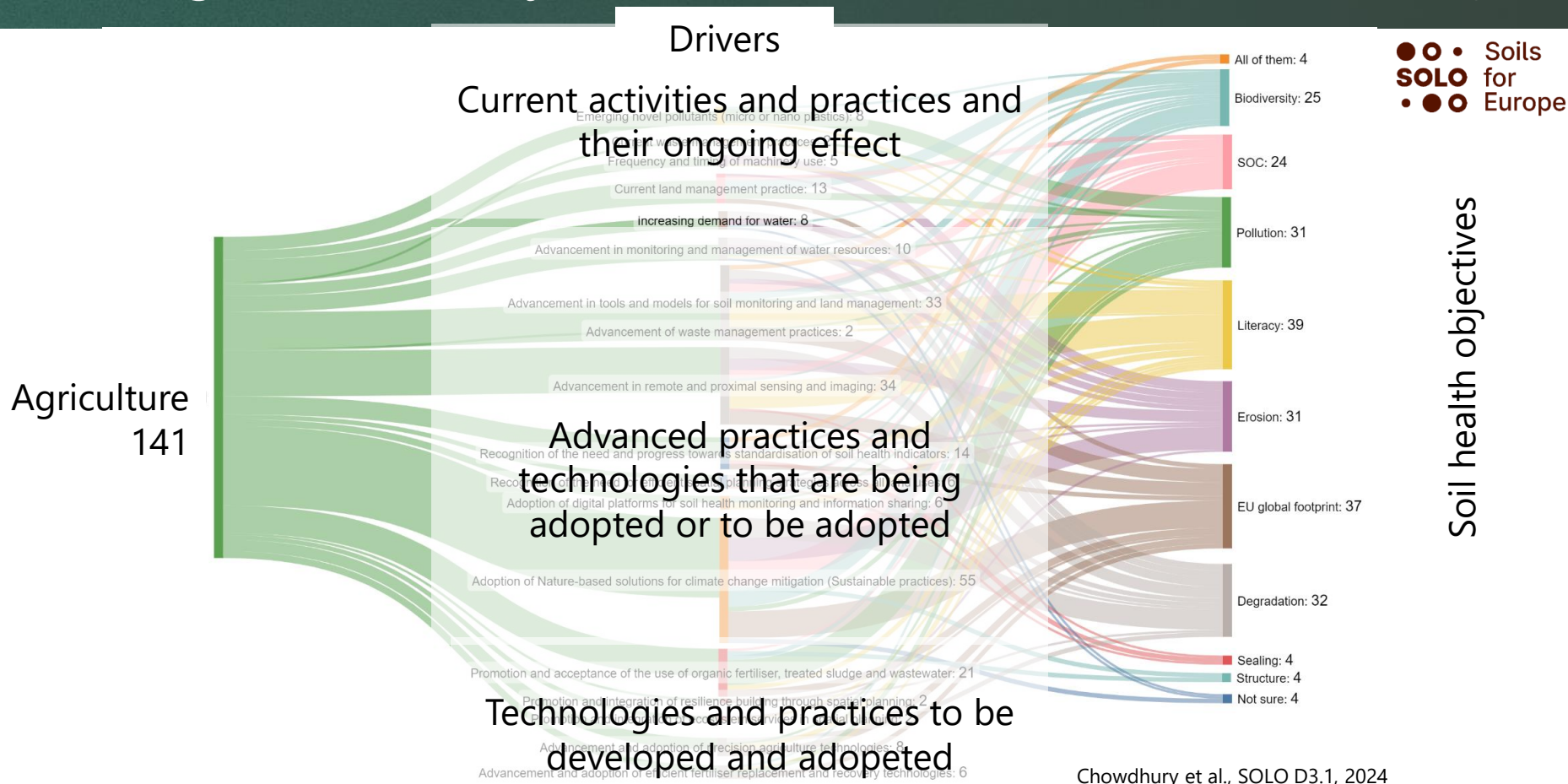
Drivers

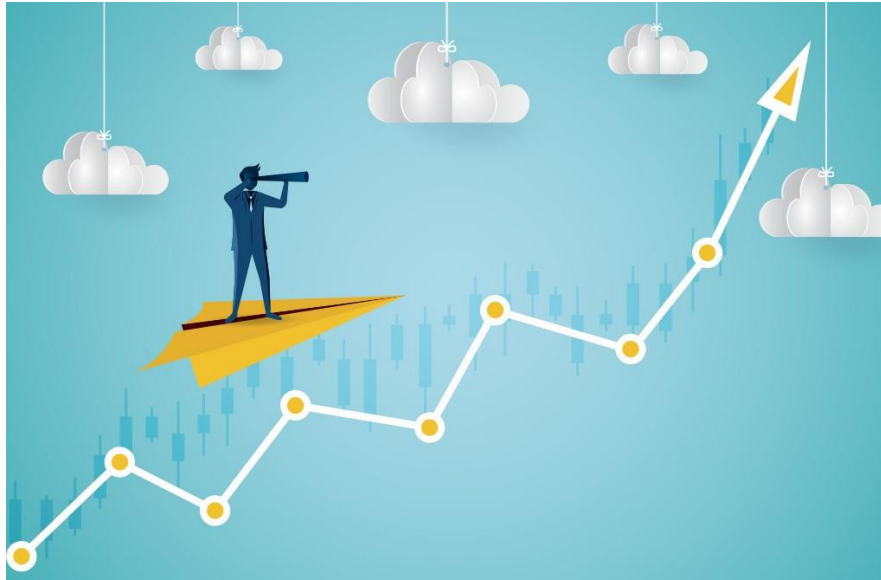
Land Use types



● ● ● Soils
SOLO for
● ● ● Europe

Agriculture: drivers of technologies and practices affecting soil health objectives





Barriers of today, opportunities for tomorrow?

Emerging drivers of soil management

■ Multiple Drivers

- Demand / Product prices
- Factor costs
- Policies
- Education and training
- Research and Development

Socio-economic

- Available agricultural land
- Soil degradation
- Climate change
- Natural resources (water, P)

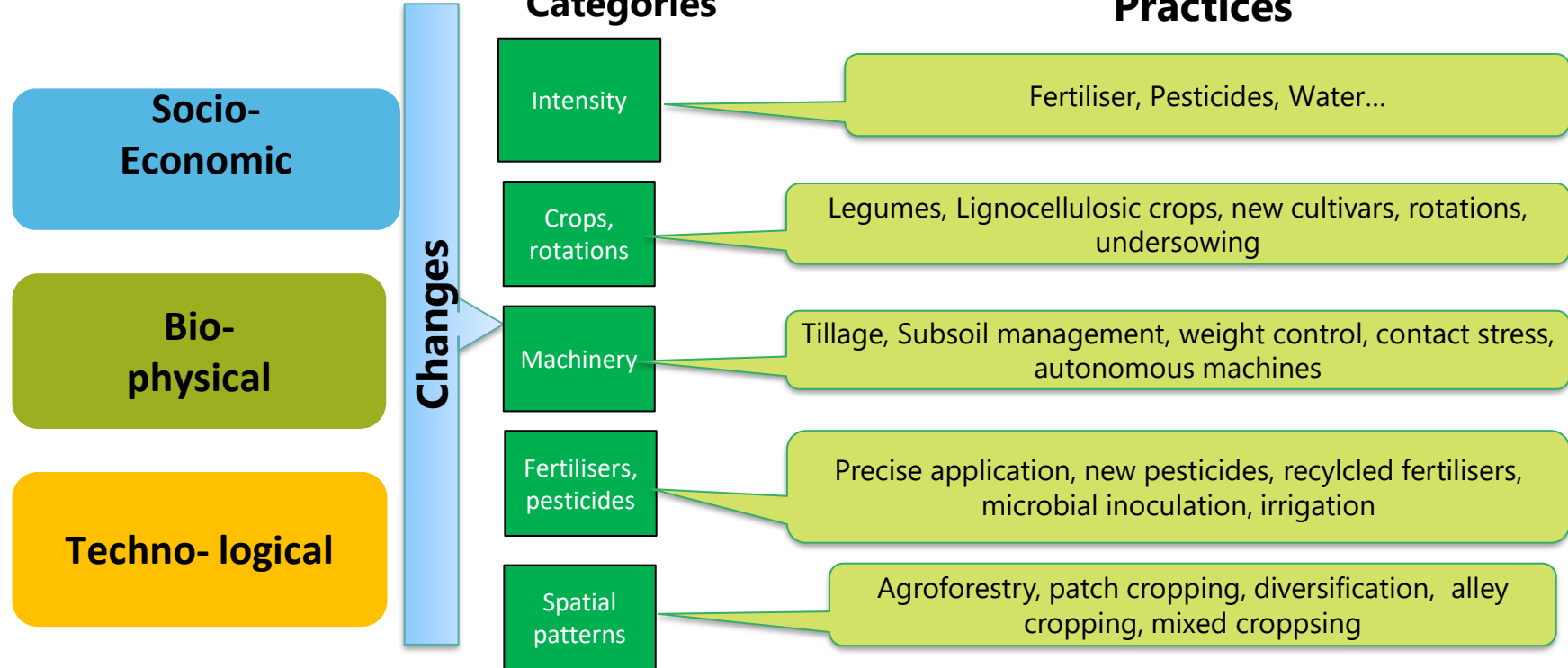
Biophysical

- Digitalization
- Data management
- Robotics
- Biomass technology

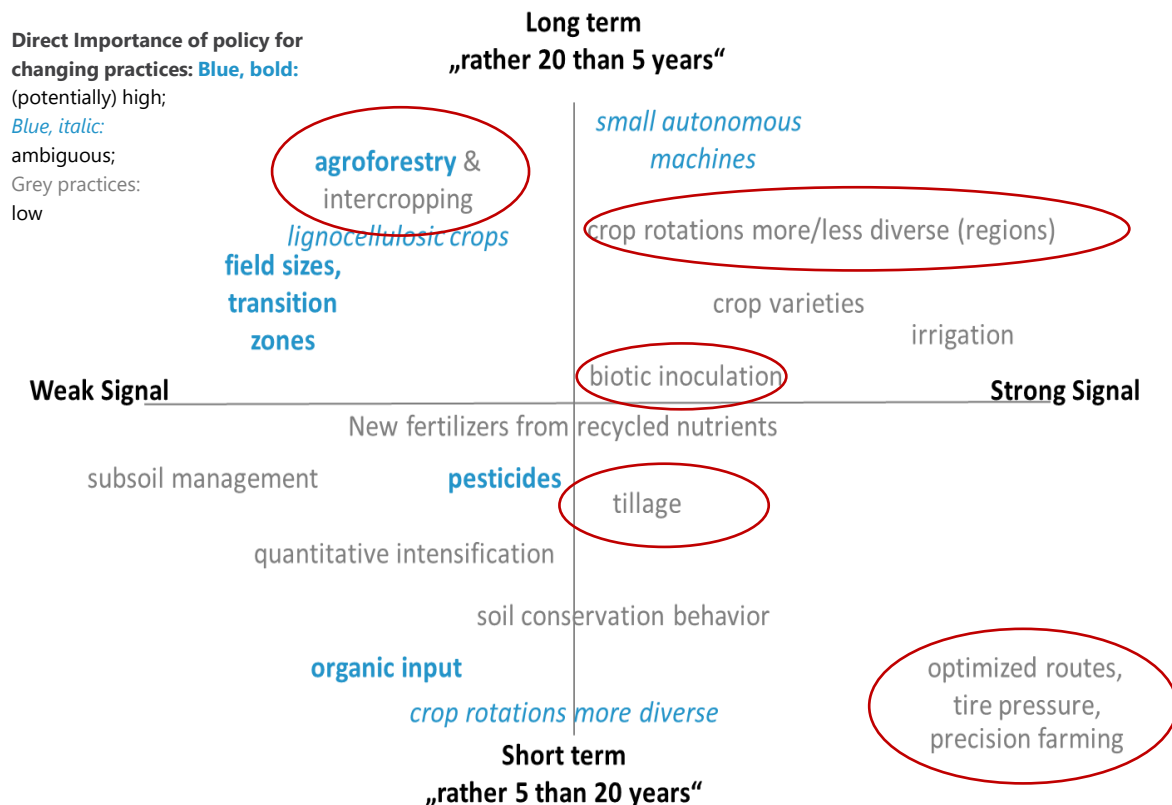
Technological



External drivers



Foresight on emerging soil management: signal strength and time frame

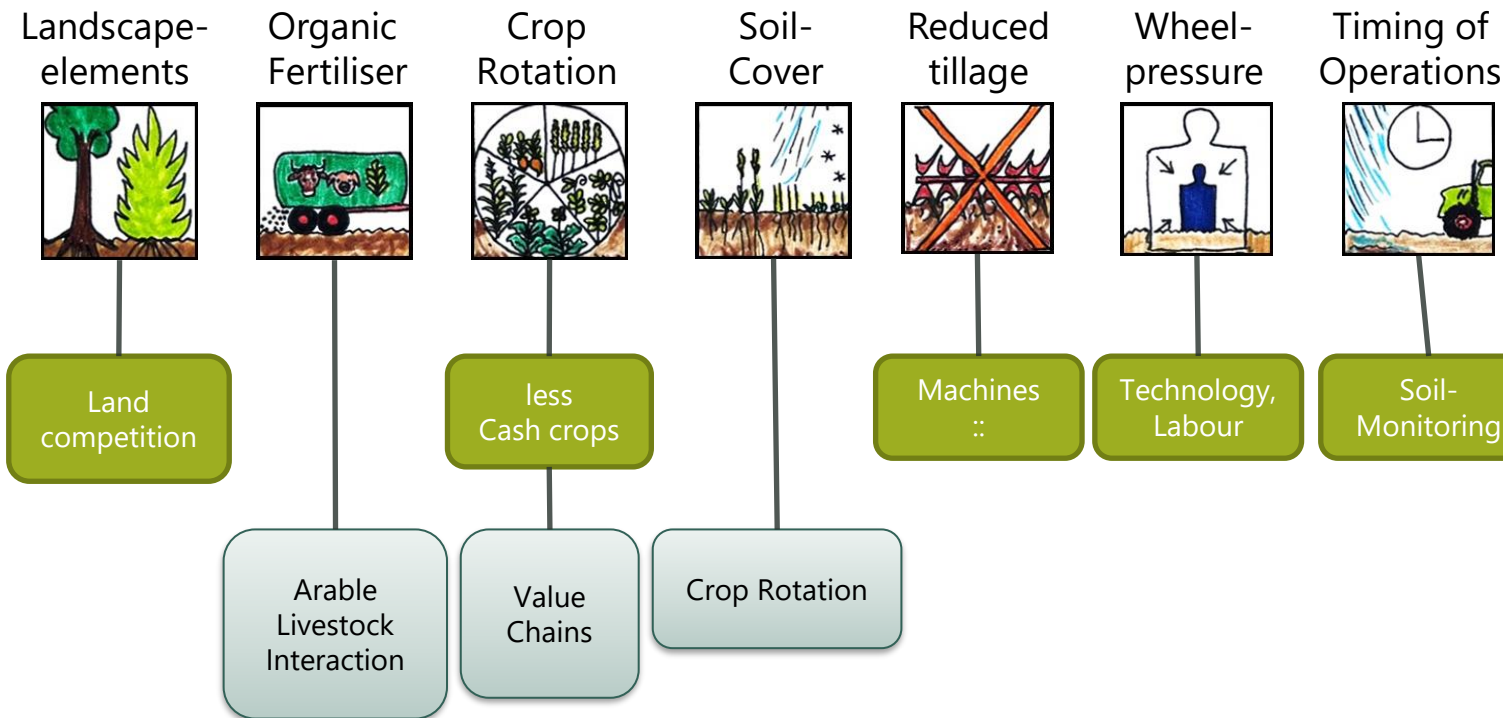


Trade-off of soil improving practices

Trade-offs

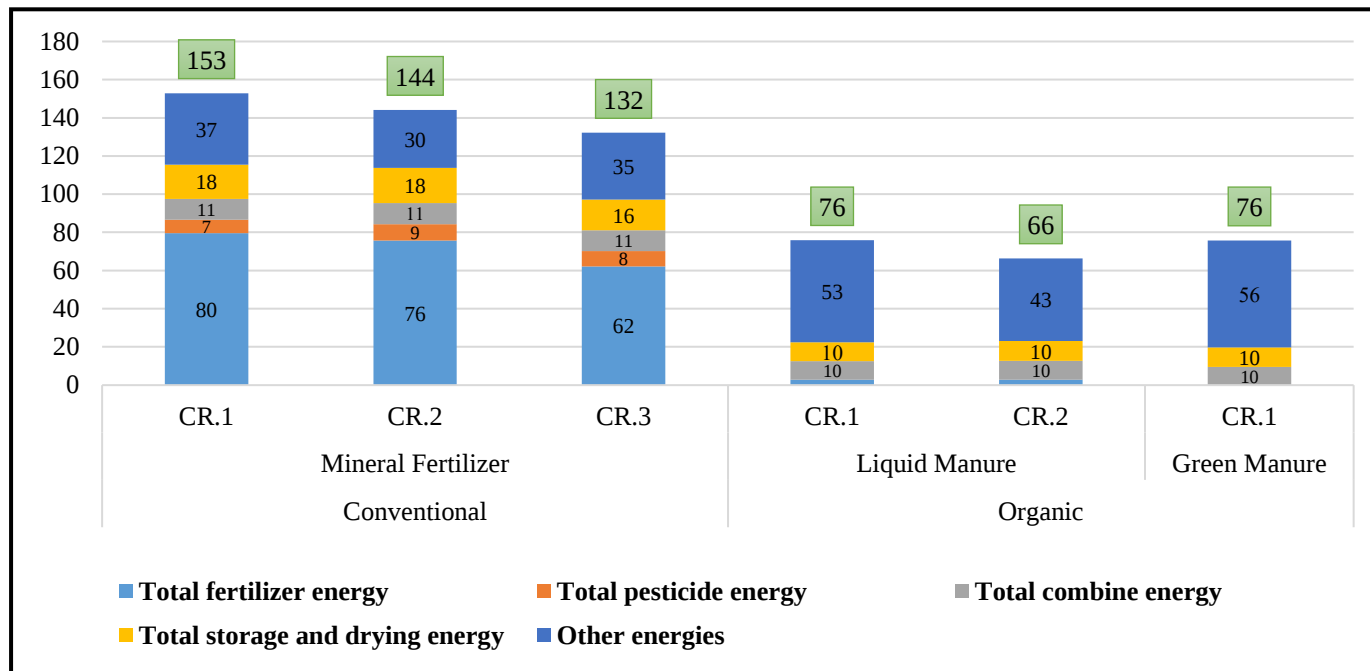
➤ Costs

➤ Systemic Changes



Energy consumption of different management practices

1000
MJ/ha



Rotation:
CR 1: wheat-barley
CR 2: wheat-barley-rape
CR 3: barley-wheat-rape-bean-wheat-rye

Future Agriculture? Uncertain, diverging visions

Agroecology



<http://patrickwhitefield.co.uk/wp-content/uploads/2015/02/mulch-14-1024x682.jpg>

High-tech large scale



<https://www.techexpert.com/wp-content/uploads/2019/09/10-T-in-Agriculture.jpg>



<https://www.thomasnet.com/insights/will-agricultural-ai-become-the-future-of-farming/>

Busines as usual



K. Helming

Agroforestry



<https://www.thuenen.de>

High Tech small scale

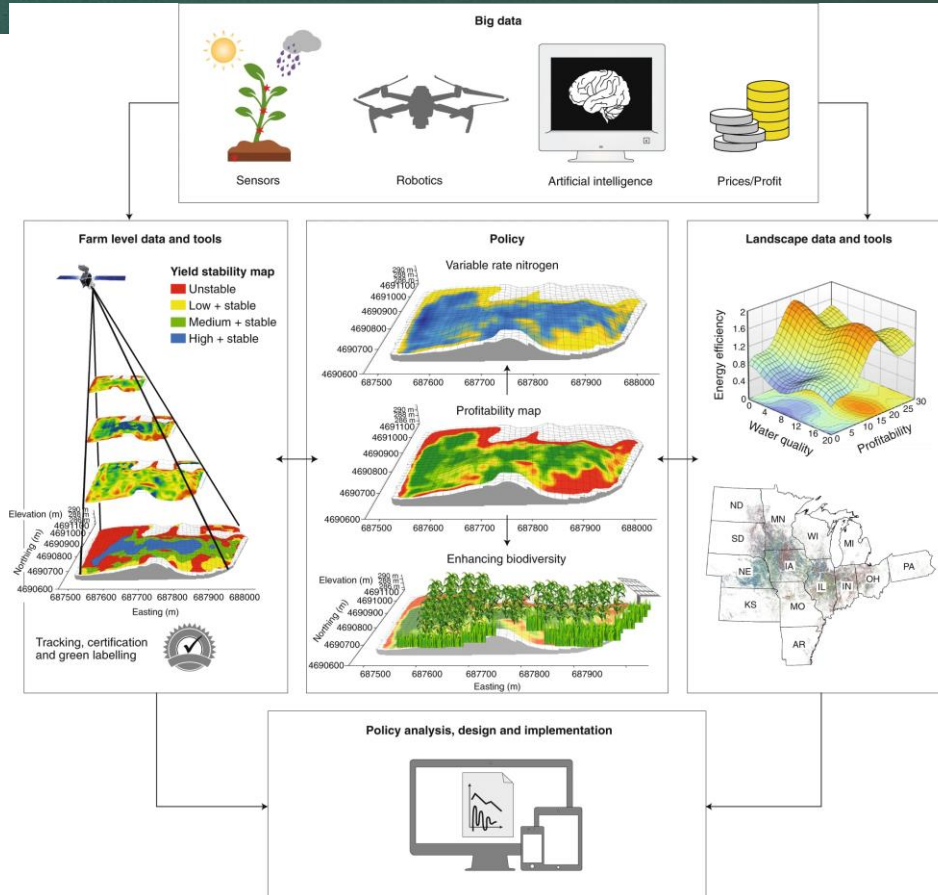


<https://www.zalf.de>

care farming

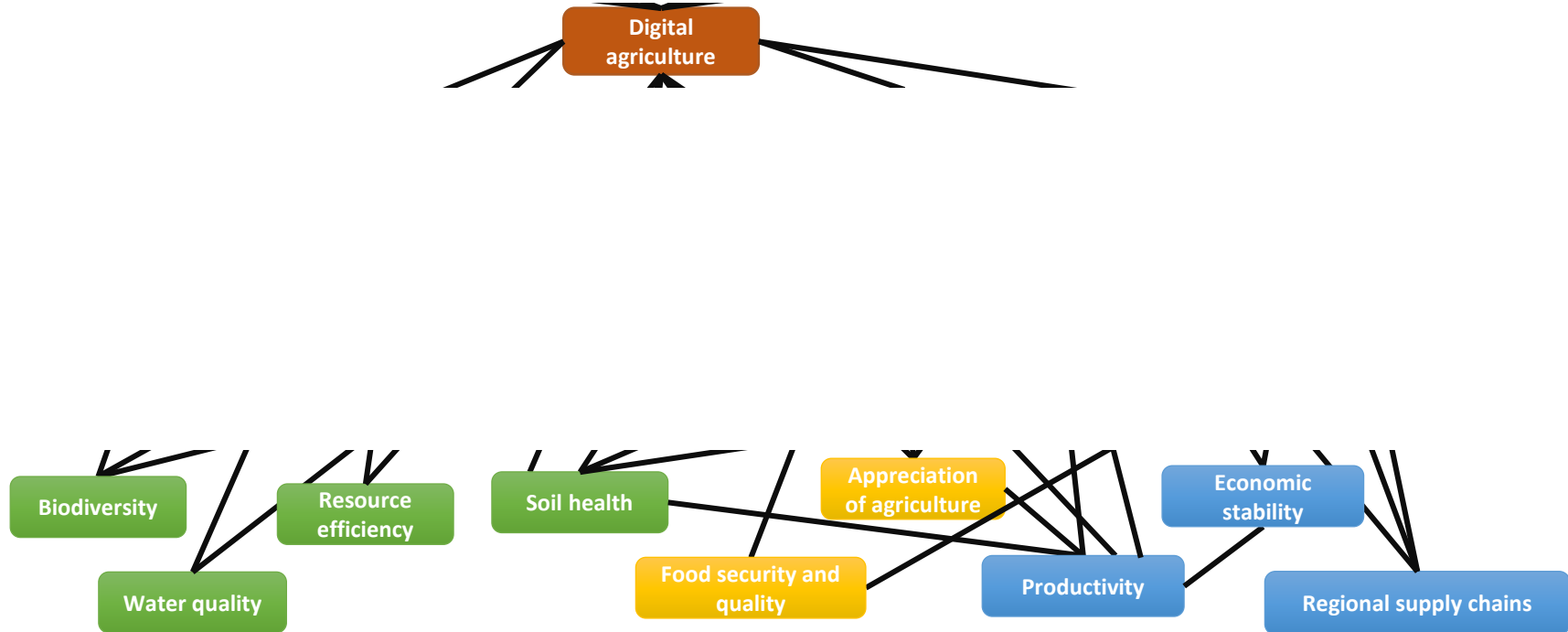


https://www.sustainweb.org/resources/images/food_growing/community_supported_agriculture.jpg

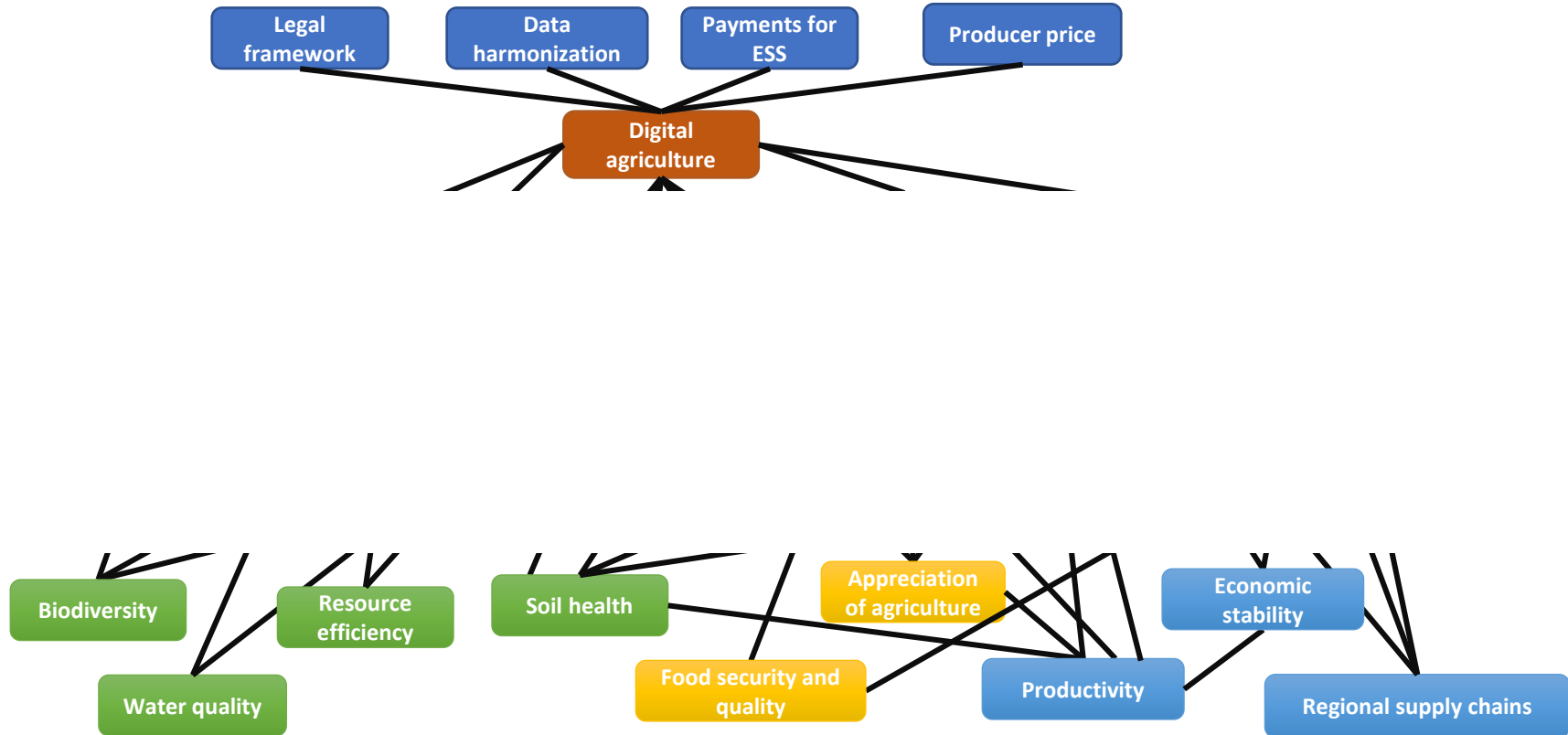


1. Monitoring
2. Management
3. Communication

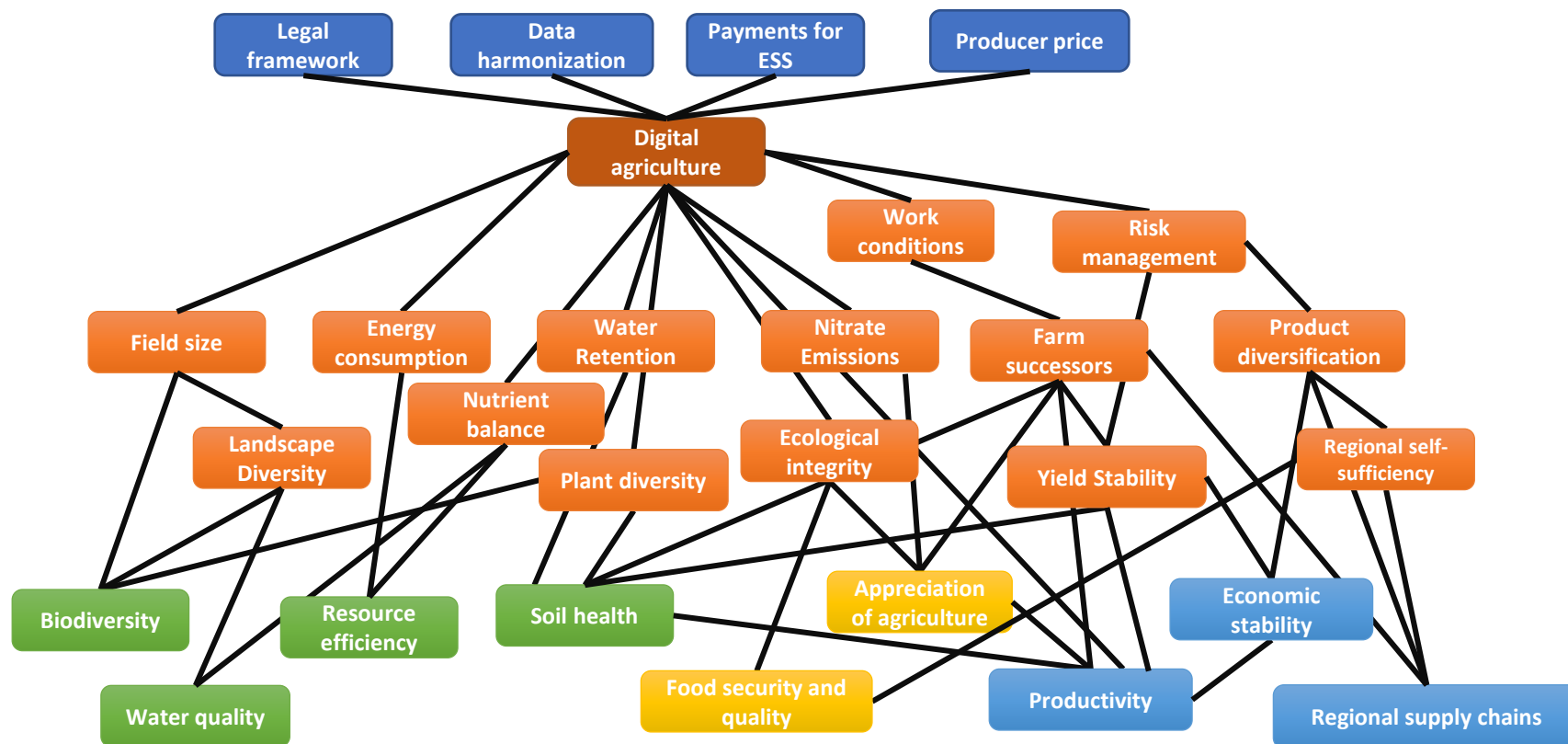
Farmers perception of digitalised agriculture



Farmers perception of digitalised agriculture

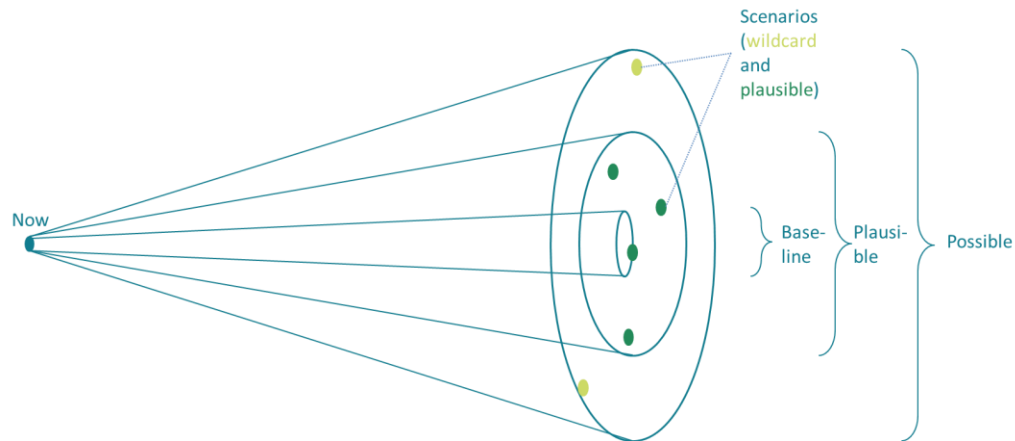


Farmers perception of digitalised agriculture



Scenarios

- Deal with uncertainties
- Future threats & challenges
- Windows of opportunity
- Solutions for tomorrow



Agroecology

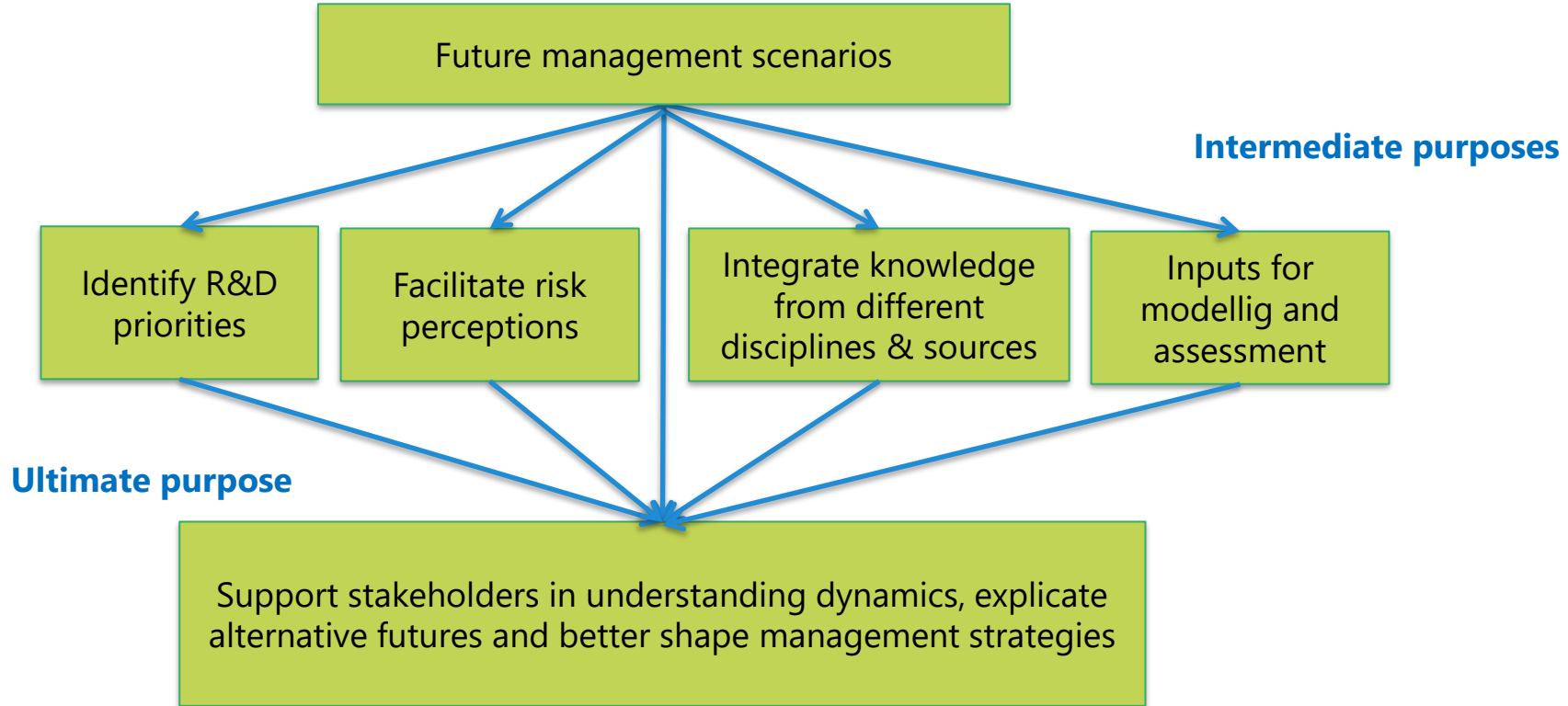
Digitalisation

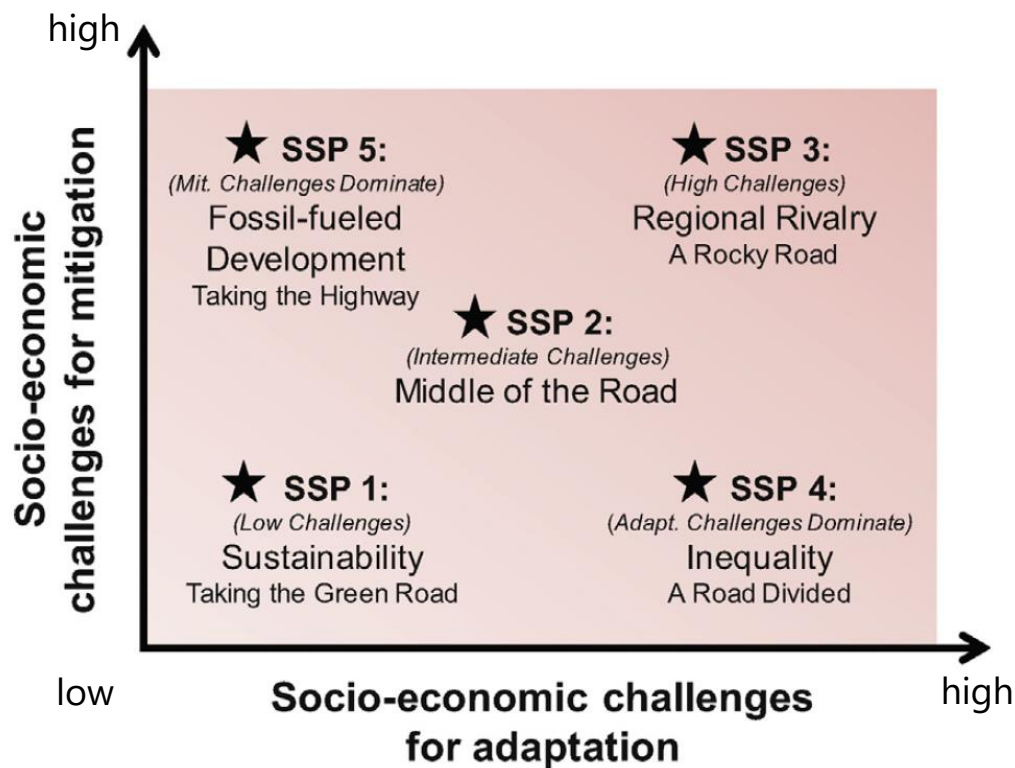
Diversification

Transformation

Link to climate change

Why scenarios?





- Developed in the climate change research community (O'Neill et al. 2017)
- „Pathways in the 21st century“
- Combining alternative futures of climate and society
- SSP storylines, including specifications for land use, SSP public data base at IIASA (modelling results)
- Used in combination with greenhouse gas emission trajectories (RCPs)

Shared Socio-economic Pathways (SSP) scenario framework Adoption and experiences

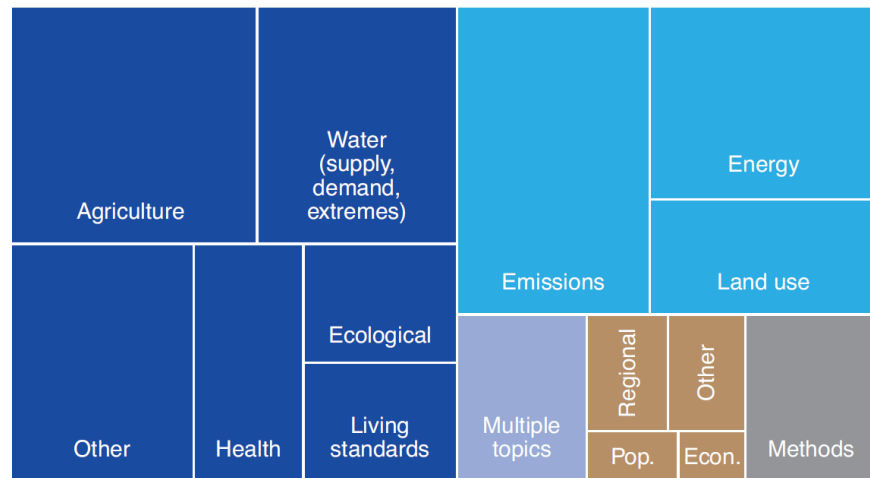
- Widely adopted: used as framework in other settings
- Regional and sectoral specifications

Pros:

- Consistency, Comparability, clarity
- Acceptance and visibility

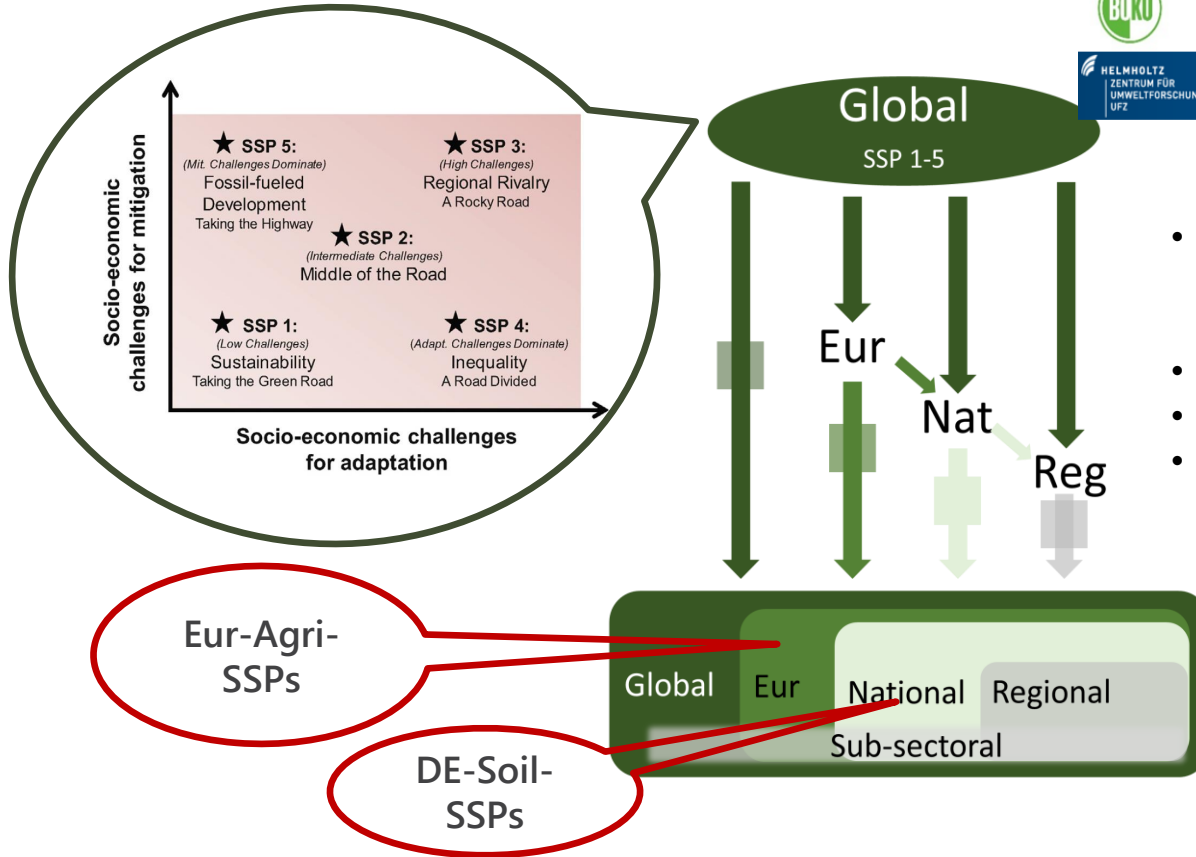
Challenges:

- Applicability at regional and local scales
- Capture relevant perspectives and uncertainties
- Keep scenarios up to date
- Improve relevancy: capacity building, communication, accessibility, stakeholder involvements



(O'Neill et al. 2020 Nature Climate Change)

Eur-Agri-SSPs: Shared Socio-economic Pathways for European agriculture and food systems



- **Thematic:** alternative future developments of agriculture and food systems
- **Spatial scale:** Europe
- **Time scale:** 2050
- **Scenario type:** problem-focused, qualitative storylines, semi-quantitative specifications of plausible futures

Mitter, Techen, Helming et.al. 2019. J Env. Mangement
 Mitter, Techen, Helming, et al., 2020. Global environmental Change

Stakeholder Workshops for specifying SSP storyline elements for soil management

- Apply SSP protocol of Eur-Agri SSPs
- 5 online participatory scenario workshops, 2020/2021
 - 2 English workshops + outreach/international collaboration
 - 3 German workshops
- **90** participants from 6 stakeholder groups:
 - State/Policy
 - Civil societies
 - Agricultural associations
 - Enterprises
 - Farmers
 - Academia

Focus on technology and environment



1. Population and urbanization*



2. Economy*



3. Policies and institutions*



4. Technology



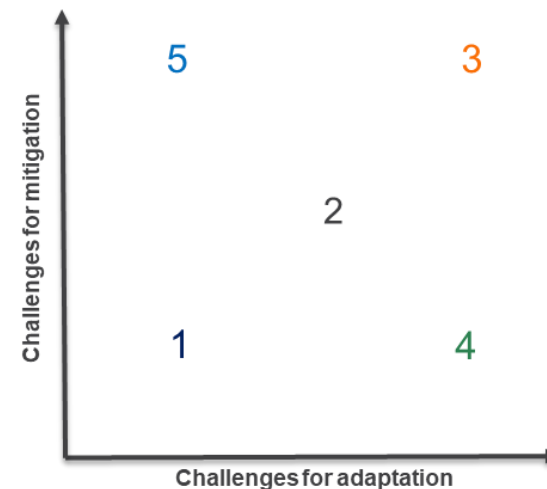
5. Environment and natural resources

Results: Environment and Natural Resources

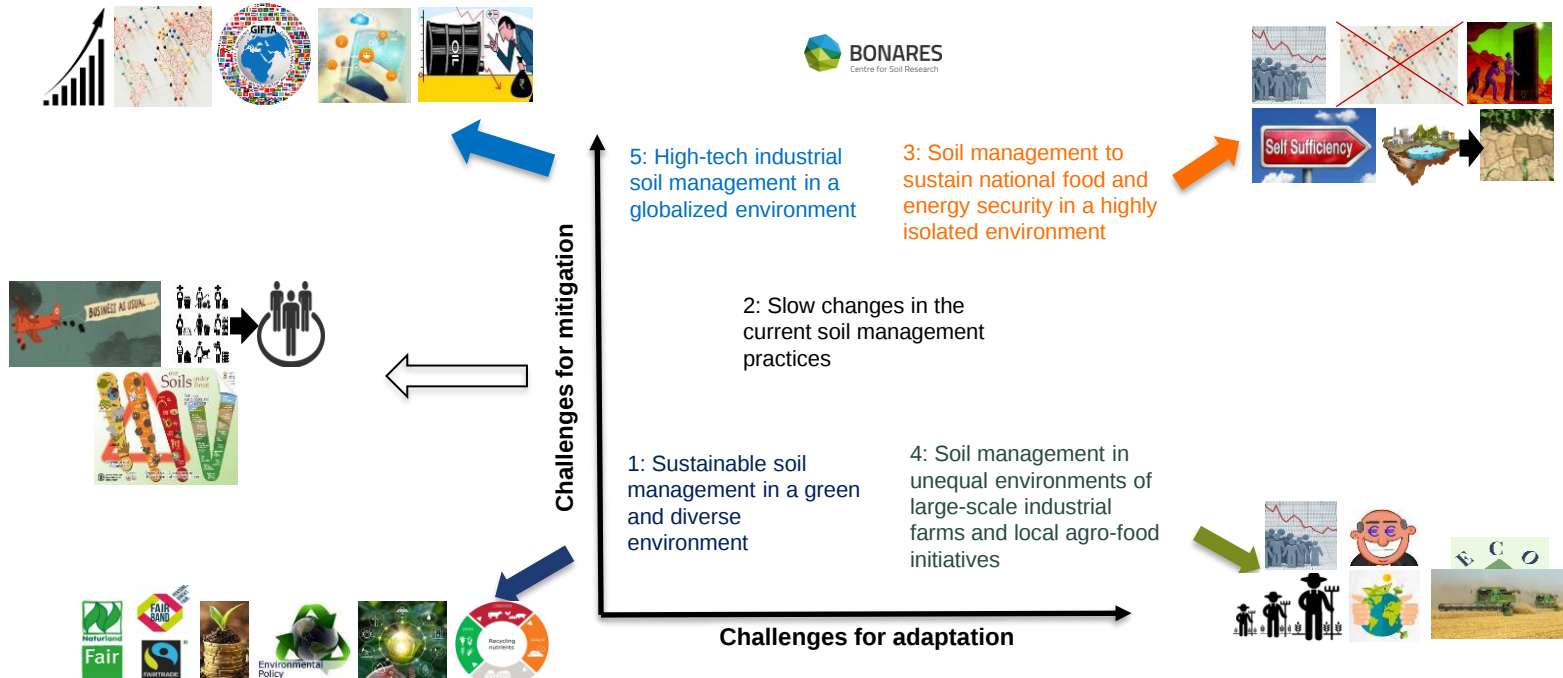
Strong decrease Tendency to decrease Remains Tendency to increase Strong increase

Storyline elements			SMP1	SMP2	SMP3	SMP4	SMP5
Soil management practices focusing on	Agricultural landscape diversity (i.e. field size and transition zones)						
	Integration of intercropping and agroforestry						
	Diversity of crop varieties						
	Diversity of crop rotations incl. cover crops and legumes						
	Subsoil management						
	Machinery weight and contact stresses						
	Intensity of tillage						
	Application of precision agricultural practices (e.g. plant- or site-specific)						
	Use of pesticides						
	Use of organic inputs, incl. inoculation and new fertilizers from recycled nutrients						
	Use of mineral inputs						
	Use of irrigation						
	Resource depletion induced by	Amount of agricultural land take (e.g. urban areas, streets etc.)					
		Amount of agricultural land transferred to nature conservation areas					
Status of soil functions	Biomass production						
	Storage and recycling of nutrients						
	Filtering and storage of water						
	Habitat for biological activity/Biodiversity						
	Carbon sequestration						
Occurrence of invasive species	Amount of weeds						
	Amount of pests						
	Number of diseases (soil-, water-, air-born)						
	Wildlife migration through the farms						
	Affecting cultural landscapes						

SMP1 – Sustainable path
SMP2 – Slow change path
SMP3 – Nationwide path
SMP4 – Divided path
SMP5 – High-tech path



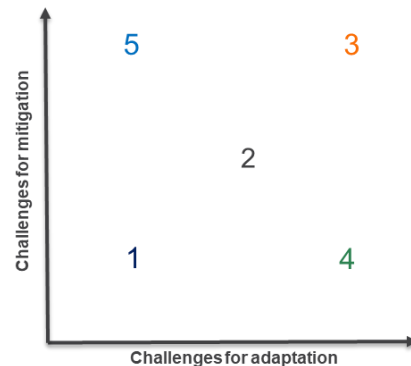
German Soil Management Pathways (DE-SMPs):



Key messages from the Soil Management Pathways

- Socio-technical innovations and technology uptake are improving strongest in SSP1 (high-tec) and SSP5 (sustainable), but the implications for sustainable soil management are different across the SSPs
- Policies and international trade-regulations and standards determine in how far innovations only improve (economic) efficiency or also sustainability
- Diversification is key in SSP1 (sustainable): rotation, intercrops, agro-forestry, value chain diversification
- The food value chain, consumption and dietary choices strongly determine farmers room for manoeuvre on sustainable soil management
- Mixed message on de-globalisation: meeting national needs may increase production and put additional pressure on soil; but producing fodder protein may actually be of benefit for soil health

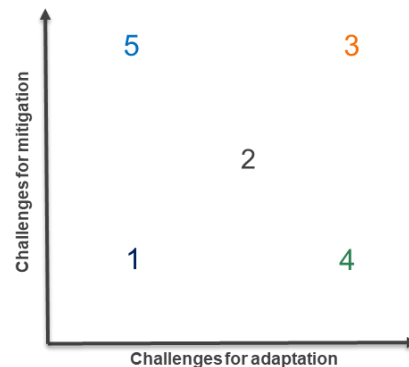
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Key messages from the Soil Management Pathways

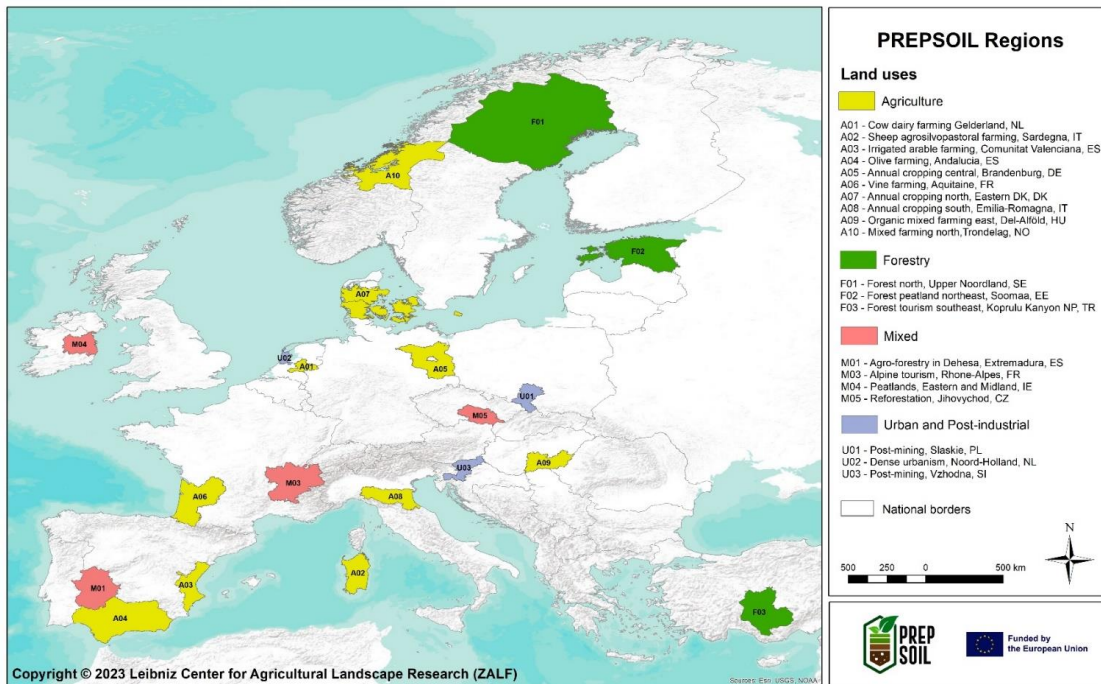
- BAU (SMP2) was not a desired future;
- Sustainable path (SMP1) integrated technological with societal innovation and consumer cooperation
- High-tech path (SMP5) used technology for improving efficiency but mostly ignored diversification
- Divided path (SMP4) was often seen as representation of the current state
- Nationwide path (SMP3) scored worst on environmental health
- Diversification key point (integration of high-tech with biological methods)

SMP1 – Sustainable path
SMP2 – Slow change path
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SMP5 – High-tech path



Stakeholder based Soil Needs Assessment in Europe

Analysis in 20 European regions, all land use types



Soil needs:

“what soil needs from humans to serve human needs”

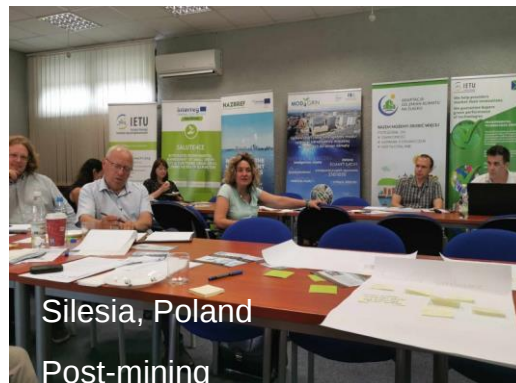
Stakeholder based Soil Needs Assessment in Europe

Stakeholder workshops



Brandenburg, Germany

Annual cropping



Silesia, Poland

Post-mining



Sardinia, Italy

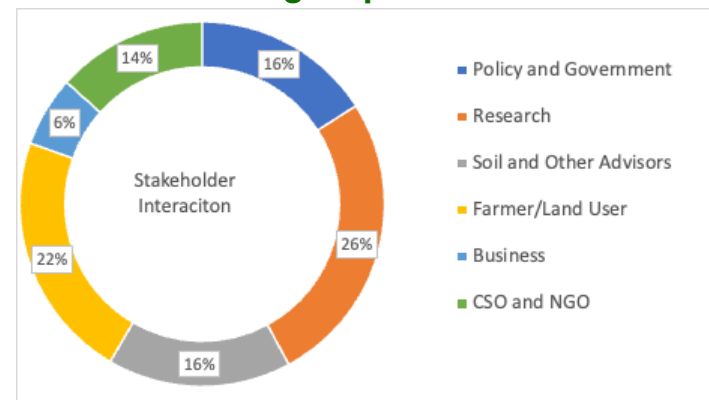
Sheep farming



Valencia, Spain

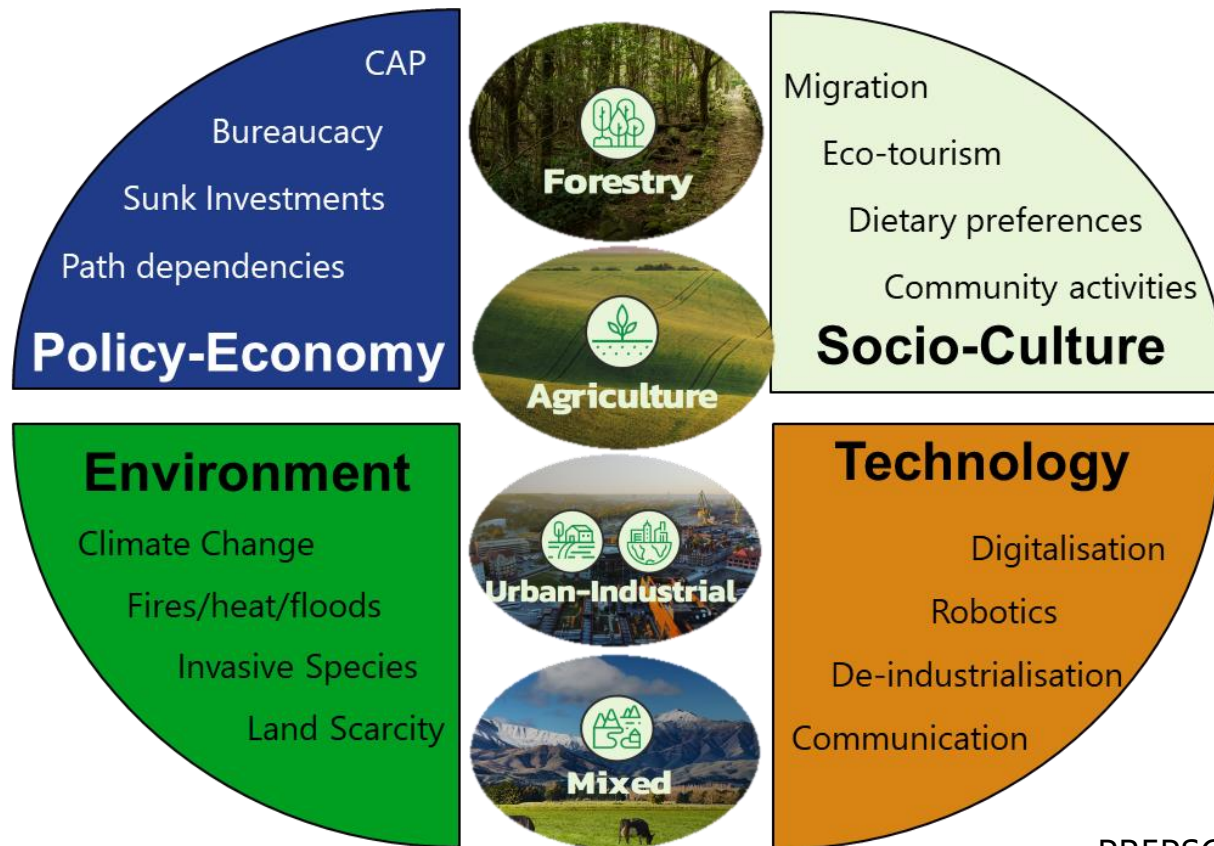
Irrigated farming

Stakeholder groups involved



> 500 individuals in total

Drivers of soil management



Soil improving management solutions are available but barriers are high

- Remove economic, policy and knowledge barriers to soil improving management
- Redirect policy (CAP) to support provision of ecosystem services alongside production
- Integrate agro-ecological principles with modern technologies in a systems approach
- Acknowledge cultural identity, ownership, and a sense of belonging to an area.
- Engage consumers into the transformation
- Consider path dependencies and land use history

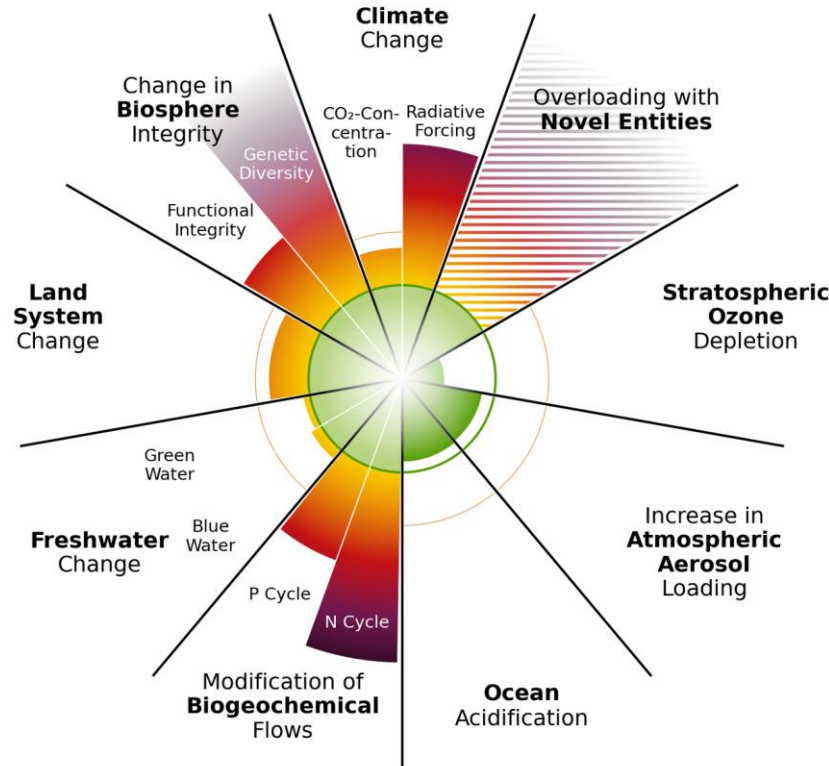


Conclusions

- Understanding **future** conditions helps to identify the **room for manoeuvre** for sustainable soil management
- Soil improving management requires **systemic changes** at the level of farming systems (and food system), not single interventions
- **Consumers** and **value chain** play important role in transformation, alongside technology and policy
- Solutions are **site specificities**, but do not get lost in details when communicating

Planetary boundaries: where is the soil?

Soil is more than
SOC



Thank you for your attention

