EO 4 Ecosystem Accounting 2022

Introduction Agroecosystem Accounts

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Physische Geographie und Landschaftsökologie

Agroecosystem Accounts

What are agroecosystems?

- communities of plants and animals interacting with their physical and chemical environments
- have been modified by people to produce food, fibre, fuel and other products for human consumption and processing

Type cropland	Type grassland
• main food production areas • both intensively and less intensively managed ecosystems • regularly or recently cultivated agricultural, horticultural and domestic habitats	• areas dominated by grassy vegetation (but including tall forbs, mosses and lichens) • includes intensively managed pastures and fodder production and • semi-natural (extensively managed) grasslands

from 5th EU MAES report; Maes (2018)

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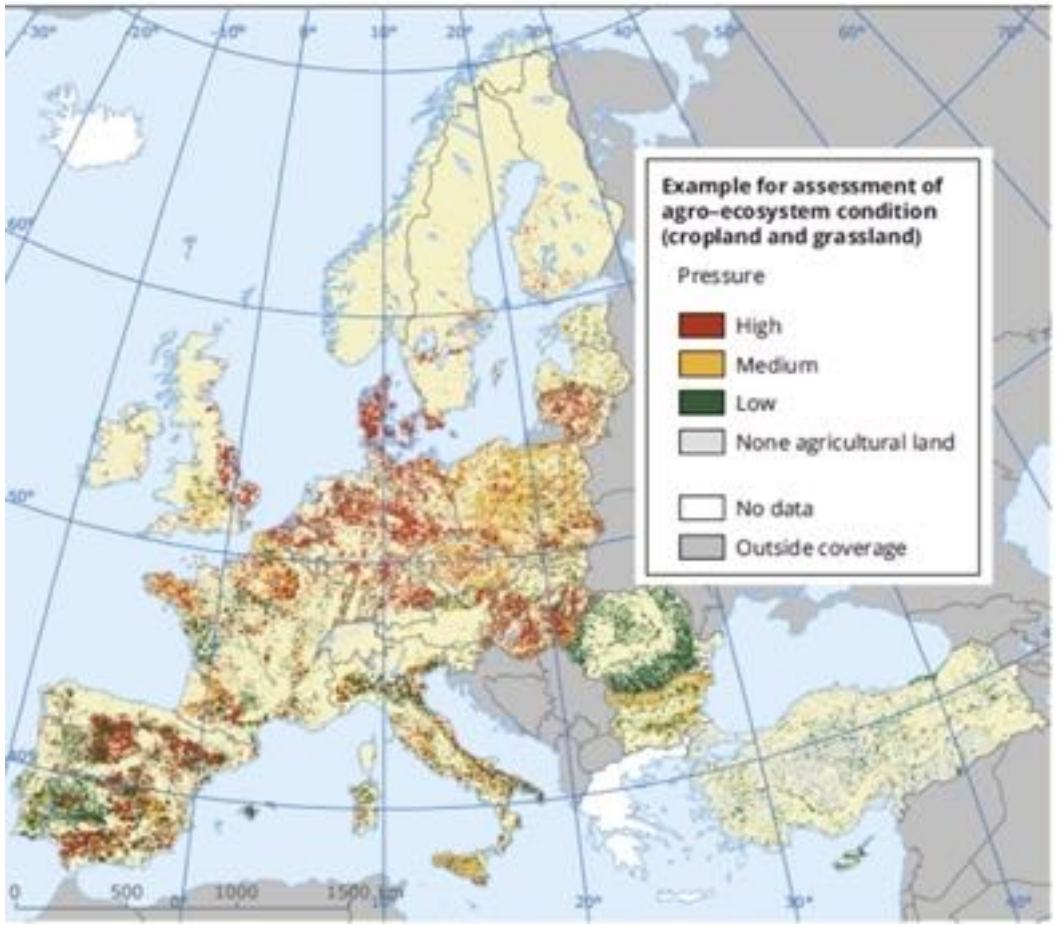
Characteristics of agroecosystems

- long history of use (in Europe introduced about 9000 years ago)
  → how to define historical reference condition?
- agricultural use has modified and shaped landscapes until today
- cover large areas (about 47% of EU's land area)
- often homogenized, thus poor in structures and biodiversity
- often highly productive systems
- supply essential provisioning ecosystem services to humankind



Aggregated assessment of cropland condition in Europe

EC (2016) from EEA (2015)

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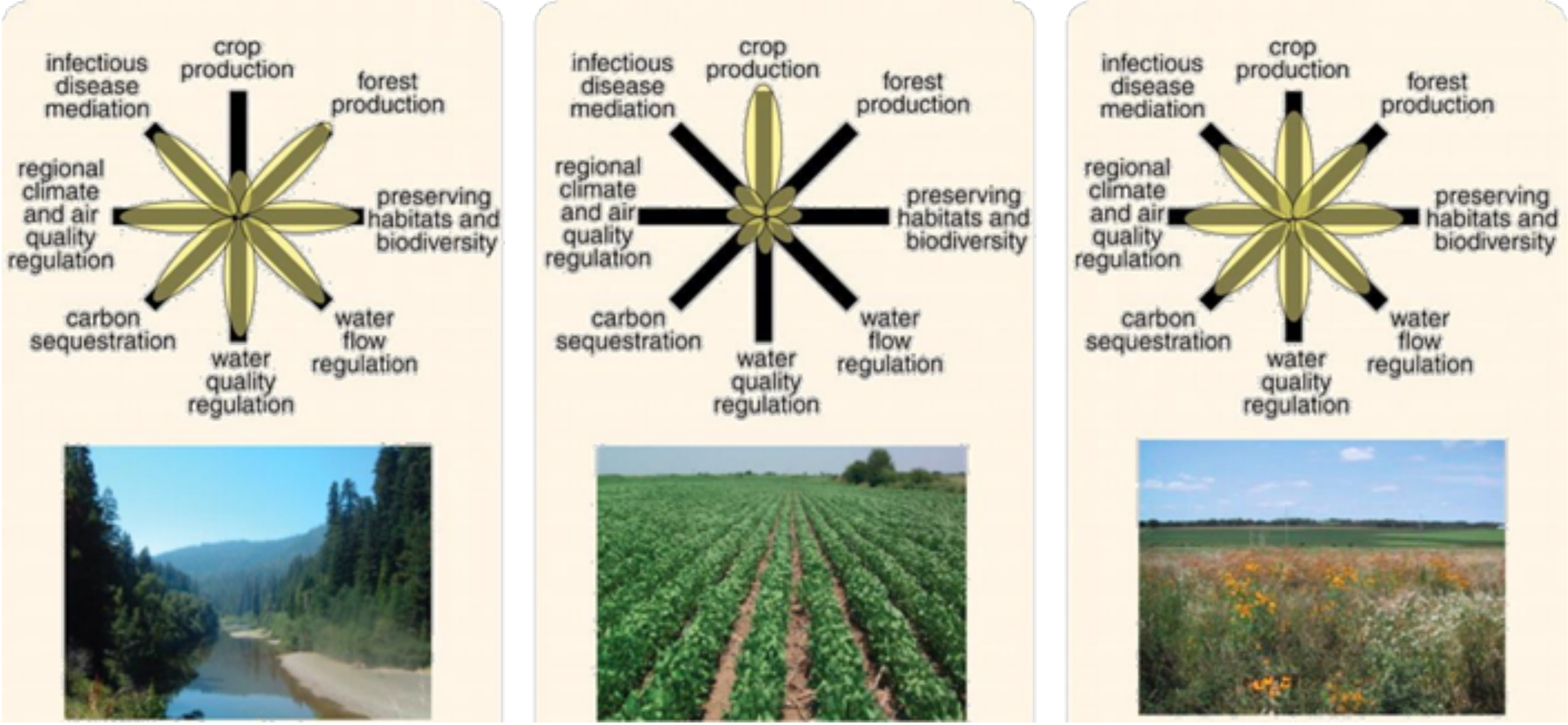
- maximization of targeted ecosystem services is causing significant trade-offs



Foley et al. (2005)

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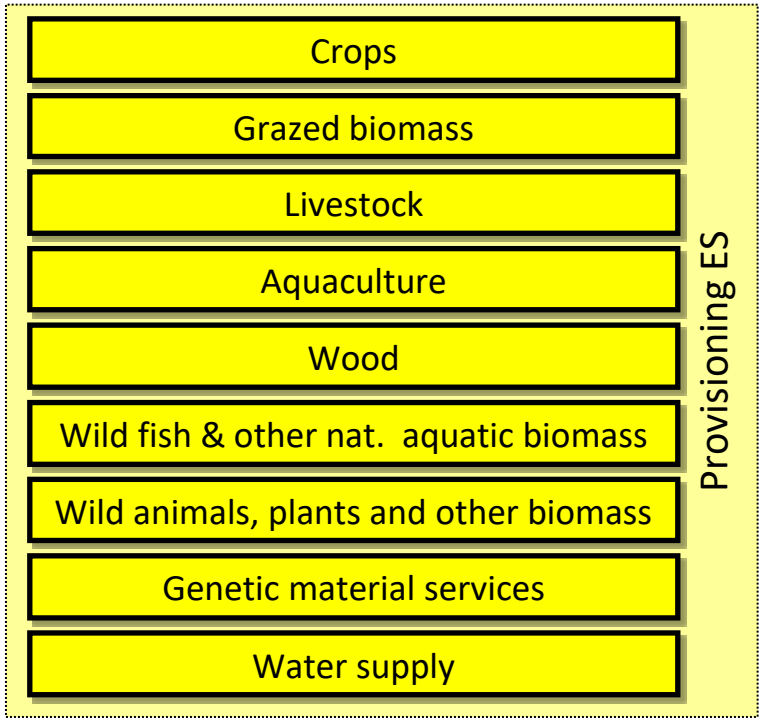
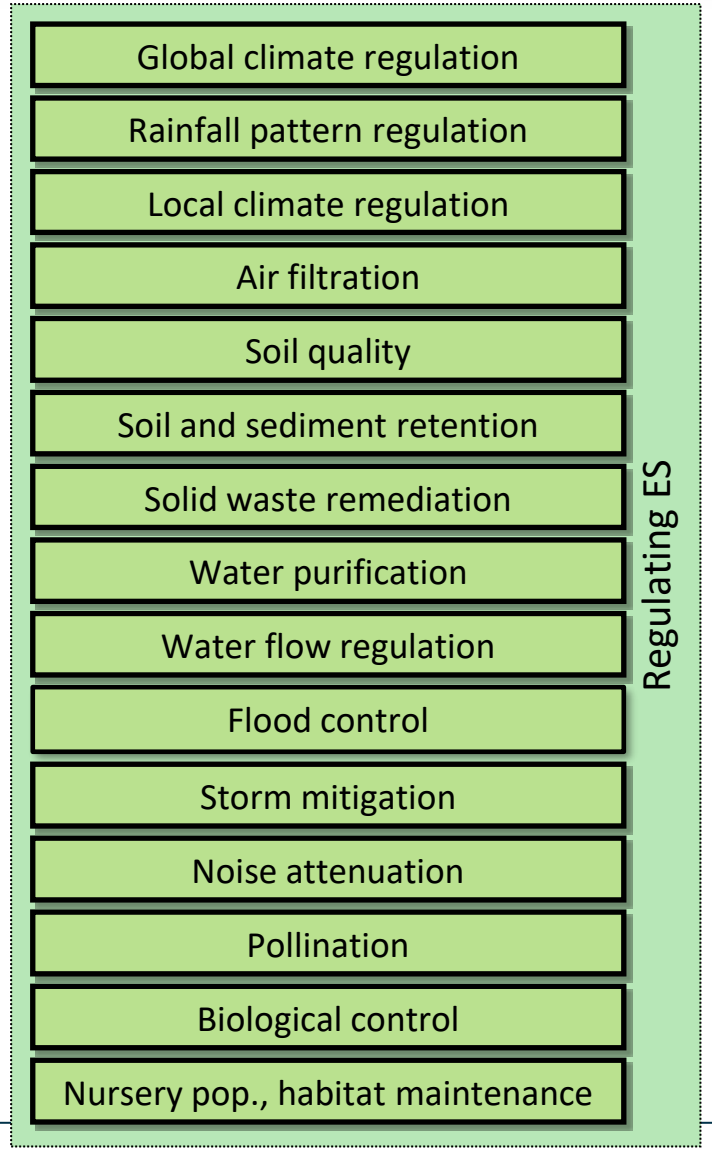
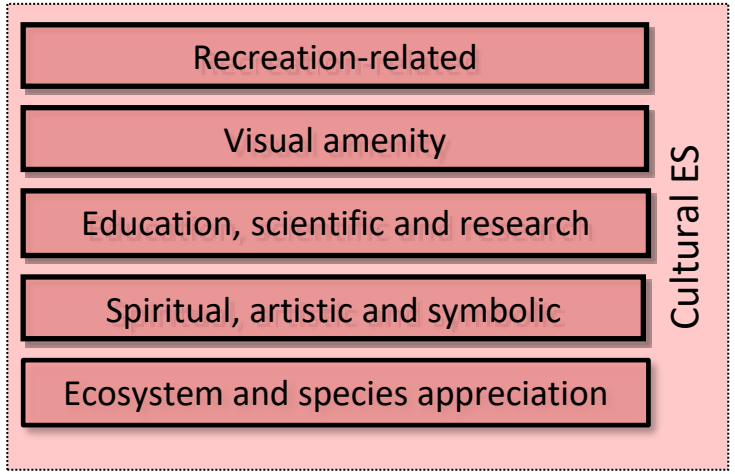
Agroecosystem services





- agroecosystems are at the same time supplier of (mainly provisioning and cultural) and user of (mainly regulating) ecosystem services



based on SEEA EA reference list of selected ecosystem services (United Nations et al. 2021)

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Agroecosystem services

Provisioning ES

- Crops
- Grazed biomass
- Livestock
- Aquaculture
- Wood
- Wild fish & other nat. aquatic biomass
- Wild animals, plants and other biomass
- Genetic material services
- Water supply

Regulating ES

- Global climate regulation
- Rainfall pattern regulation
- Local climate regulation
- Air filtration
- Soil quality
- Soil and sediment retention
- Solid waste remediation
- Water purification
- Water flow regulation
- Flood control
- Storm mitigation
- Noise attenuation
- Pollination
- Biological control
- Nursery pop., habitat maintenance

- agroecosystems are at the same time **supplier of** (mainly provisioning and cultural) and user of (mainly regulating) **ecosystem services**

Cultural ES

- Recreation-related
- Visual amenity
- Education, scientific and research
- Spiritual, artistic and symbolic
- Ecosystem and species appreciation

based on SEEA EA reference list of selected ecosystem services (United Nations et al. 2021)

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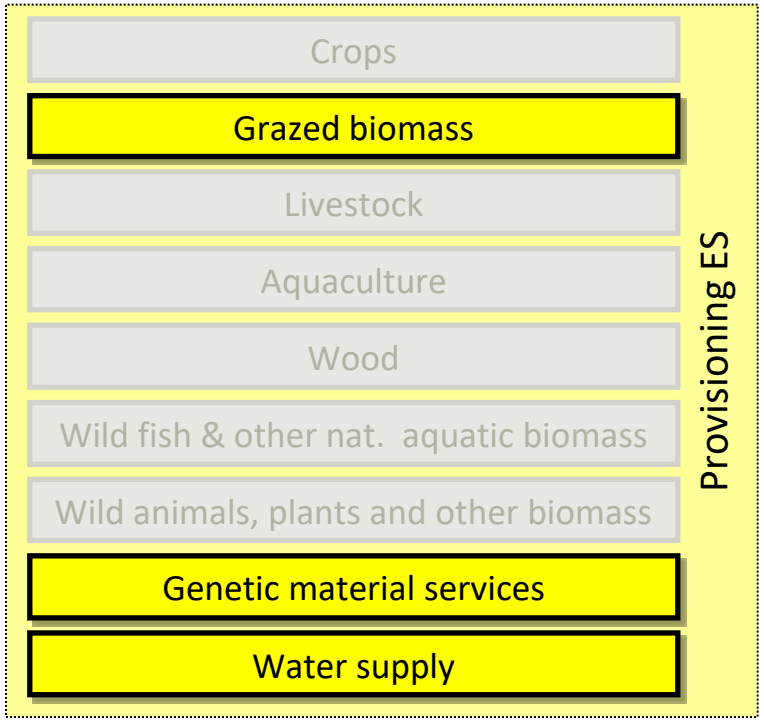
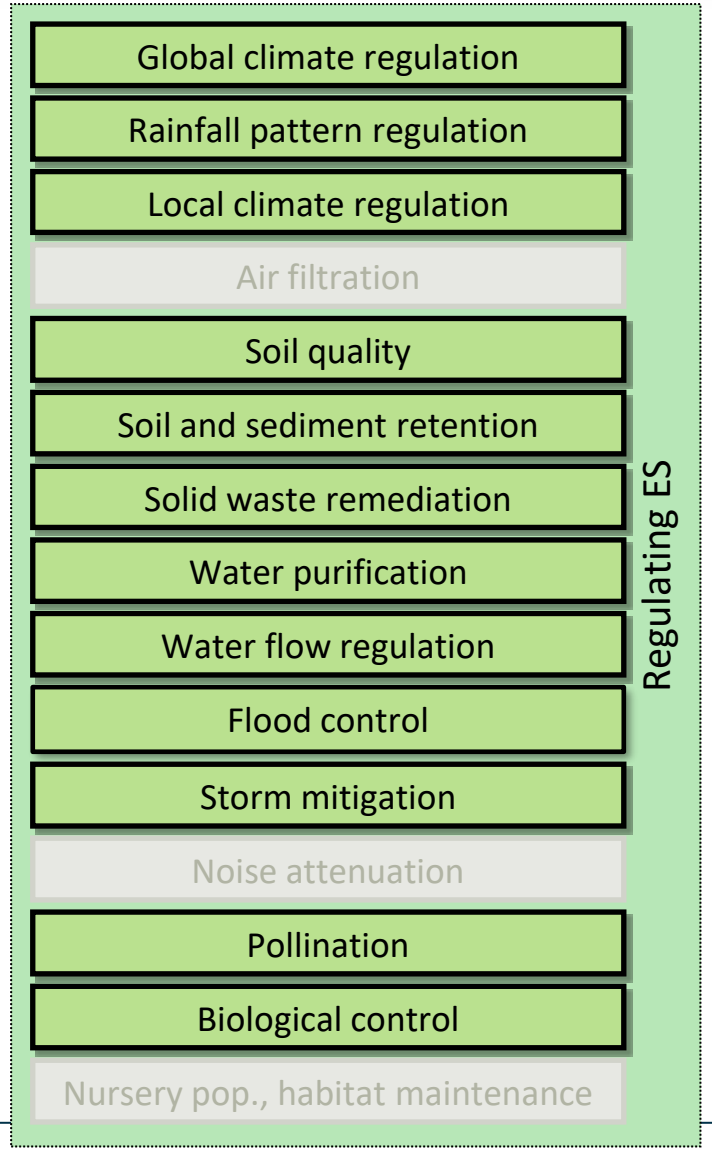
Agroecosystem services





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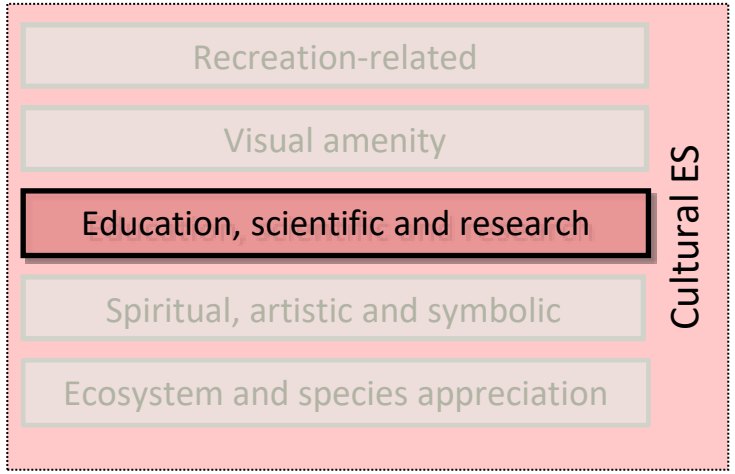

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Agroecosystem services

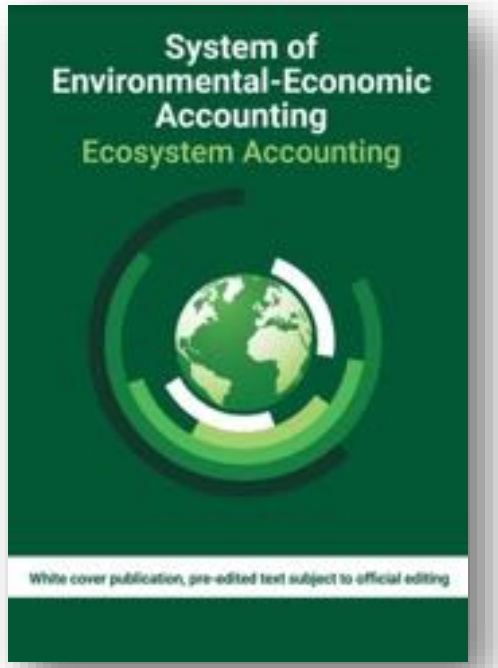
- supply and use – how to (spatially) account for?

Table 7.2: Basic Ecosystem services physical supply and use table #1

	Units of measure	Economic units (selected)			Ecosystem assets (selected types)		
		Agri.	Gov.	Households	Forest	Cropland	Grassland
SUPPLY							
ES #1: Biomass provisioning services (rice)	Tonnes					100	
USE							
ES #1: Biomass provisioning services (rice)	Tonnes	100					

Note: Grey cells indicate not applicable. "ES" denotes final ecosystem services.

from SEEA EA (United Nations et al. 2021)



Agroecosystem Accounts

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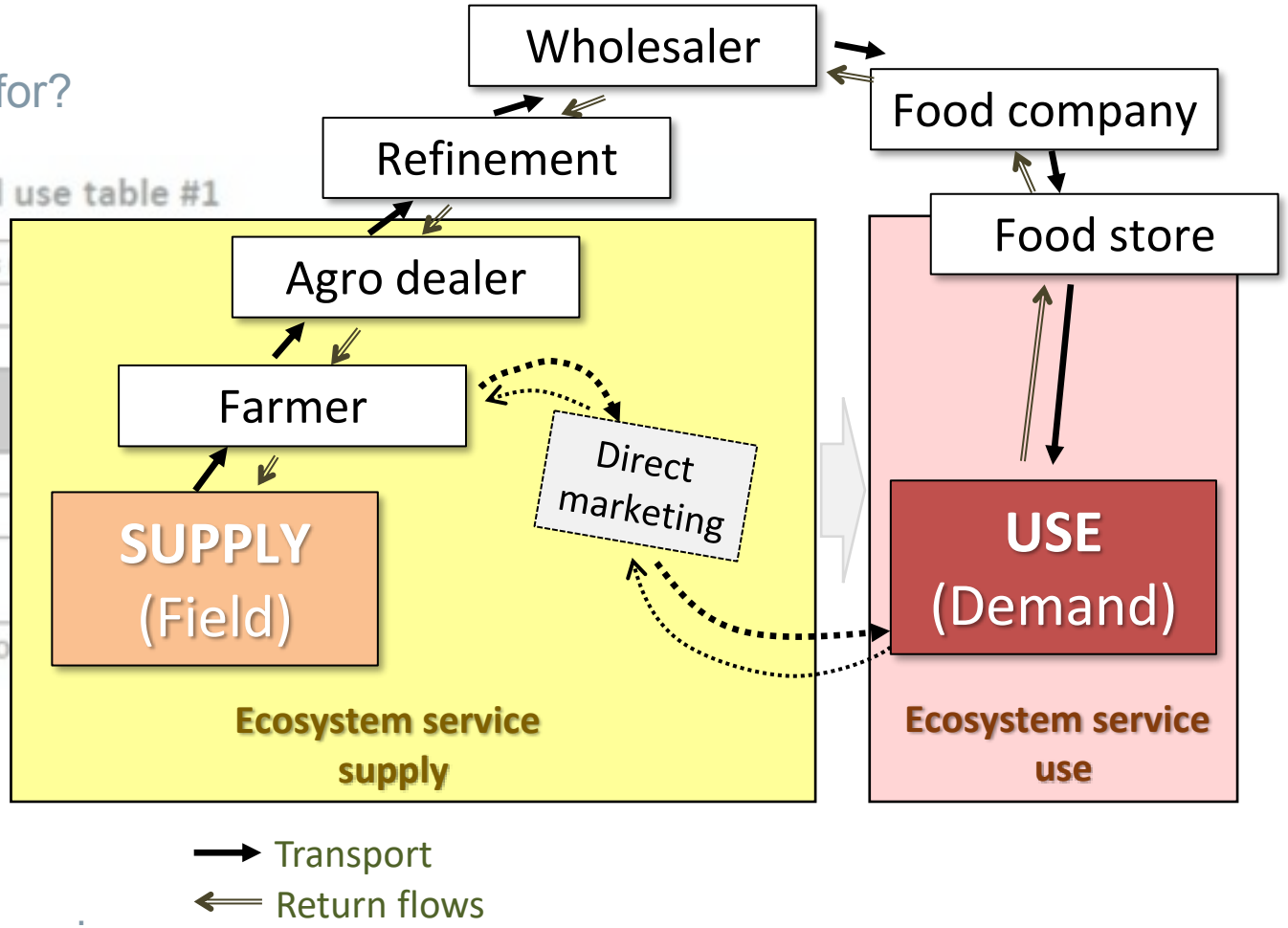

(from Burkhard et al. 2014)

- complex supply – use patterns
- various transactions and beneficiaries/economic units involved

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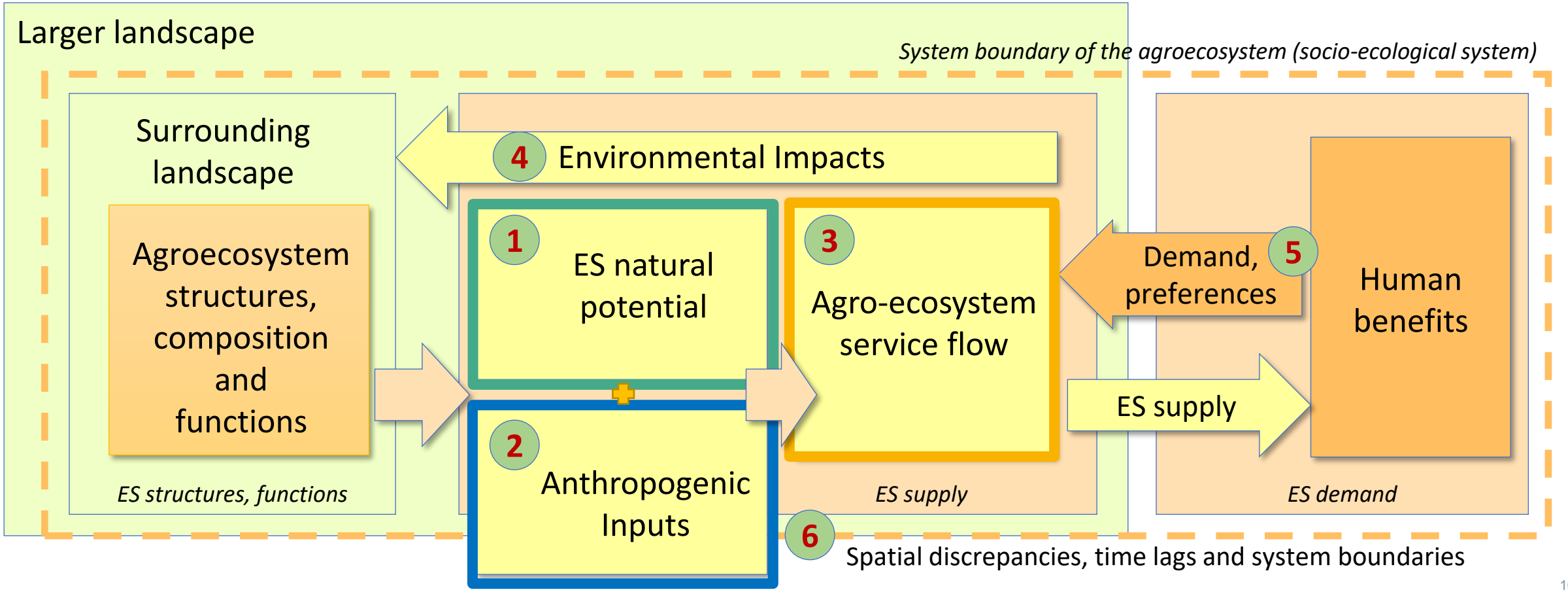
Agroecosystem services supply

- Co-production based on natural + anthropogenic inputs (seeds, fertilizers, water, pesticides, labor, time, energy, ..)



from Bethwell et al. (2021)

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Towards an enhanced indication of provisioning ecosystem services in agro-ecosystems

Claudia Bethwell · Benjamin Burkhard · Katrin Daedlow · Claudia Sattler · Moritz Reckling · Peter Zander

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Abstract Provisioning ecosystem services play a vital role in sustaining human well-being. Agro-ecosystems contribute a significant share of these services, besides food and fodder and also fuel and fibre as well as regulating and cultural ecosystem services. Until now, the indication of provisioning ecosystem services of agro-ecosystems has been based almost only on yield numbers of agricultural products. Such an indication is problematic due to several reasons which include a disregard of the role of significant anthropogenic contributions to ecosystem service co-generation, external environmental effects and strong dependence on site conditions. We argue for an enhanced indication of provisioning ecosystem services that considers multiple aspects of their delivery. The conceptual base for such an indication has been made by prior publications which have been reviewed. Relevant points were taken up in this article and condensed into a conceptual model in order to develop a more holistic and expanded set of indictors, which was then exemplarily applied and tested in three case studies in Germany. The case studies represent different natural conditions, and the indicator set application showed that ecosystem services (ES) flow—in terms of output alone—does not characterise agro-ecosystems sufficiently. The proposed aspects of provisioning ecosystem services can give a fuller picture, for example, by input-output relationships, as it is possible by just using single indicators. Uncertainties as well as pros and cons of such an approach are elaborated. Finally, recommendations for an enhanced indication of provisioning ecosystem services in agro-ecosystems that can help to integrate agricultural principles with ideas of sustainability and site-specific land use are derived.

This article is part of the Topical Collection on *Managing Ecosystem Services and Biodiversity of Agricultural Systems*

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Keywords Agricultural landscapes · Site-specific land

Table 1 Indicators for provisioning ES, example for cultivated crops for human nutrition (indicators in bold were quantified in the case studies)

Supply side				Demand side
1. ES potential	2. Anthropogenic inputs (as biophysical and monetary values)	3. Actual ES flow (actual provision as biophysical and monetary values)	4. Environmental externalities of provisioning ES (positive, negative)	5. ES demands and preferences
		6. Spatial modelling and mapping of provisioning ES		
Soil and climate conditions - Soil quality rating (index)[1a,b] - Temperature[1b] - Precipitation[1b]	Direct inputs: Non-aggregated biophysical and monetary values - Seeds[2a] - Fertiliser[2a] - Pesticides[2a] - Energy (fuel consumption)[2a] - Irrigation[2a] - Working time[2a] - Machine use[2a] Aggregated biophysical and monetary values - total fuel use[2b] - Sum of N-, P_2O_5- and K_2O input[2b] - stand. treatment index[2b] - Factor costs (total)[2b] Relational and balancing biophysical values: - Energy use efficiency[3,4a] - Water use efficiency[3,4b] - N farm gate balance[2b,4c] - N soil surface balance[2b,4c] Indirect inputs: - Development in technology and knowledge[3] - Farmers' education[3]	Non-aggregated, biophysical values - Crop yield[2a] Non-aggregated, monetary values: - Crop sales2a Aggregated, biophysical values: - Grain equivalent units (total)[2b] - Grain equivalent units (crops)[2b] - Grain equivalent units (livestock)[2b] Aggregated, monetary values: - Sales (total)[2b] Relational and balancing monetary values: - Income (total)[2b]	Highly integrated /index-coded values Impacts on climate - GHG emissions (CO_2 equivalent)[2] Impacts on soil - Erosion by water[3] - Erosion by wind[3] - Humus balance[3] - Soil compaction[3] Impacts on ground and surface water - Water quantity[3] - Water quality[3] Impacts on flora and fauna - Habitat suitability for species of agricultural landscapes (e.g. field birds)[3] Impacts on cultural ES - Landscape aesthetics[3] - Recreation[3]	Consumer interests (products) Consumption patterns[3] - Food consumption (e.g. organic vs. conventional) - Expenses for food Preferences[3] - Willingness to pay - Willingness to accept Local and regional stakeholder interests (regional ES demand)[3] Specific preferences for ES of local and regional stakeholders[3] - Willingness to accept Societal demand (policy strategies)[3] Indicators belonging to the following mitigation strategies: - greenhouse gas-emissions[3] - N input into water bodies[3] - Endangerment of flora and fauna[3]

from Bethwell et al. (2021)

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PRESSURES	CONDITION	ECOSYSTEM SERVICES	POLICY OBJECTIVES (examples)
Habitat and land conversion	Landscape and habitat fragmentation	Food/feed/fibre/energy	Healthy soils
Climate change	Crop rotation and diversity	Reared animals and their output	Clean water
Input of nutrients and pesticides	Livestock density	Water quality and quantity	Maintenance of biodiversity
Over-exploitation	Density and connectivity of semi-natural elements	Mediation of smell/noise/visual impacts	Improved air quality
Introduction of invasive alien species	Area under management practices potentially supporting biodiversity	Erosion prevention	Mitigation of climate change
	Share of fallow land	Flood protection and water regulation	Provision of landscape amenities
	Species richness and abundance (different taxa)	Pollination	
	Conservation status of habitats and species of Community interest	Pest and disease control	
	Soil condition	Global climate regulation	
	Water quality and availability	Micro and regional climate regulation	
	Gross primary production	Maintenance of genetic diversity	
		Maintenance of nursery populations	
		Outdoor recreation	
		Intellectual/representative /spiritual interactions	

Synthesis of pressures, condition and ecosystem services in agroecosystems

from 5th EU MAES report; Maes (2018)

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Ecosystem Service	Common ecosystem type/s	Factors determining supply		Factors determining use	Potential physical metric(s) for the ecosystem service	Benefits	Main users and beneficiaries
		Ecological	Societal				
Crop provisioning services	Cropland	Soil fertility, especially chemical state (e.g., soil organic carbon, nutrients); climate; water supply; pollination; genetics	Farm management at different stages of production process; Harvesting practices; Air pollution affecting soil quality	Demand for biomass (e.g., for food)	Gross tonnes of cultivated plants e.g., wheat (proxy measure)	Crop products – e.g., harvested wheat (SNA benefit)	Agricultural producers, including household and subsistence production
Grazed biomass provisioning services	Pastures	Soil fertility; climate; water supply; genetics	Farm management at different stages of production process	Demand for biomass (e.g., as food for livestock); farming practices	Gross tonnes of grazed biomass	Livestock and livestock products (e.g., meat, milk, eggs, wool) (SNA benefits)	Agricultural producers, including household and subsistence production; households

Logic chains for two key agroecosystem services

rom SEEA EA (United Nations et al. 2021)

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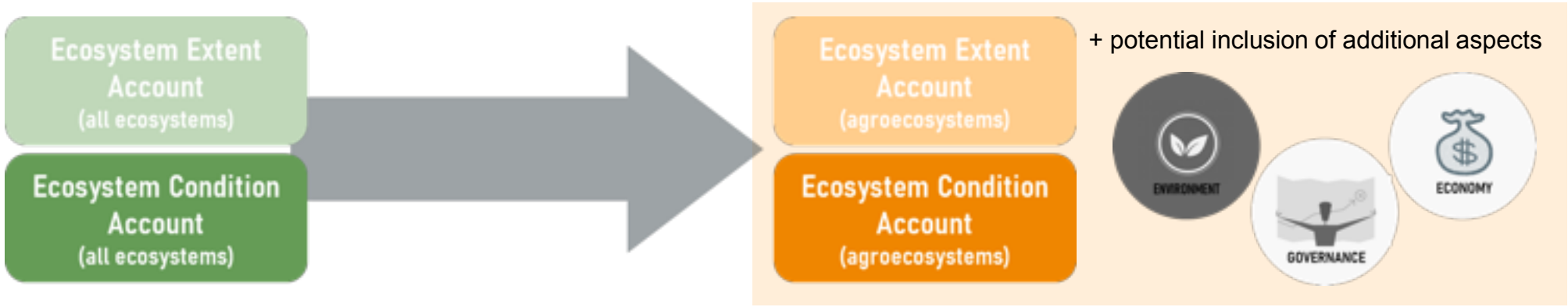
Thematic Accounting – Agroecosystems

- opportunity to integrate information/data from
  - Ecosystem Accounts
  - other accounts of the SEEA Central Framework and the SNA and
  - additional sources (e.g. Earth Observation data)
- challenge: ensuring consistency
- agroecosystem accounts can, amongst others, be compiled by extending and adapting existing SEEA accounts
  - e.g. by inclusion of additional details (i.e. linear landscape features such as hedgerows)
  - integration of alternative classifications (i.e. distinction of crop types and management measures)



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Conclusions

Theme	Account	EO data relevancy
agroecosystems are the dominant type of land use/land cover in most European countries	**extent accounting**	✓
related accounts have to consider the specifics of agroecosystem service co-production	**condition accounting**	✓
agroecosystems are highly relevant supplier and user of multiple ES	**ES supply & use accounts**	✓
agroecosystem services are key for human well-being	**welfare accounts**	✓
accounts could be used to assess e.g. environmental objectives of the EU Common Agricultural Policy (CAP) by supporting agri-environmental reporting and assessments of related measures' effectiveness		✓

Thanks for your attention!