

Sustainability Assessment of Agricultural Soil Management

Conference on

Soil Biota driven Eocystem Services in European Agriculture

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Soils and Sustainable Development



- Food Security (Goal 2)
 - population: > 9 billion in 2050
 - Increasing meat consumption
- Energy security (Goal 7)
 - Bioenergy
- Sustainable production (Goal 12)
 - Resource use efficiency
 - Climate Change (Goal 13
 - Adaptation

- Mitigation
- Terrestrial ecosystems (Goal 15)
 - Biodiversity
 - Land degradation neutrality

BUSTAINABLE GOALS



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How to reduce the environmental impact of the food system?



Springmann et al., Nature 2018

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Sustainability Assessment of Soil Management



Concept

- Sustainable Intensification (Garnett et al., 2013)
- Ecological Intensification (Tittonell, 2014)
- Regenerative agriculture (who?)

Questions:

- What are future soil management options?
- How can they improve agricultural production and maintain the othr soil functions?
- What are the impacts on ecosystem services, resource use efficiency and sustainable development targets?
- What are the trade-offs?



The BonaRes approach to systemic soil analysis



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Vogel et al., 2018. Soil



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External driving forces of future soil management

Libriz Leibniz Association

Ceteris paribus is not plausible

Multiple driving forces determine future developments



Foresight on emerging soil management practices and technologies







Digitization for precision farming







Quelle: 3)



Quelle: 1) 1) WEGENER, J. K., MINBEN, T.-F. & GAUS, C.-C. 2017. Developing new cropping systems - Which innovative techniques are required? Landtechnik, 72 2);3) Gandofer (LfL 2018).

Small autonomous machines

Drivers: production costs, soil threats, technology, policy

Time frame for relevant spread: 15-20 years

Probability: very high for autonomous machines, high but uncertain for small autonomous machines

Impact: opportunities for smaller-scaled farming, intercropping, less weight stresses \rightarrow positive impact on all soil functions possible, but details and other impacts unclear (e.g. resource efficiency)









Sources top to down:

http://otizvora.com/forum/index.php?topic=1116.15, Farm Journal Media: Ecorobotix autonomous robot weeder 2016:

Herlitzius, TU Dresden, https://tudresden.de/ing/maschinenwesen/int/ressourcen/dateien/ agrarsystemtechnik/forschung/Poster AST Maehdrescher konzepte.pdf?lang=de 11

Multifunctional land use



	g term than 5 years"	
agroforestry & intercropping lignocellulosic crops field sizes,	small autonomous machines crop rotations more/less	s diverse (regions)
transition zones	crop varieties	
Weak Signal	biotic inoculation	irrigation Strong Signal
new fertilizers from	n recycled nutrients	
subsoil management pesticides	tillage	
quantitative intensification		
soil con	servation behavior	
Short	s <mark>more diverse</mark> t term an 20 years"	optimized routes, tire pressure, precision farming



How relevant are new practices for soil functions?

Techen et al., Advances in Agronomy (in review)

			Assumed r	elevance for so	il functions	
Section Key research challenges	Storing and filtering water	Storing and recycling nutrients	Production of biomass	Carbon storage	Habitat for organisms	
3.1 Spatial arrangements of cropping systems	Nutrient response efficiencies and nutrient retention efficiencies in agroforestry systems and conventional agriculture under comparative conditions					
	Water consumption at the field scale of agrofrestry and conventional agriculture under comparative conditions					
	Effectiveness of agroforestry to reduce erosion and improve C sequestration					
	Resource competition in intercropping systems					
3.2 Crops and rotations	Root architecture and functions					
	Benefits and consequences of crop diversification					
	Functions of the soil-rhizosphere microbiome					
3.3 Mechanical pressures	Spatial prediction of actual soil compaction risk and identification of soil compaction patterns					
	Effects of soil compaction on soil - plant - atmosphere interactions based on a systemic approach					
	Recovery and amelioration of compacted subsoils					
3.4 Inputs into the soil	Precise quantification of above- and below- ground carbon input by different crops/varieties in long-term exerperiments to improve SOM management					
	Effects of stoichiometric (C:N:P) relation- ships on soil nutrient dynamics and on agricultural nutrient use efficiency					
	Ecotoxicity of plastics and pharmaceuticals in soil					
	Long-term agronomic effectiveness of P-recycling products	1				
	Sustainable biotic inoculation methods for field appliaction					BONAI Centre for Soil R

European Agricultural Socio-Economic Pathways EU-Agri-SSPs



IPCC shared socioeconomic pathways



Challenges to adaptation



The BonaRes approach to systemic soil analysis



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Vogel et al., 2018. Soil



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A meta-study of European cases: Impacts of climate change adaptation scenarios on soil functions

Location of 20 case study areas across environmental zones in Europe



	Adaptation options						
Case studies	crops & crop rotation	tillage	irrigation / drainage	fertilization	share of arable land		
Foggia (IT)	more winter wheat, tomato		increase irrigation efficiency	increase efficiency			
Oristanese (IT)	more grain, forage	increase conservation tillage	increase in irrigation areas and efficiency	increase efficiency	increase cropland		
South Tyrol (IT)	same crop but adapted varieties		increase irrigation efficiency				
Baakse Beek (NL)	more maize, potato			reduce amount	increase cropland, reduce grassland		
Flevoland (NL)	more winter wheat		increase irrigation efficiency				
Hobøl, Østfold (NO)	more forage	increase conservation tillage	improve drainage system		increase grassland reduce cropland		
Jæren, Rogaland (NO)			improve drainage system		increase grassland reduce cropland		
Lowland Trøndelag (NO)			improve drainage system		increase grassland reduce cropland		
Romerike Akershus (NO)	more forage	increase conservation tillage	improve irrigation system				
Kujawsko-Pomorskie (PL)	more cereals, maize, rape	increase conservation tillage	increase irrigation efficiency	increase amount			
Transylvanian Plain (RO)	more maize, soybean, wheat	increase conservation tillage	introduce irrigation for key crops	apply organic fertilizers			
NE Scotland (UK)		-			increase cropland, intensify grasslanc		

Adaptation pathways

Hamidov et al., 2018. LandDegr.Dev

A meta-study of European cases:

Anticipated impacts of agricultural adaptation options



on soil threats

on soil functions

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Sustainability Assessment

You are here : Home > Soil functions > Socioeconomics > Sustainability Assessment > Welcome Page



Welcome to the BonaRes Assessment Platform

This platform is designed to support researchers in conducting state of the art assessments for evaluating impacts of agricultural soil management. It is also addressed to a wider audience who want to use and interpret findings of published impact assessments.

It is the first edition of a living document and further editions will be published at irregular intervals to allow for improvements, updates and the inclusion of new research.

www.bonares.de platform is structured to follow the process of conducting impact assessments, starting

Impact Assessment

Welcome Page	ñ
Background Knowledge	>
Designing Research	>
Impact Areas & Indicator Fact Sheets	>
Implementing Impact Assessment	>

Multifunctional land use





Ecosystem Services Soil Function 1.1.1.1 Food from plants 1.1.1.2 Fibres from plants 1.1.1.3 Energy from plants 2.1.1.1 Bio-remediation 2.1.1.2 Biotic filtration/sequestration/storage/accumulation Storage and recycling 2.2.5.1 Chemical regulation of freshwaters of nutrients 2.2.5.2 Chemical regulation of salt waters 2.2.4.2 Maintaining soil organic matter and nutrients 2.2.6.1 Chemical regulation of atmosphere Habitat for biological 2.2.3.2 Disease control 2.2.2.3 Maintaining habitats 3.1.1.2 Ecosystems enabling passive enjoyment 2.2.1.3 Hydrological cycle & water flow regulation Filtering and storage of water 4.2.1.1/4.2.2.1 Surface water/ Groundwater for drinking 4.2.1.2/ 4.2.2.2 Surface water/ Groundwater for non-drinking

Figure 10: Connection between soil functions and selected soil related ecosystem services. Please note that all soil function are connected to and influencing each other.



Paul & Helming 2019. BonaRes Series

Multifunctional land use Lifniz Zalf Resource Use Efficiency Productivity (land) [yield/ hectare] Productivity (energy) [yield/ energy used] Productivity (water) [yield/ water input] Soil Function Productivity (fertilizer) [yield/ fertilizer input] **Biomass production** Productivity (pesticides) [yield/ pesticide input] GHG Intensity [yield /CO2 eq.] Energy use efficiency [Energy in yield/ Energy input] Storage and recycling of nutrients Profitability [€ /€] Revenue [€ /hectare] Habitat for biological Nutrient use efficiency [fertilizer P/ P in crops] activity Nutrient use efficiency [fertilizer N/N in crops] Soil based GHG mitigation [CO2 eq. / €] Carbon Filtering and storage of water Water Use Efficiency [water used by plants/ water input]

Figure 12: Connection between soil functions and selected resource use efficiency categories relevant for agricultural soil management. Please note that all soil function are connected to and influencing each other.



How are soils addressed in European Policies?



5 Policy Sectors, 19 Policies, 2 Strategies

Agriculture (5)

- Gemeinsame Agrarpolitik
- Nitrates Directive
- Pesticide use directive
- GMO directive
- Plant protection products directive

Environment (4)

- Habitat directive
- Water framework directive
- Air quality directive
- Floods directive

Climate (3)

- Carbon Storage directive
- Renewable energy directive
- Kyoto protocol

Industry (5)

- Landfill directive
- Mining waste directive
- Waste directive
- Industrial emmissions directive
- Biocides directive

Urban settlements (2)

- Sewage Sludge directive
- Urban waste directive

Strategies (2)

- Resource efficiency roadmap
- 7th Environmental Action Plan

Soil policy analysis - key points



- Many policies address single aspects of soil conservation
- Among soil threats, Soil compaction and soil salinization are not addressed at all
- Policy targets are mainly on soil conservation, not on improving soil health and soil functions
- A paradigm shift is emerging in environmental policies: from conservation to support of functions and services
- Multifunctionality of soils is not considered in policies, policy coherency is lacking
- The contribution of soils to societal services needs to be better emphasized, measured, monitored and demonstrated!

Policy goals related to soil functions









"healthy soils are farmers insurance against climate change"

Farmer in Brandenburg, 2018

Thank you for your attention!

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