



The multifunctionality of soils – who defines soil value?

Else Bünemann and Andreas Fliessbach, FiBL

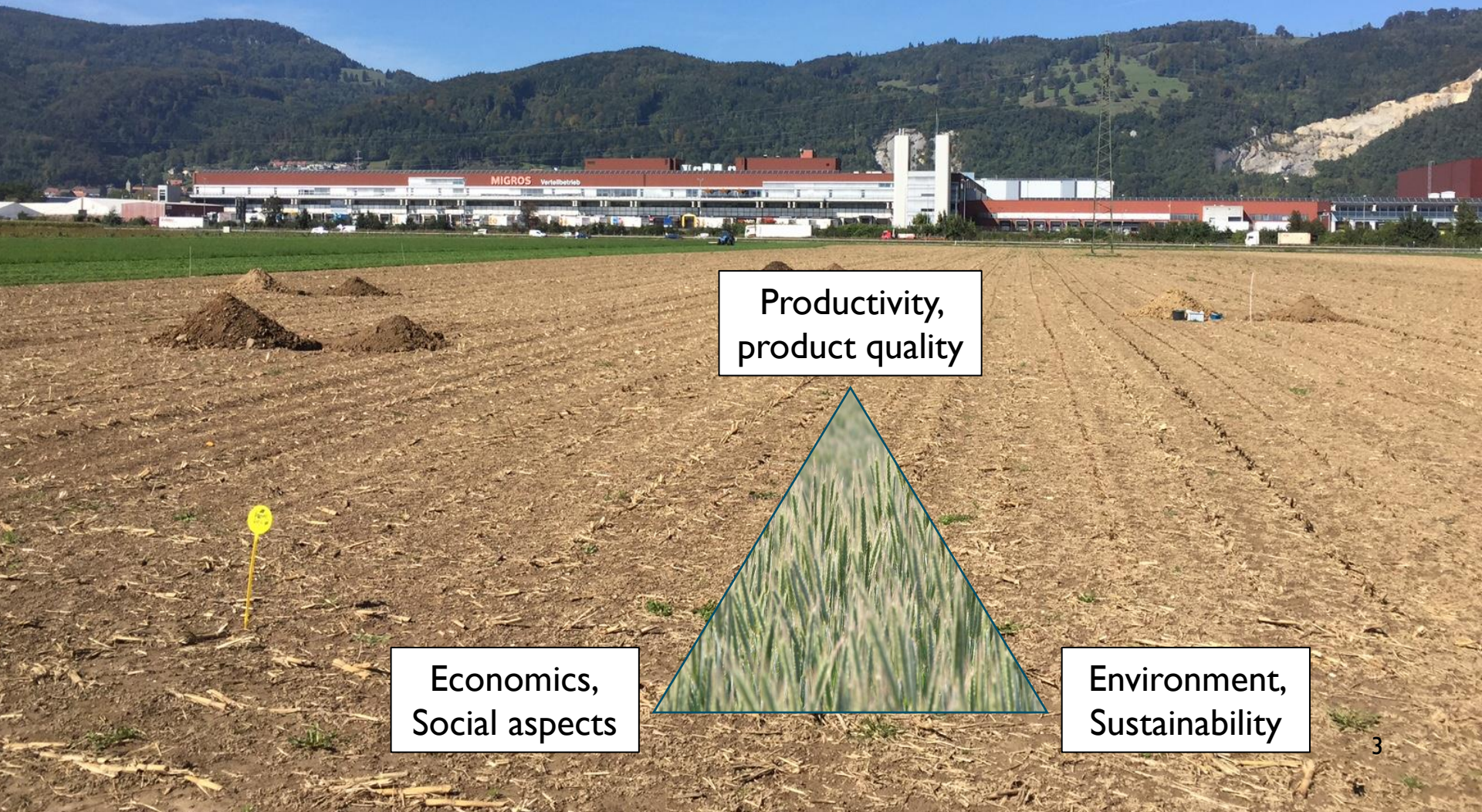
EURAGRI



EURAGRI Conference 2021: Bringing Science to Society through Co-Innovation and Co-Creation – The Soil-Health and Food Mission

September 27-28, 2021, Evora (Portugal) and online

Example: Nitrate leaching in Switzerland



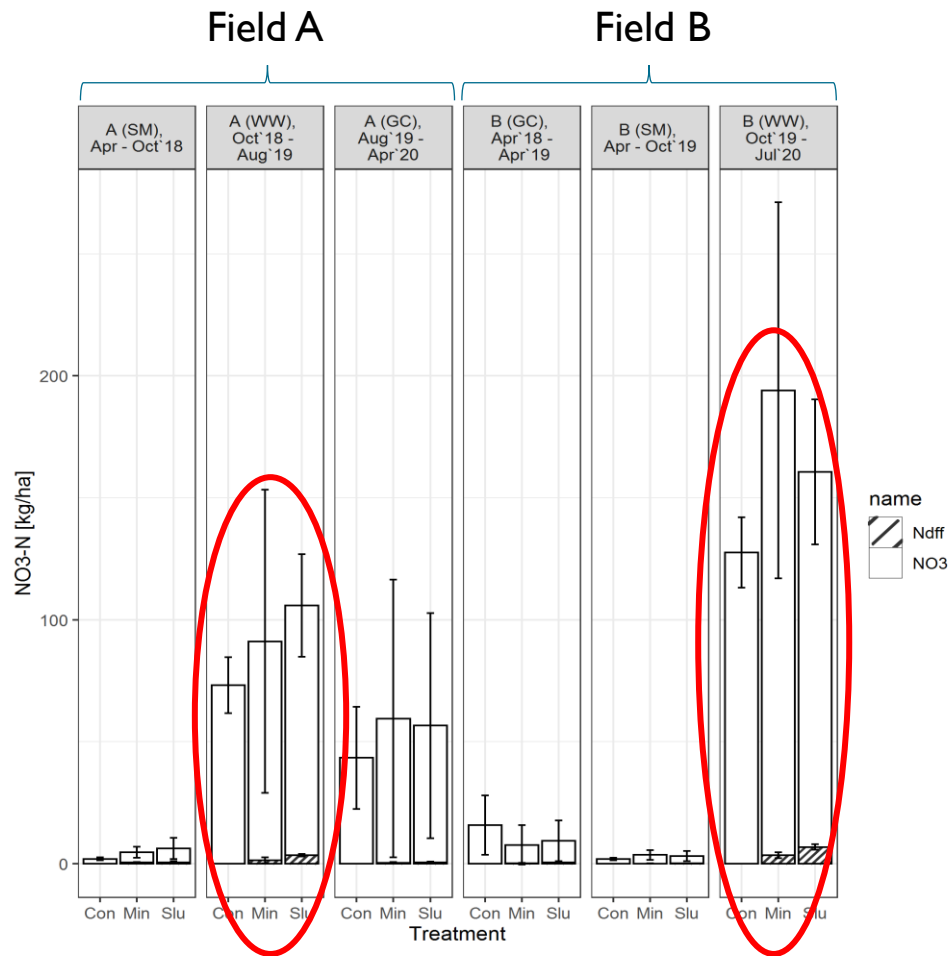
Productivity,
product quality

Economics,
Social aspects

Environment,
Sustainability



High nitrate leaching, but not from applied fertilizers



Main nitrate leaching period in the winter after ley termination

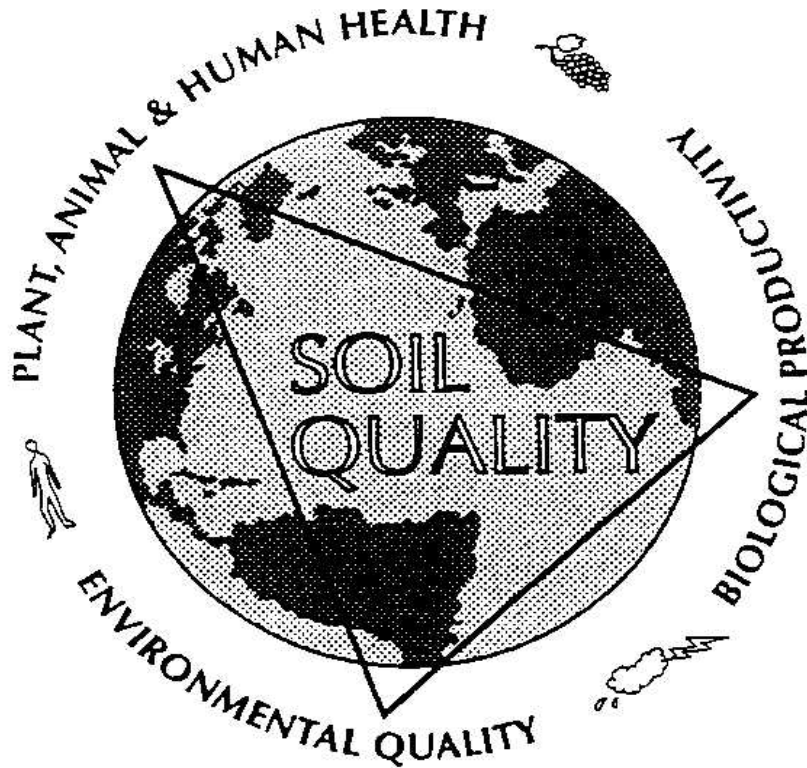
Frick et al., in preparation

Message to farmers: reduce N inputs to avoid buildup of large soil N reserves

Who defines the value of soils?



What is soil quality?



“The capacity of a soil to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health“

(Doran & Parkin, 1994; 1996)

«Capacity of soils to fulfill their functions in ecosystems»

(Swiss National Research Program
‘Soil as a resource’ 2018)

Soil quality

= soil health ?

- more associated with biological soil properties
- preferred by farmers (Romig et al. 1996)

but often used synonymously with soil quality

= soil fertility ?

- more associated with chemical and physical soil properties
- predominantly aligned to yields (Patzel et al. 2000)

but often used synonymously with soil quality

Focus on *dynamic* soil properties in the topsoil



Land quality, land evaluation:

Focus on *inherent* soil properties in the soil profile

How to assess soil quality?



Cornell Soil Health Assessment				
Jane Grower Main St Youtown, NY, 12345 Agricultural Service Provider: Schandelbeck, Bob Ag Services rrs3@cornell.edu		Sample ID: M_1 Field Treatment: Veg field Tillage: No Till Crops Crown: COG; COG Date Sampled: 3/2/2015 Given Soil Type: Lima Given Soil Texture: Silt Loam Coordinates: Coordinates Not Provided		
Measured Soil Textural Class: Sandy Loam		Sand: 65% Silt: 26% Clay: 9%		
Test Results				
Indicator	Value	Rating	Constraint	
Physical	Available Water Capacity	0.14	53	
	Surface Hardness	240	22	Rooting, Water Transmission
	Subsurface Hardness	310	53	
Biological	Aggregate Stability	56.6	47	
	Organic Matter	3.3	55	
	ACE Soil Protein Index	5.8	25	Organic Matter Quality, Organic N Storage, N Mineralization
	Respiration	0.37	26	Soil Microbial Abundance and Activity
Chemical	Active Carbon	366	28	Energy Source for Soil Biota
	pH	6.9	100	
	Phosphorus	7.5	100	
	Potassium	65.3	91	
	Minor Elements Mg:20 Fe:12 Mn:7 Zn:14		100	
Overall Quality Score		58	Medium	

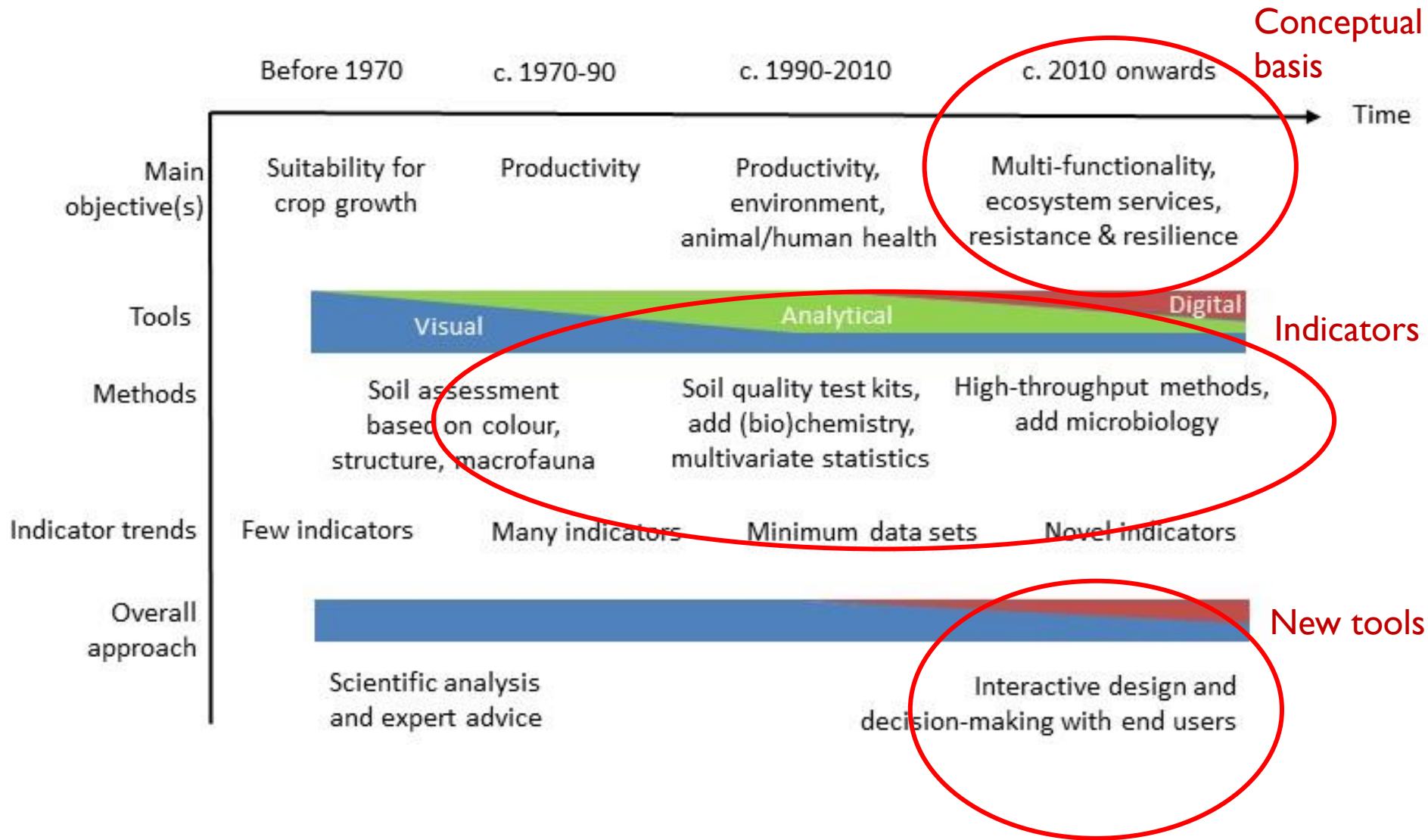
Visual methods:

- + instant results
- + simple, holistic
- qualitative, subjective, standardisation difficult
- soil chemistry not included

Analytical methods:

- + quantitative, objective
- + soil chemistry covered especially
- time, money, lab needed
- soil physics, rooting pattern rarely included

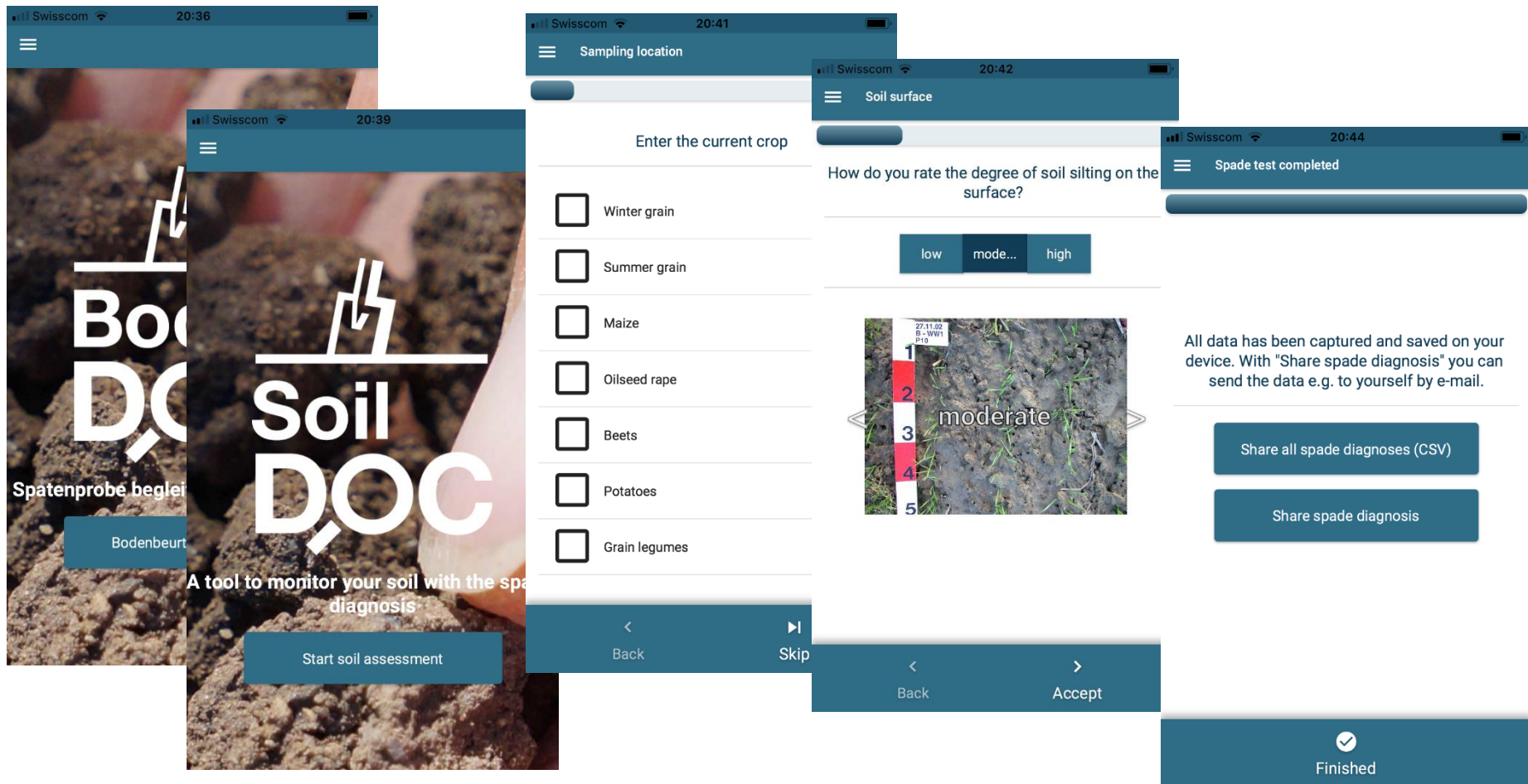
How to assess soil quality: Development over time



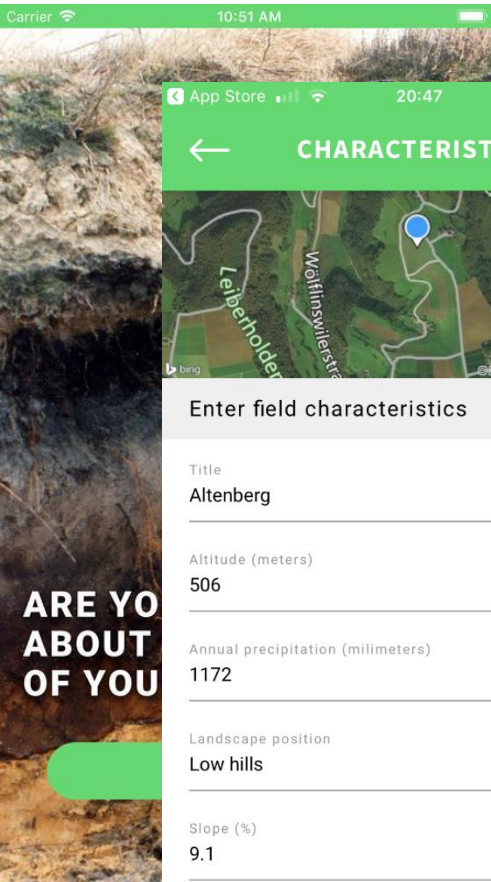
New tools



BodenDOK / SoilDoc – an app for spade diagnosis



SQAPP – an app which makes soil data available



FiBL

< Suchen



Soil Quality App

Immense

ÖFFNEN



4.1

Overall threat level



Soil threats needing attention

- Susceptibility to compaction
- Phosphorus using the Olsen method
- Total nitrogen in soil



The Soil Navigator – a web-based decision support tool

SOIL NAVIGATOR ☰ 🇩🇪 🇩🇰 🇬🇧 🇫🇷 🇮🇹 🇯🇪

Navigator

Scenario: 81db4f84-0449-44d4-8c48-b9044d0f34cc

INITIALLY ASSESSED AND DESIRED CAPACITY OF SOIL FUNCTIONS

Primary productivity (PP) | Water purification and regulation (WR) | Biodiversity and habitat provision (BD) | Nutrient cycling (NC) | Climate regulation (CR)

Initial and desired capacity

Assessment of functional indicators

Primary productivity 1/5

What is your demand (preference) regarding the capacity of the soil function?
Provide the value by sliding the slider to the right, for better capacity than the initially assessed.

Low Medium High

What is your importance (priority) of the soil function?
Equally important soil functions reduce chances the system to find an optimal solution. Choose the level of priority/importance that best describe the soil function.

Very low Low Medium High Very high

Previous soil function Next soil function

Optimize soil functions
Save
Back to input

Preferences input setting
 Guided wizard
 Direct input

LANDMARK

New tools require maintenance beyond project lifetime

The image displays the SOIL NAVIGATOR web application interface. The top navigation bar includes the title "SOIL NAVIGATOR" and language selection icons for German, Danish, English, French, Italian, and Spanish. A left sidebar menu lists "Home", "Navigator", "Input", "Optimization", "Report", and "Archive". The main content area is titled "INITIALLY ASSESSED AND DESIRED CAPACITY OF SOIL FUNCTIONS" and features a scenario ID: 81db4f84-0449-44d4-8c48-b9044d0f34cc. It lists four soil functions: "Primary productivity", "Water purification and regulation", "Biodiversity and habitat provision", and "Nutrient". The "Primary productivity" section is expanded, showing a slider for "What is your demand (preference)" and a scale for "What is your importance (priority)".

Two mobile app overlays are shown. The left overlay is for "Soil DOC", featuring a spade icon and the text "A tool to monitor your soil with the spade diagnosis" and "Start soil assessment". The right overlay is for "Soil Quality", featuring a magnifying glass icon and the text "ARE YOU CURIOUS ABOUT THE QUALITY OF YOUR SOIL?" and "Register".

At the bottom left, the "LANDMARK" logo is visible. At the bottom center, the "FiBL" logo and the website "www.fibl.org" are displayed. At the bottom right, the page number "14" is shown.

How to do research that will be adopted?



Why do farmers not adopt promising innovations?

Innovation	Reasons for poor adoption
Integrated soil fertility management (ISFM)	<ul style="list-style-type: none">• Recommended fertilizer rates unaffordable• Knowledge intensive
New legume species for soil fertility	<ul style="list-style-type: none">• Not multipurpose, some not palatable• Compete for space, nutrients, water
Agroforestry	<ul style="list-style-type: none">• Surface area limiting• Land tenure rights (<i>who plants trees owns the land</i>)
Animal manure, compost	<ul style="list-style-type: none">• Poorly managed → low quality manure, compost• Messages unclear or even controversial/confusing
Conservation agriculture	<ul style="list-style-type: none">• High cost of equipment and inputs• Inability to market/store bumper yield

=> Important to understand the reasons

Four countries – eight sites

Technologies tested on-station and on-farm



Mali

Kenya

Ghana

Zambia

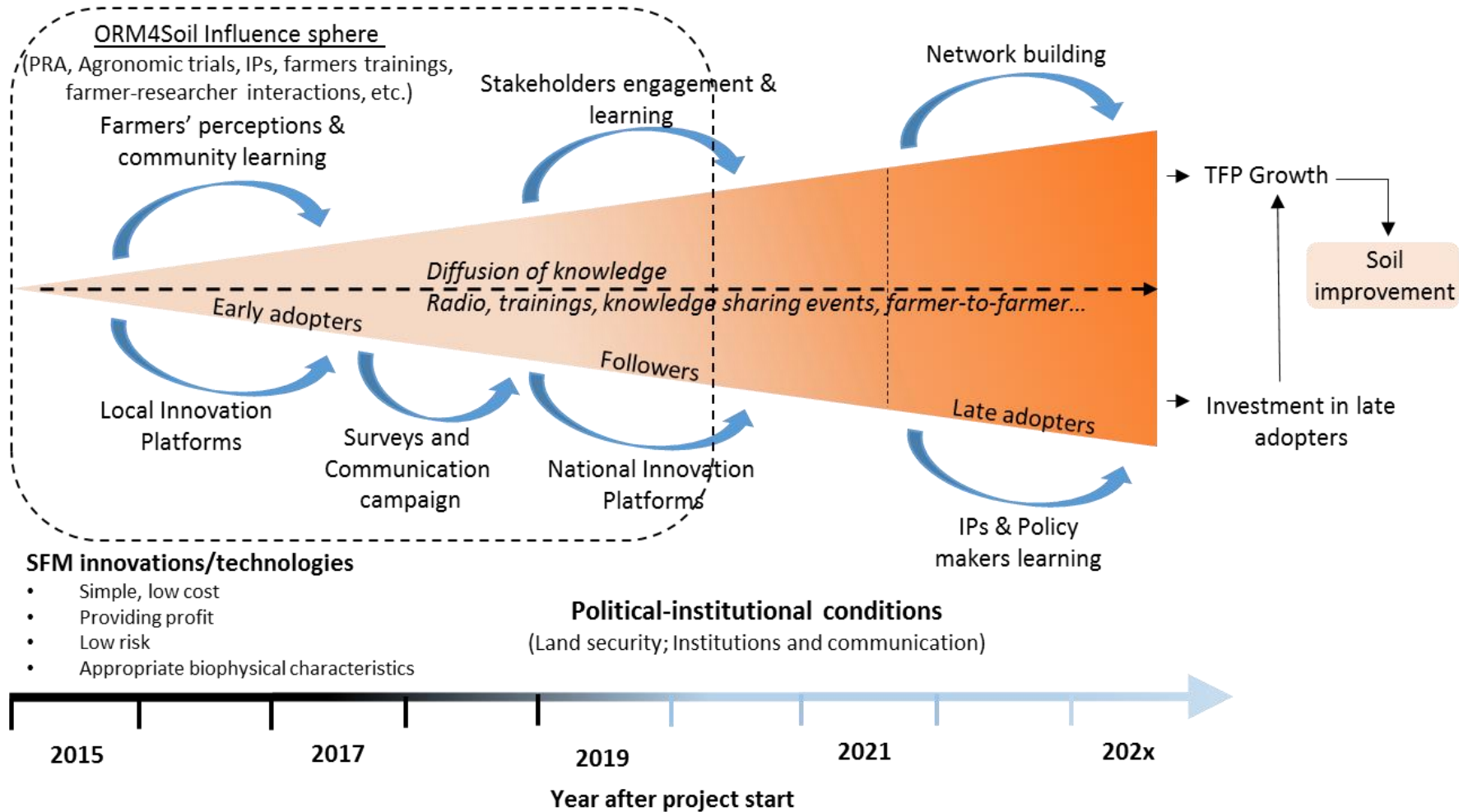


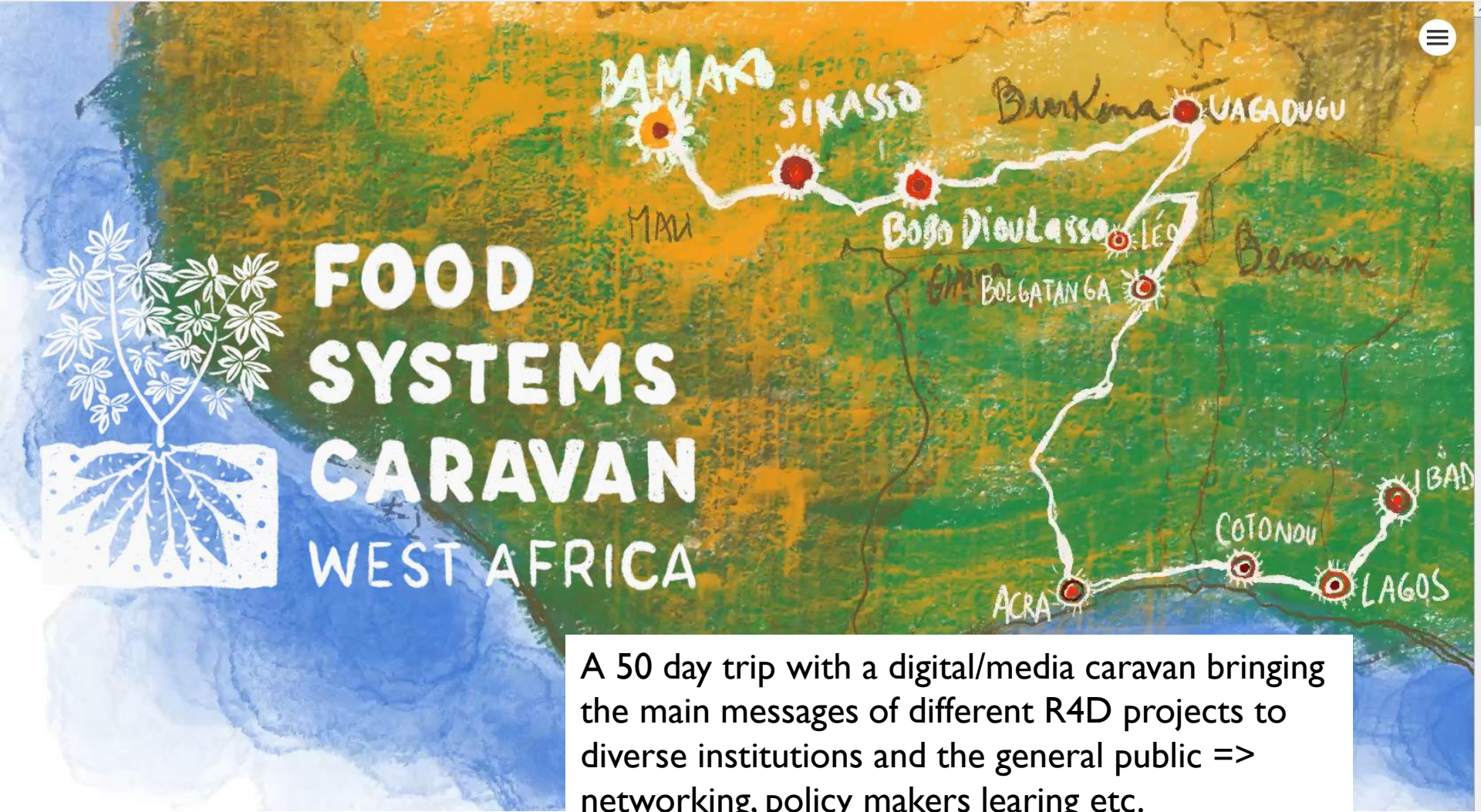
Pathway to adoption of an ORM technology



Socio-cultural conditions

(Community dynamics and support; personal and demographic factors)





The success of organic agriculture

- Organically cultivated area in Switzerland:
from 10'000 ha in 1990 to 170'000 ha in 2019
- DOK trial (long-term trial since 1978) founded together with farmers
- Farming system rather than single measures – benefits for soil quality, tradeoffs concerning productivity
- Market development, consumers!



Conclusions

- Soils have many functions; soil organic matter is central for the ecological functions
- There are trade-offs between the different soil functions
- Farmers are under pressure and hear different messages (political interests, subsidies, and facts from knowledge and experience)
- Tools and solutions need to be developed together with the users; support beyond project lifetime needed
- Adoption of innovations requires stakeholder engagement and joint efforts of policy, research and practice beyond project lifetime



Thank you for your attention!