Co-designing a landscape experiment to investigate diversified cropping systems

GRAHMANN, K., RECKLING, M., **HERNANDEZ-OCHOA, I.**, DONAT, M., BELLINGRATH-KIMURA, S., EWERT, F., 2024, AGRICULTURAL SYSTEMS 217 (HTTPS://DOI.ORG/10.1016/J.AGSY.2024.103950)

**IXCHEL HERNANDEZ OCHOA,
UNIVERSITY OF BONN,
IHERNANDEZ@UNI-BONN.DE**

UNIVERSITÄT BONN
PHENOROB
zalf Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.

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- Diversification
- Digital technologies
- Landscape experiments

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Co-design method

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Regional key challenges

Simplified landscapes & crop rotations

Poor & highly heterogenous soils

Loss of Biodiversity

Increasing frequency of weather extremes like prolonged droughts and extreme rainfalls→ crop failure

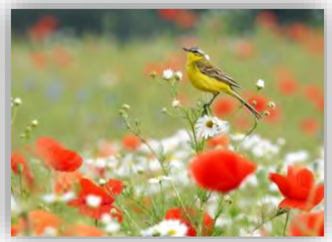
Increasing legal limitations of pesticide usage

Diversification of landscapes

Field & Crops

Farm & Cropping systems

Landscape



Food systems

Consumption, diets, trade, waste, circularity, regionality…

Governance systems

Policies, collective actions, cooperations, certificates, branding…

Landscape systems

Land use patterns, field arrangements, drainage, wildlife, hedges, infrastructure…

Farming systems

Conventional, organic, regenerative, agroforestry, arable, livestock, energy, tourism, care farming, …

Cropping & grassland

Crop rotations, tillage, crop choices, grazing strategies,

Digital technologies to manage diversified systems

Accurate and targeted operations at the plant level

Labour shortage compensation

Higher work rates; modular; scalable

GPS/RTK signal for optimized path planning

Highly mobile, slower speeds

Lighter weight, small size

Often electric or renewable energy

Sensor-equipped for automated, additional data collection

Objectives

1

(i) Design research process with stakeholders for co-designing sustainable cropping systems that integrate crop diversification facilitated through digital technologies

2

(ii) Develop and implement a landscape experiment that effectively promotes cropping systems diversification and incorporates digital technologies to address the challenges of sustainable agricultural intensification in Eastern Germany

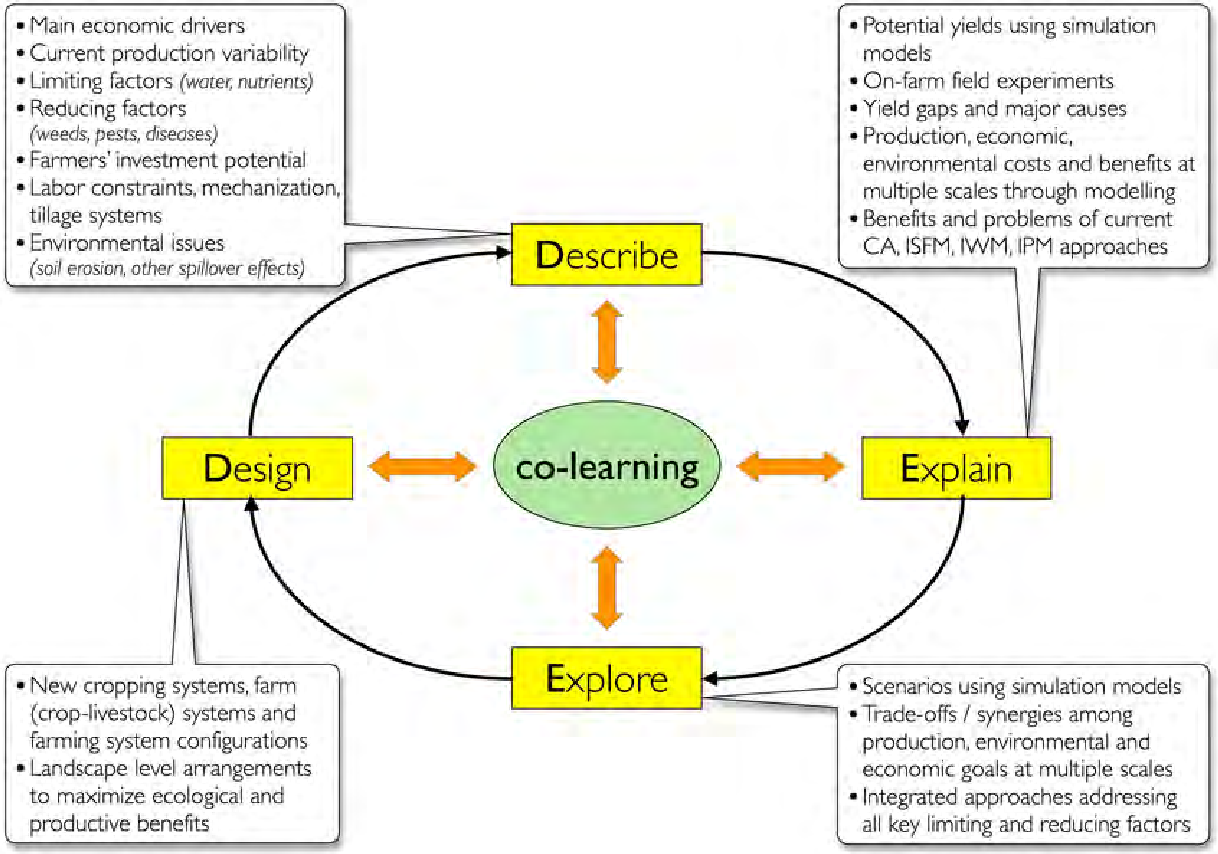
3

(iii) Identify opportunities and constraints associated with implementing crop diversification approaches under on-farm conditions in experimental landscape set-ups

Co-design method: DEED- approach

Describe, Explain, Explore, and Design research cycle to structure the co-design of the experiment

- adapted from Kolb's learning cycle (Kolb, 1984)
- involves participatory work with farmers, modelling and experimentation in an iterative process
- generation of tailored options to re-design systems
- used for co-learning by farmers, advisors and scientists to identify which options fit best

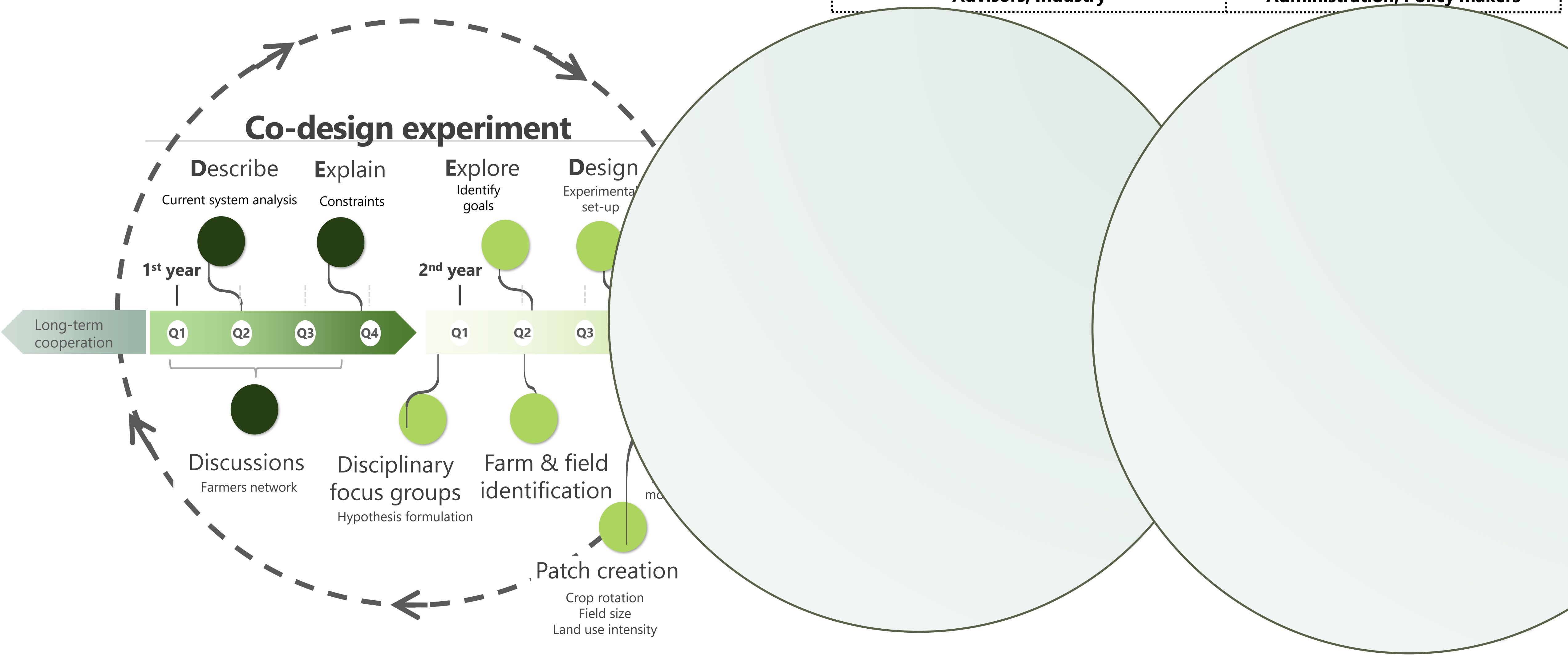


Giller et al., 2011; doi: 10.1016/j.agsy.2010.07.002

Scientists

Farmer network | Single farm | Farmer network | Multiple farms

Advisors, Industry | Administration, Policy makers



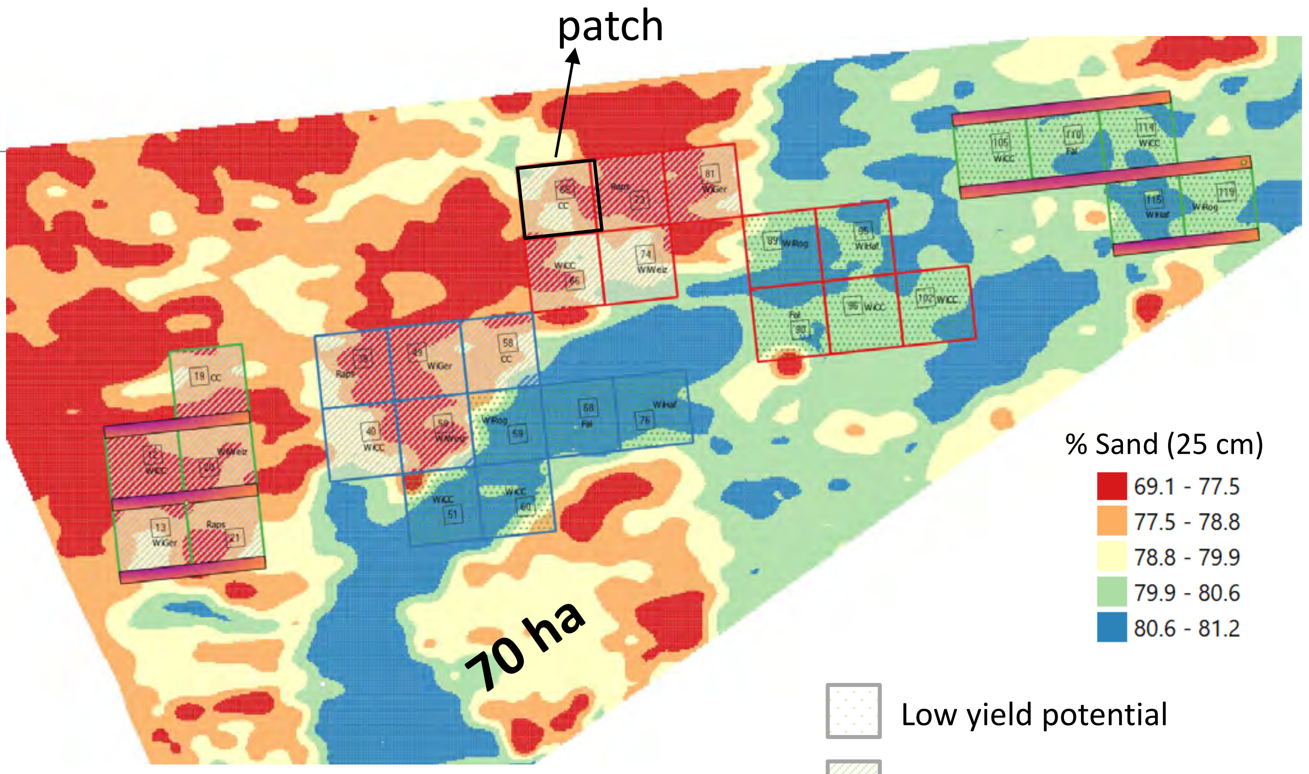
(1) Concept phase

Results: experimental design of the landscape experiment

1. <u>Small vs. big</u>
   Patches of 0.5 ha vs. commercial fields of 50-100 ha with surrounding reference areas
2. <u>Diverse vs. simple</u>
   Site-specific crop rotations (high & low yield potential) vs. commercial field (one rotation)

Yield potential	1st year	2nd year	3rd year	4th year	5th year
High	Rape	Barley	CC-Soybean	CC-Maize	Wheat
Low	CC-Sunflower	Oats	CC-Maize	Lupin	Rye

3. <u>Reduced vs. standard pesticide use</u>
   A. Standard plant protection
   B. Pesticide reduction strategies (IPM) developed by JKI
   C. Pesticide reduction as B) PLUS Flower strips

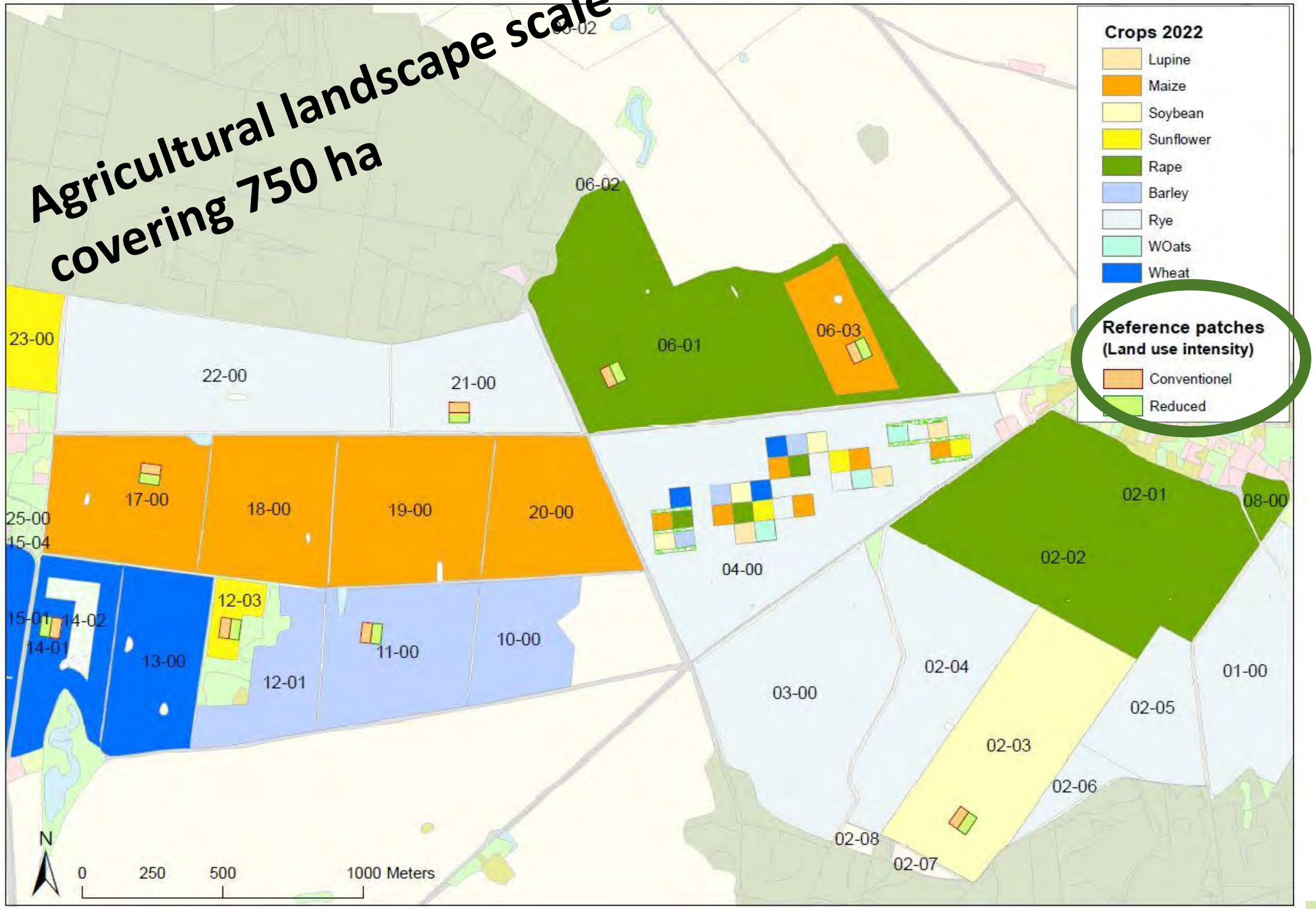


Low yield potential
High yield potential
Standard plant protection
Reduced pesticides
+ flower stripes

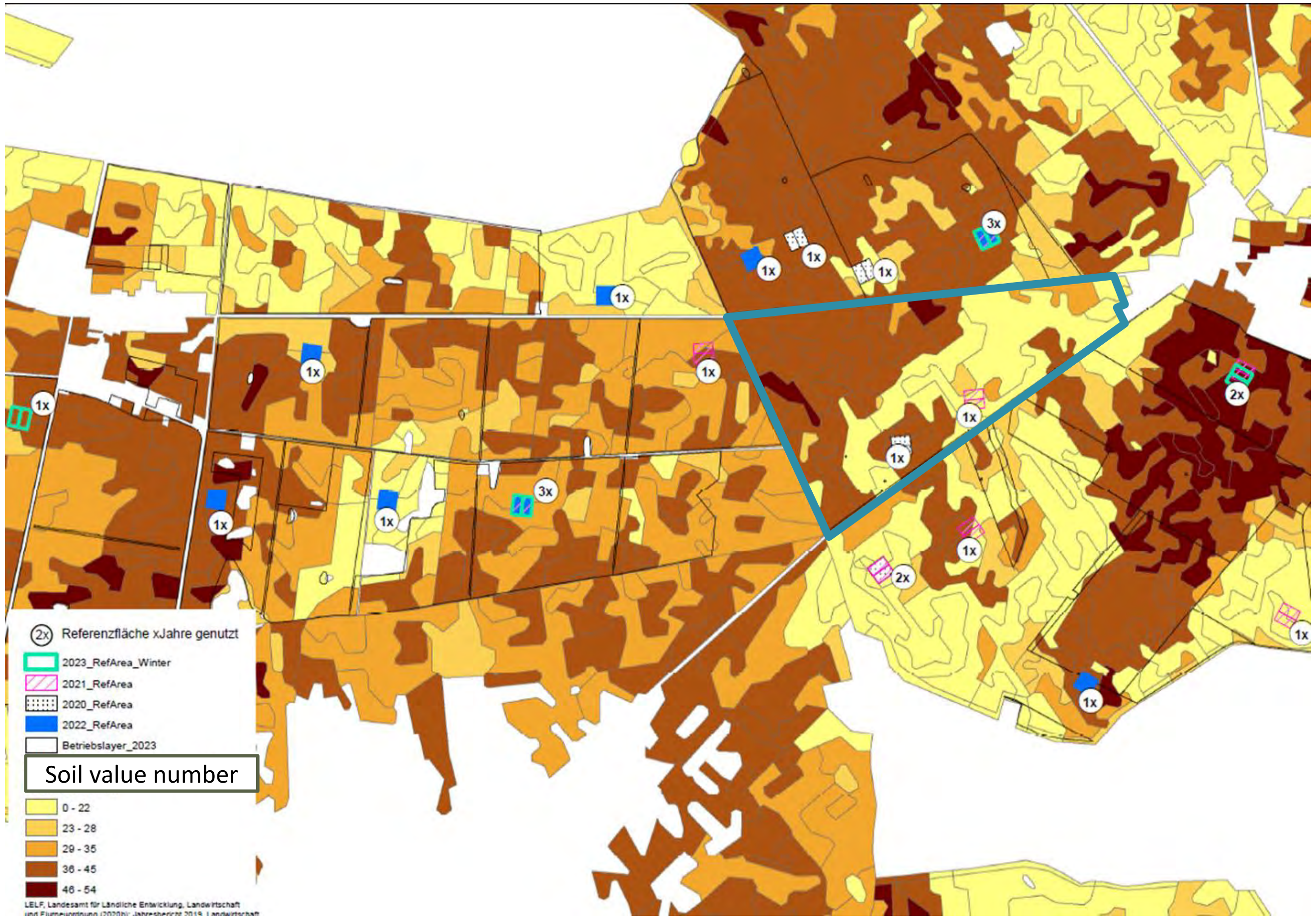
Donat et al., 2022: Patch cropping- a new methodological approach to determine new field arrangements that increase the multifunctionality of agricultural landscapes.

patchCROP

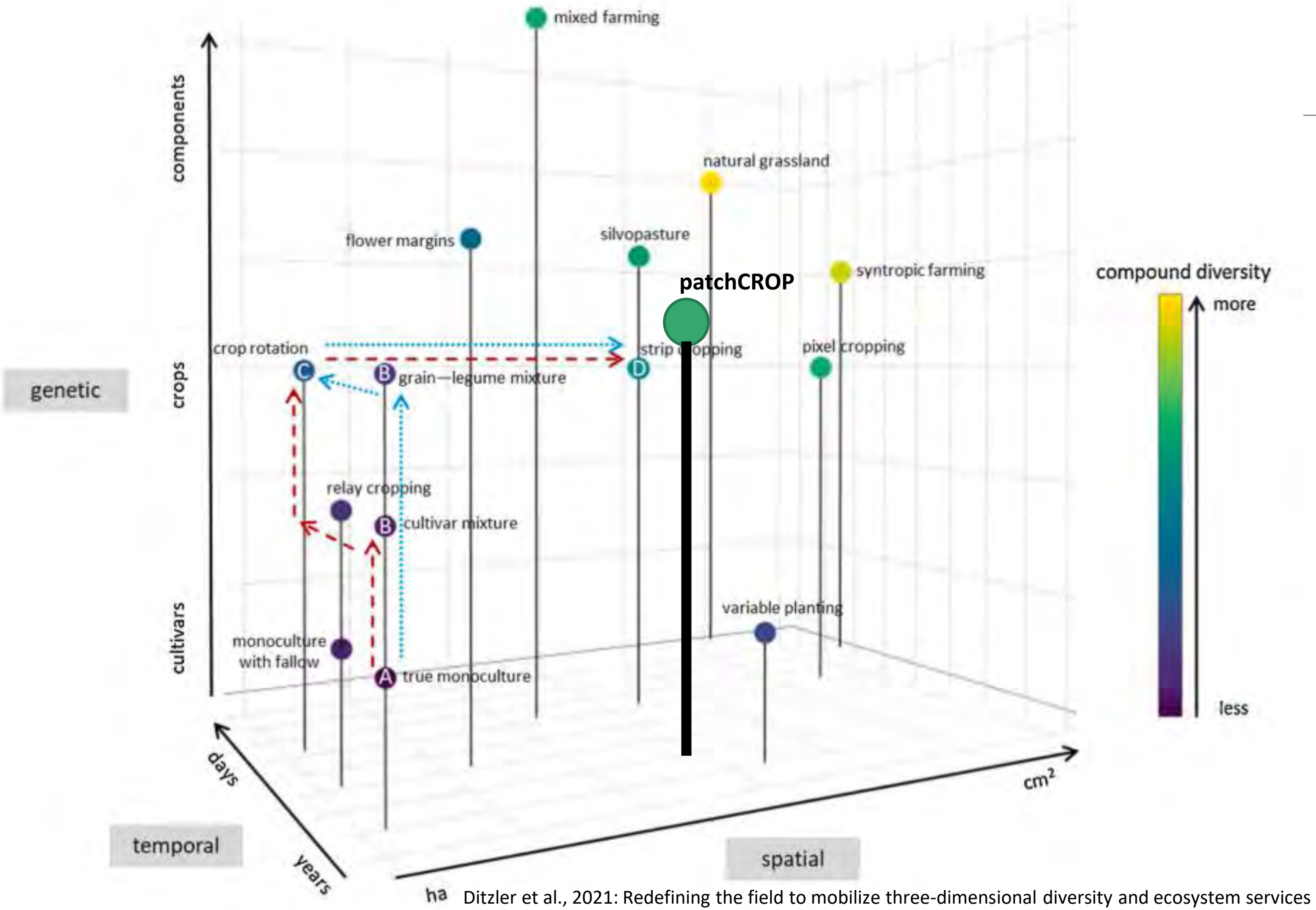
Spatial context and “factors” or “environments”



Soil heterogeneity

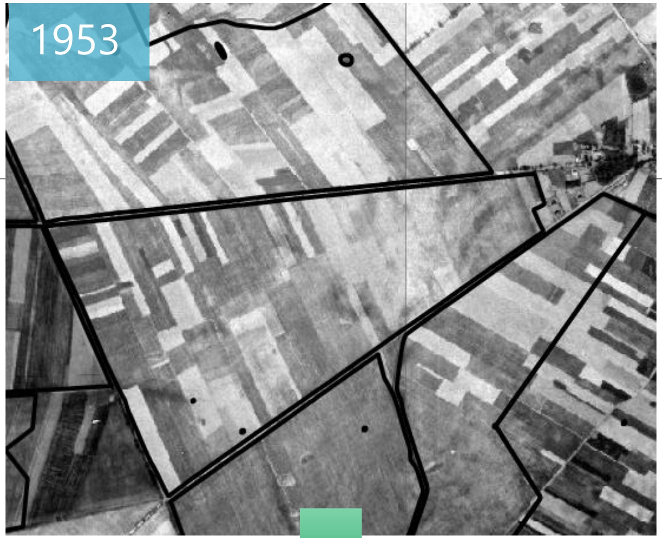


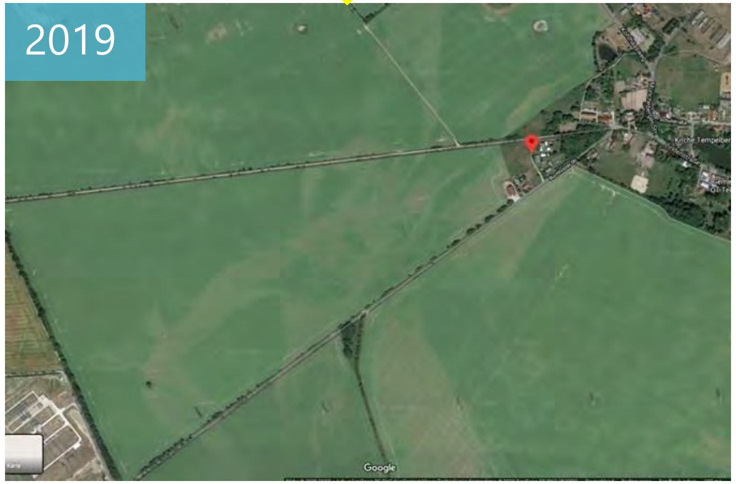
Dimensions of diversity in patchCROP

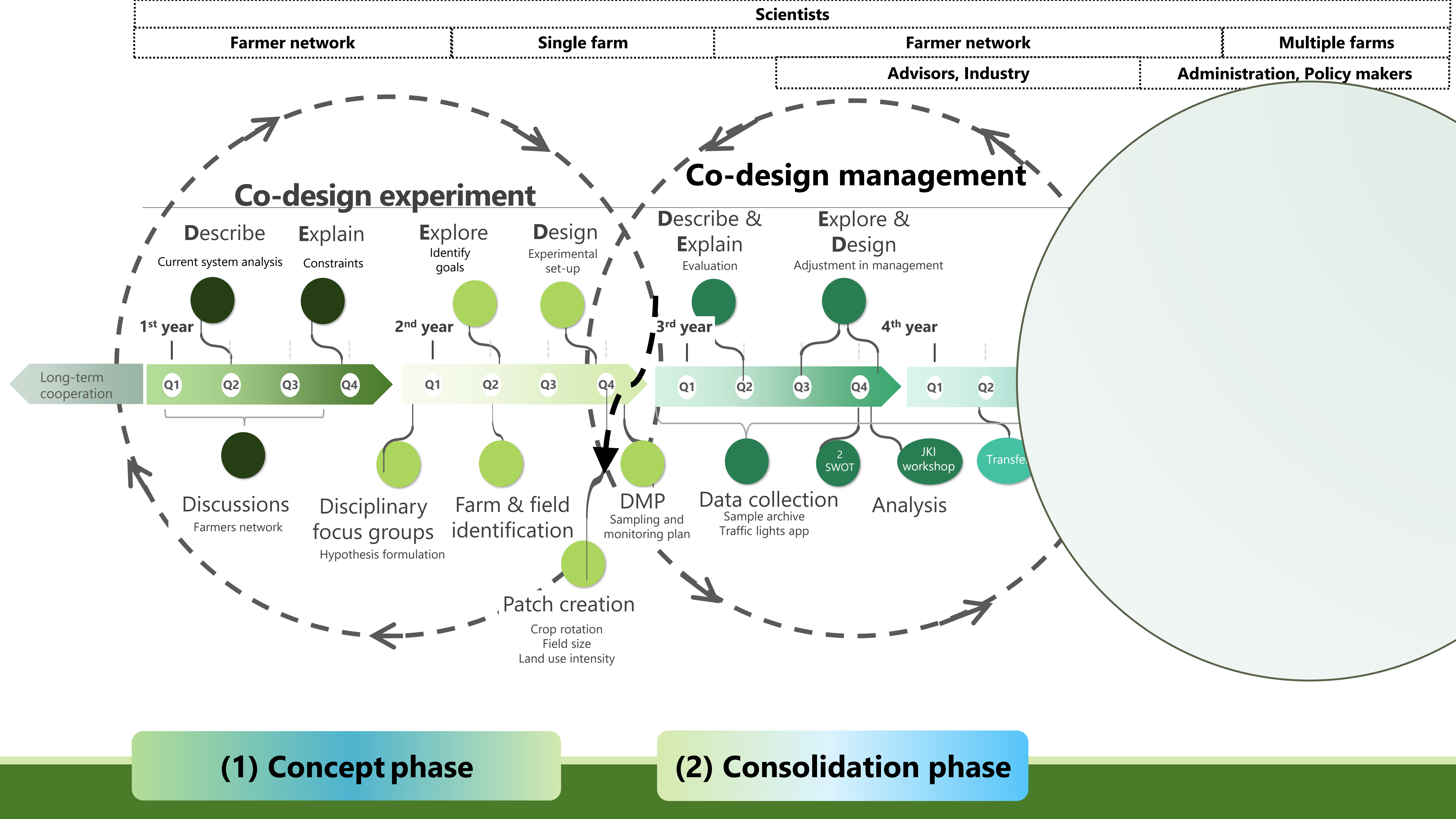


Ditzler et al., 2021: Redefining the field to mobilize three-dimensional diversity and ecosystem services on the arable farm. European Journal of Agronomy 122 (2021)

Purpose: Re-designing agricultural landscapes







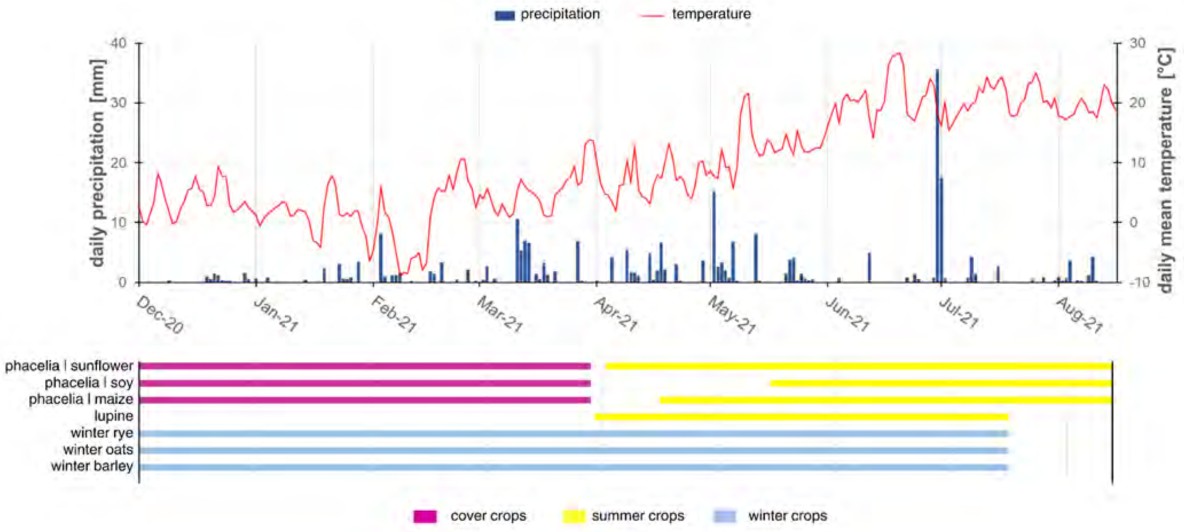
Scientists
Farmer network
Single farm
Farmer network
Multiple farms
Advisors, Industry
Administration, Policy makers
Co-design experiment
Describe
Current system analysis
Explain
Constraints
Explore
Identify goals
Design
Experimental set-up
1st year
2nd year
Long-term cooperation
Q1
Q2
Q3
Q4
Discussions
Farmers network
Disciplinary focus groups
Hypothesis formulation
Farm & field identification
DMP
Sampling and monitoring plan
Patch creation
Crop rotation
Field size
Land use intensity
Co-design management
Describe & Explain
Evaluation
Explore & Design
Adjustment in management
3rd year
4th year
Data collection
Sample archive
Traffic lights app
2 SWOT
JKI workshop
Analysis
Transfe
(1) Concept phase
(2) Consolidation phase

1. **Patch scale**
    a. Soil sampling-N_{min}, SOC
    b. Soil health indicators
    c. LoRa Soil Sensor Network (IouT)
    d. Hood infiltrometer
    e. Portable photosynthesis system
    f. N_2O chambers
2. **Field scale**
    a. Soil profiles
    b. Remote sensed data
3. **Landscape scale**
    a. Yield maps
    b. Proximal sensed data
    c. Agricultural practices
    d. Apps and other sensor syste
    e. Biodiversity monitoring
    f. Digital yellow traps
    g. Bird monitoring

Fig. 2. patchCROP landscape experiment set up for the 2023 season. a) main 70 ha field, b) reference fields around the main field c) patch description, soil, biomass, biodiversity and multipurpose quadrants, buffer area of 18 m with around the quadrants.

Hernandez et al. 2024; https://doi.org/10.1016/j.eja.2024.127181

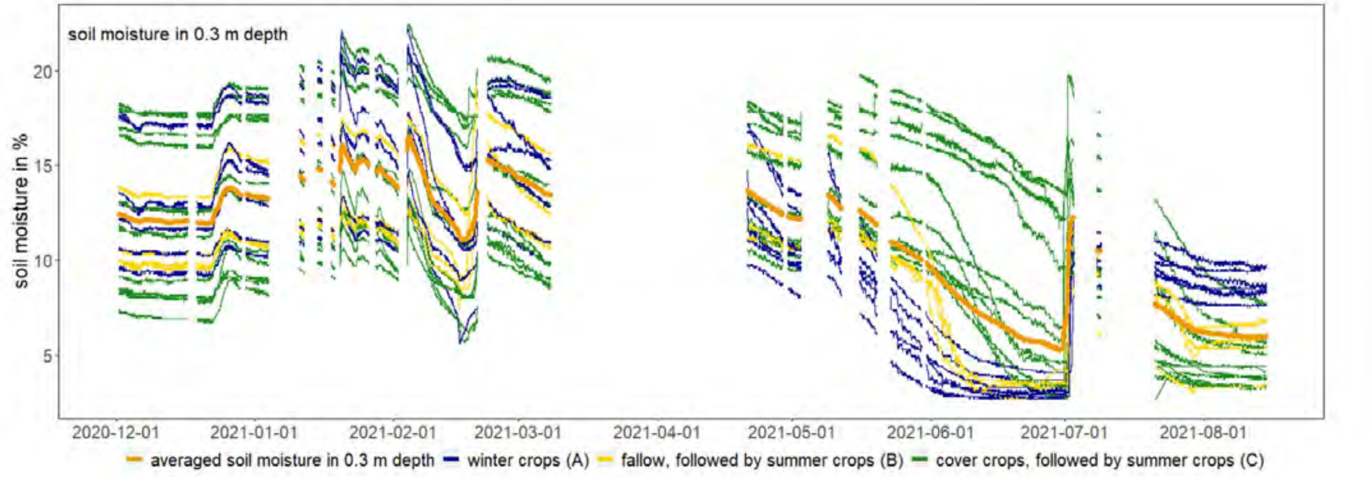
LoRa based soil sensor network for real-time monitoring

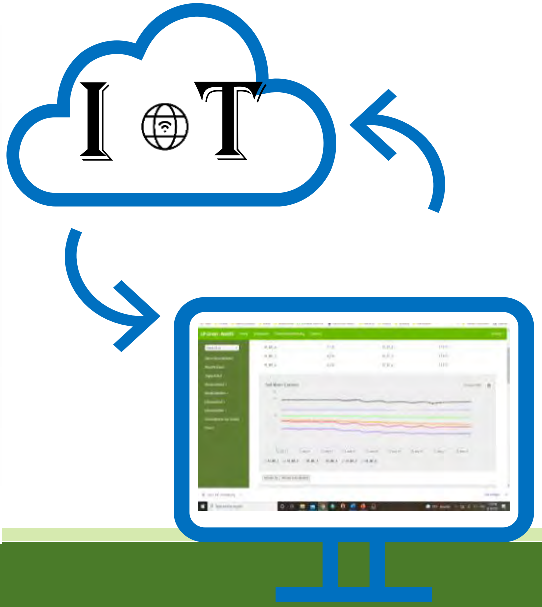



Acclima TDR-310H sensor


Mobile sensor


Transmission tower & LoRa Gateway



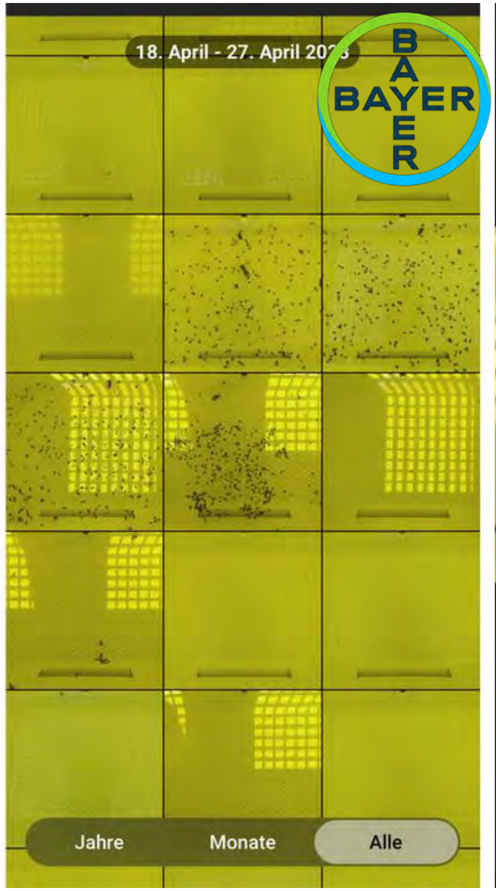


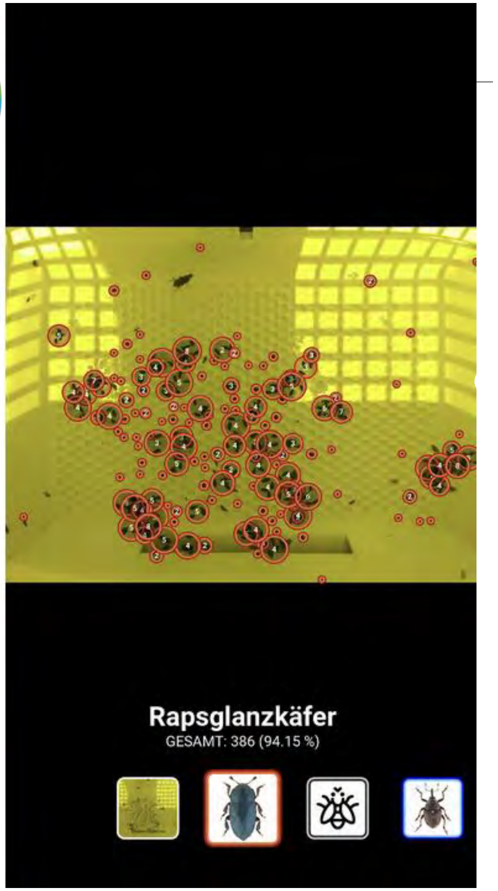
- Optimized sowing
- Water requierments
- Leaching risk
- Modelling input

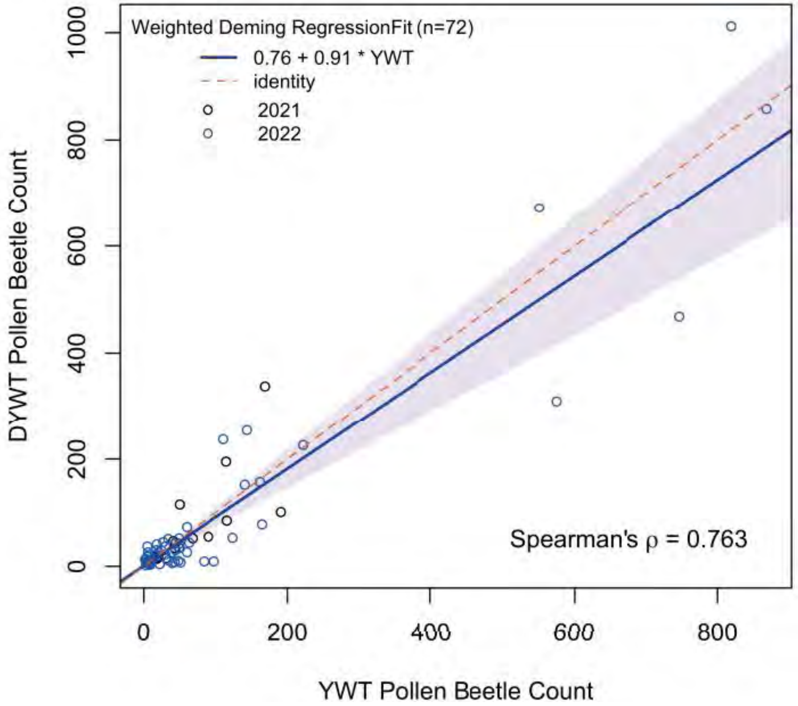
Scholz et al. (2024): Differentiating between crop and soil effects on soil moisture dynamics. HESS

Innovative technologies for pest monitoring: Digital yellow traps

Hardware (kommerziell seit 2023)







Dovydaitis et al. 2024 Assessing pollen beetle dynamics in diversified agricultural landscapes with reduced pesticide management strategies

Bird observations

Western yellow wagtail

European goldfinch

Optimized Hotspot Analysis

provided by Jenny Kröcher & Franco Ehlert

Results: Evaluation using SWOT

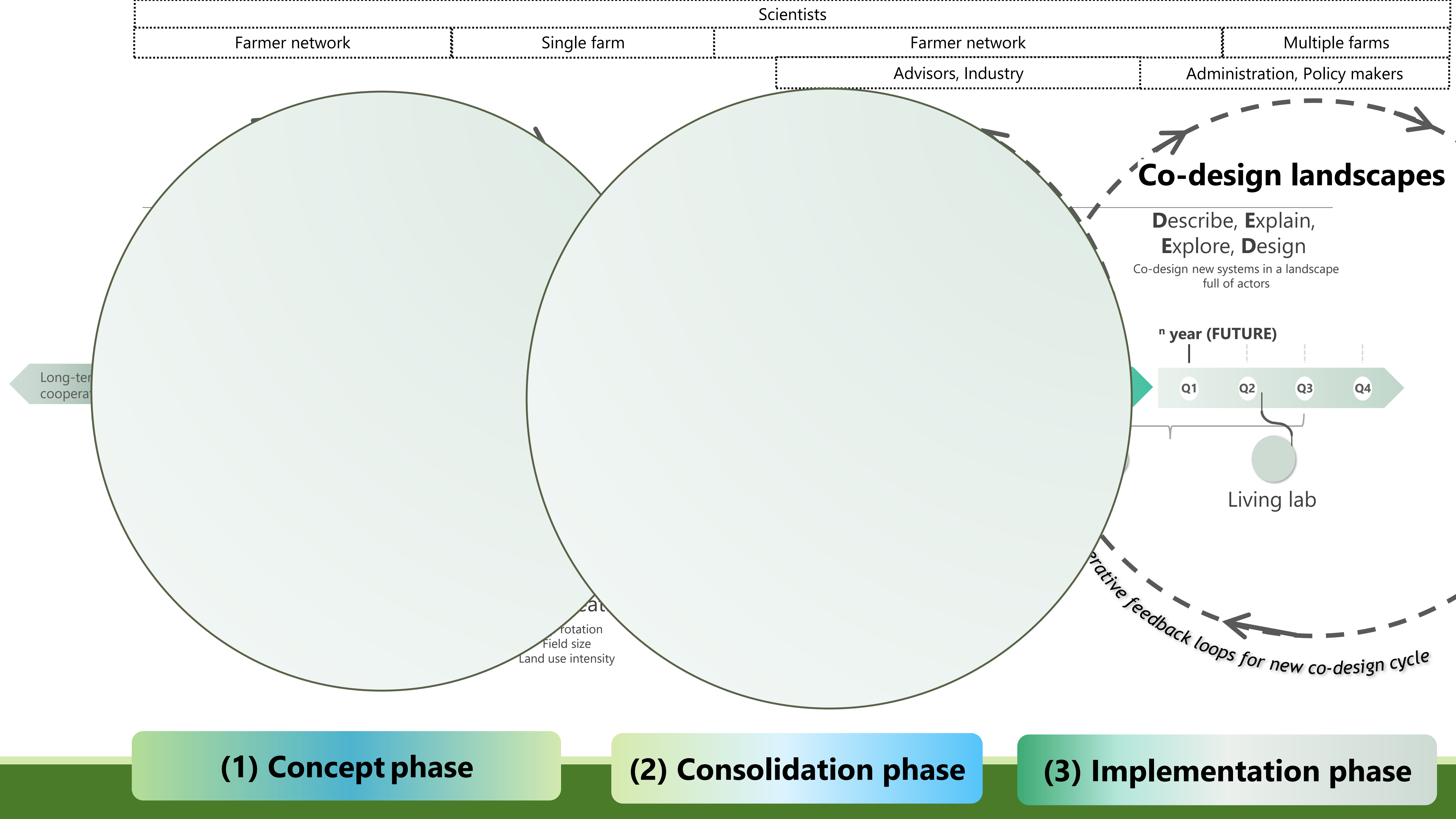
Strengths	Opportunities
• Significant structural and crop diversity increase at the field scale • Intensive data collection • Interdisciplinarity • Upscaling • High visibility	• Integrated assessments • Improved and systematic understanding of ESS • Use of model (complementary for design) • Digital tools and autonomous robots are evaluated • Community outreach

Weaknesses

- Time demanding data collection
- Interpretation and analysis of the spatial data
- Sustainability/socio economic feasibility?
- Measurements at landscape still limited
- Resource intensive (€€€)
- High soil within field heterogeneity

Threats

- Long term financing
- Greater diversification limited by availability of suitable machinery
- Lack of extension capacity within and beyond the experimental platform
- Site specific conditions
- Experimental desig unsuitable for conventional statistical analysis

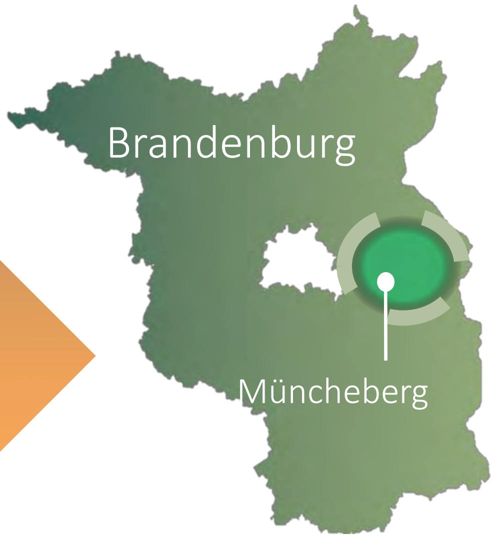


Scientists
Farmer network
Single farm
Farmer network
Multiple farms
Advisors, Industry
Administration, Policy makers
Co-design landscapes
Describe, Explain,
Explore, Design
Co-design new systems in a landscape
full of actors
year (FUTURE)
Q1
Q2
Q3
Q4
Living lab
feedback loops for new co-design cycle
Field size
Land use intensity
(1) Concept phase
(2) Consolidation phase
(3) Implementation phase

Perspectives

- ➔ Develop patchCROP landscape experiment towards a **living lab**
- ➔ Connect **on-farm experiments** with value chain approaches (e.g. for new crops)
- ➔ **Co-design** on-farm experiments with new topics (e.g. strip cropping)
- ➔ Collaborate with social science groups in the co-design process and analysis
- ➔ Analyse results from on-farm experiments across Brandenburg

Addressing & Solving regional key challenges



Transformation goals at regional scale

- ➢ Climate-resilient, diversified arable farming systems
- ➢ Landscape & structural elements and small-scale fragmentation of agricultural landscapes
- ➢ Cross-sectoral interaction of management solutions & technologies
- ➢ Diversified income and marketing structures

Conclusions

1. We established an agricultural landscape experiment and adjusted it continuously using an iterative co-design process.

2. We created a platform to explicitly test the effects of spatial and temporal diversification of cropping systems and explore options of pesticide reduction using traditional and digital technologies within the landscape context

3. The DEED cycle served as a framework ensuring dynamic improvement and progress during the project development and will be applied further to scale out diversification approaches into a larger regional living lab context with a larger group of farmers.

4. In the larger context of agricultural systems transformation of entire regions and countries, co-design landscape experiments may be considered as essential nucleus for the development of agroecosystem living labs.

www.landschaftslabor-patchcrop.de

Contact

Kathrin Grahmann; kathrin.grahmann@zalf.de
Ixchel Hernandez-Ochoa; ihernandez@uni-bonn.de

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