JSPS Allumnai Symposium

Bioeconomics

20. / 21. May 2022, Berlin

Agriculture of the Future: New Bioeconomic Possibilities Due to Digitalisation

Prof. Dr. Sonoko Bellingrath-Kimura

3 Take home messages

I. Agriculture provides valuable ecosystem services

- Direct link to sustainable developing goals

II. Soil is the base for ecosystem services

- Site specific and temporal variable

III. Digital tools can help detangling the complexity

- Sustainable bioeconmy should consider ecosystem services and biodiversity

I. Agriculture provides valuable ecosystem services
Bioeconomy

The bioeconomy is the knowledge-based production and use of biological resources to provide products, processes and services in all economic sectors within the frame of a sustainable economic system.
(Definition of the Bioeconomy Council)

I. Agriculture provides valuable ecosystem services
Economic value of the ecosystem service of Japanese paddy fields

Prevent land slide
(478 billion yen/year)

Relaxation
(2.4 trillion yen/year)

Climate mitigation
(8.7 billion yen/year)

Prevent flooding
(3.5 trillion yen/year)

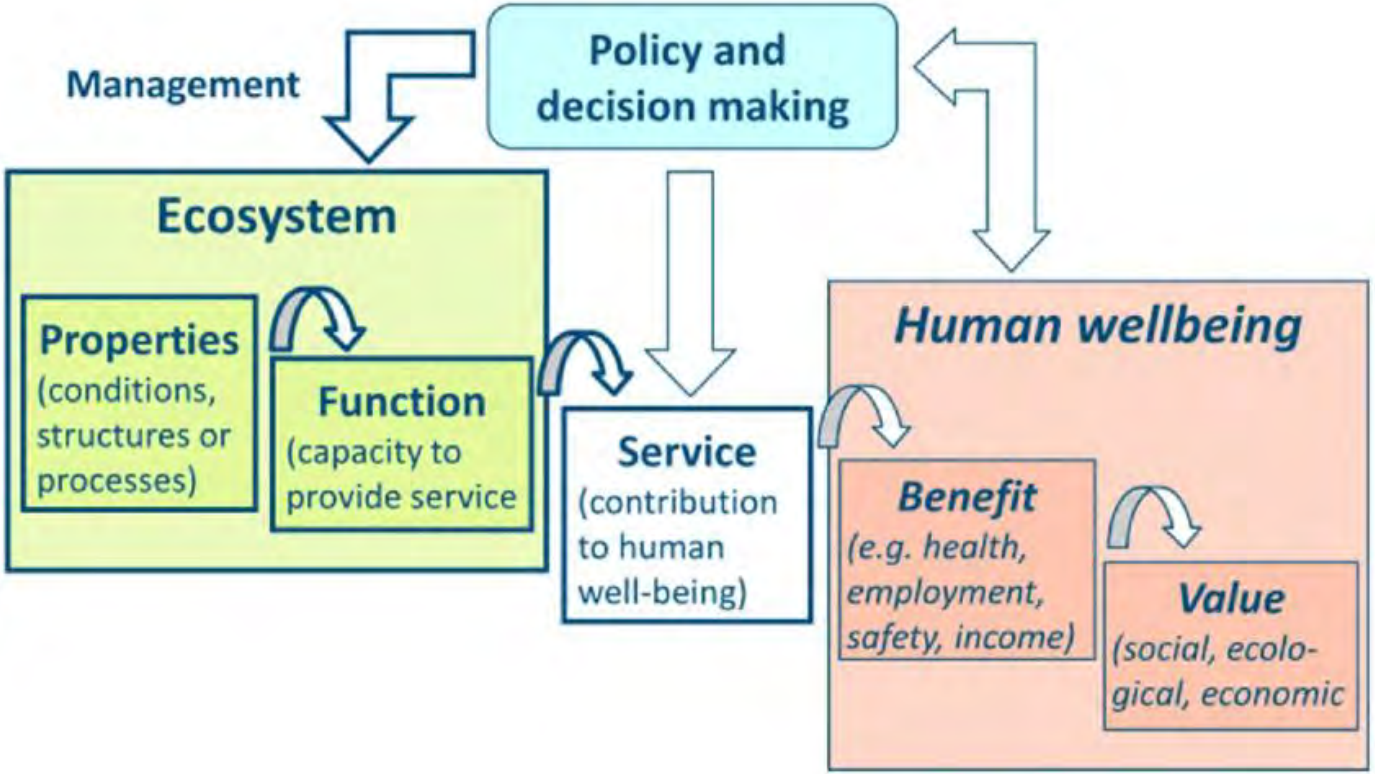
Water storage
(1.5 trillion yen/year)

Prevent soil erosion
(332 billion yen/year)

Treatment of organic waste
(12.3 billion yen/year)

(Science Council of Japan 2001)

I. Agriculture provides valuable ecosystem services
What is Ecosystem Services?



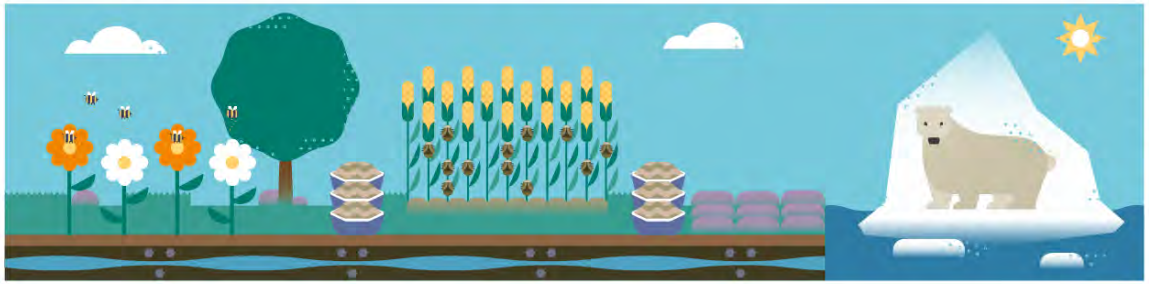
De Groot et al. (2010), Haines-Young and Potschin (2010)

I. Agriculture provides valuable ecosystem services
Examples in Agricultural landscape

Provisioning services

- Crops, soil fertility
- Livestock
- Timber
- Fiber
- Wild foods (e.g. mushrooms, berries, etc.)
- Fisheries
- Genetic resources, medicines
- Fresh water
- Clean air

Regulating services



- Pollination
- Temperature regulation
- Carbon sequestration and storage
- Pest regulation
- Erosion regulation
- Flood regulation
- Water purification
- Air purification

Cultural services

- Recreation (e.g. swimming, hiking, skiing etc.)
- Aesthetic (e.g. sceneries)
- Cultural identity

https://www.eea.europa.eu/signals/signals-2021/infographics/what-are-ecosystem-services/view

I. Agriculture provides valuable ecosystem services
Examples in Agricultural landscape

Erosion event at Müncheberg, 21.09.2018

Bild: Bloch 2018

II. Soil is the base for the ecosystem services
What is soil?

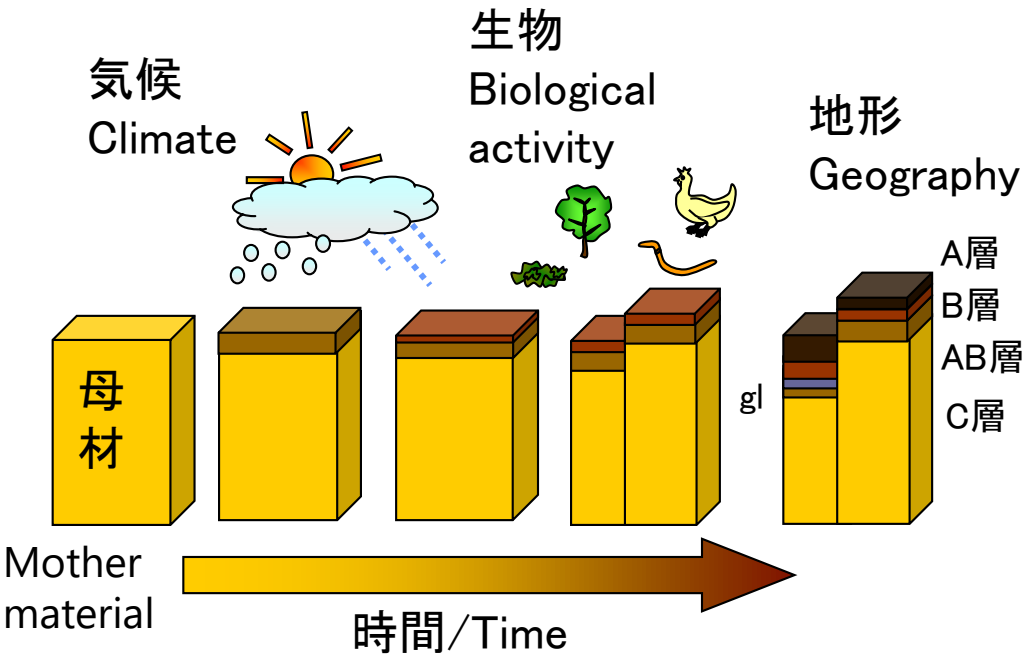
© Bellingrath-Kimura

	SiO_2	Al_2O_3	Fe_2O_3	Cation	Org.	other
	(%)					
Rock	59.1	15.2	6.8	15.4	0	3.5
Soil	36.7	35.6	9.4	3.1	15.2	0

(Ikkokku 1979)

II. Soil is the base for the ecosystem services
What is soil?

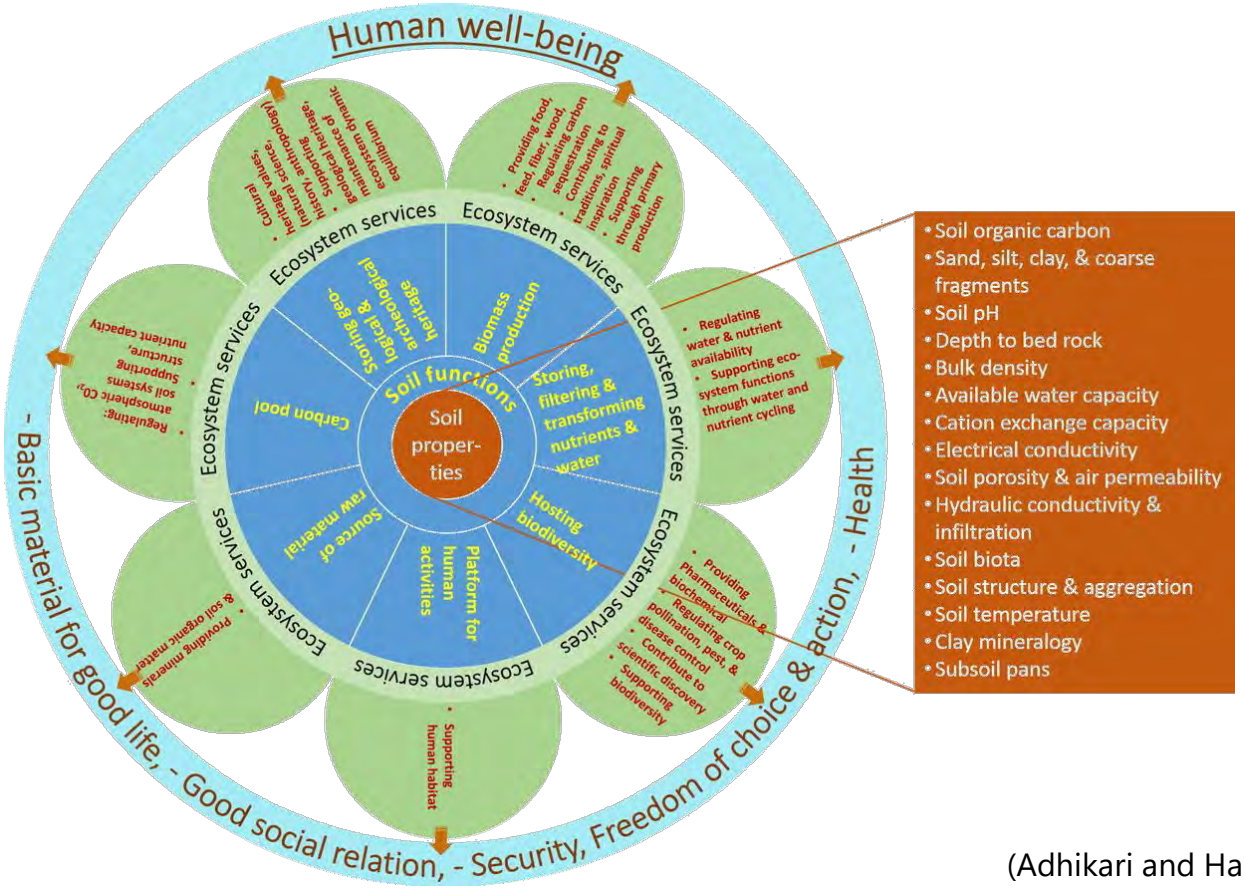
5 factors for soil formation



Soil formation speed:
about 100 years to create 1cm soil

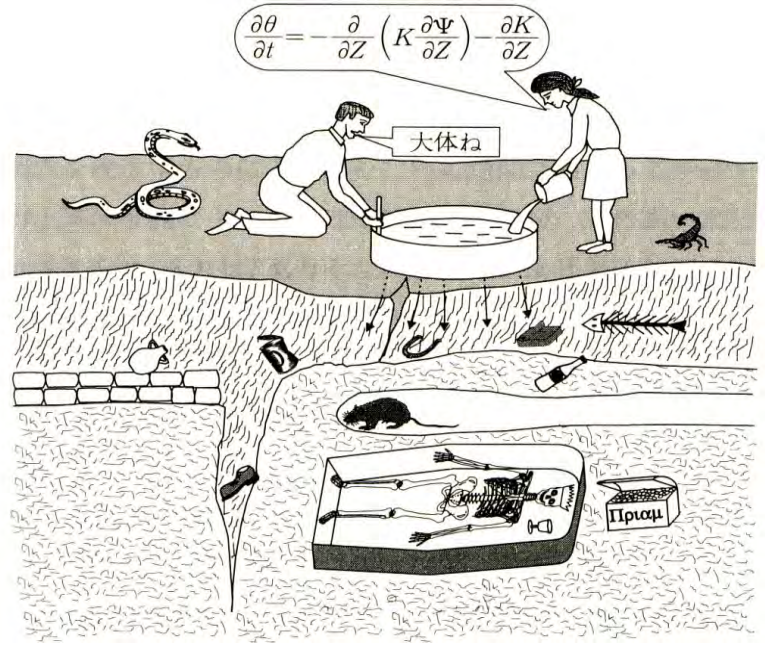
Average depth of soil: 18cm

II. Soil is the base for the ecosystem services
Ecosystem services of Soil



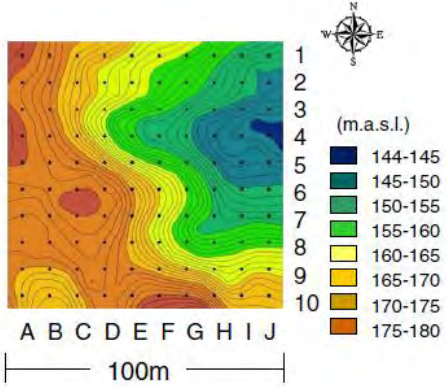
(Adhikari and Hartemink 2016)

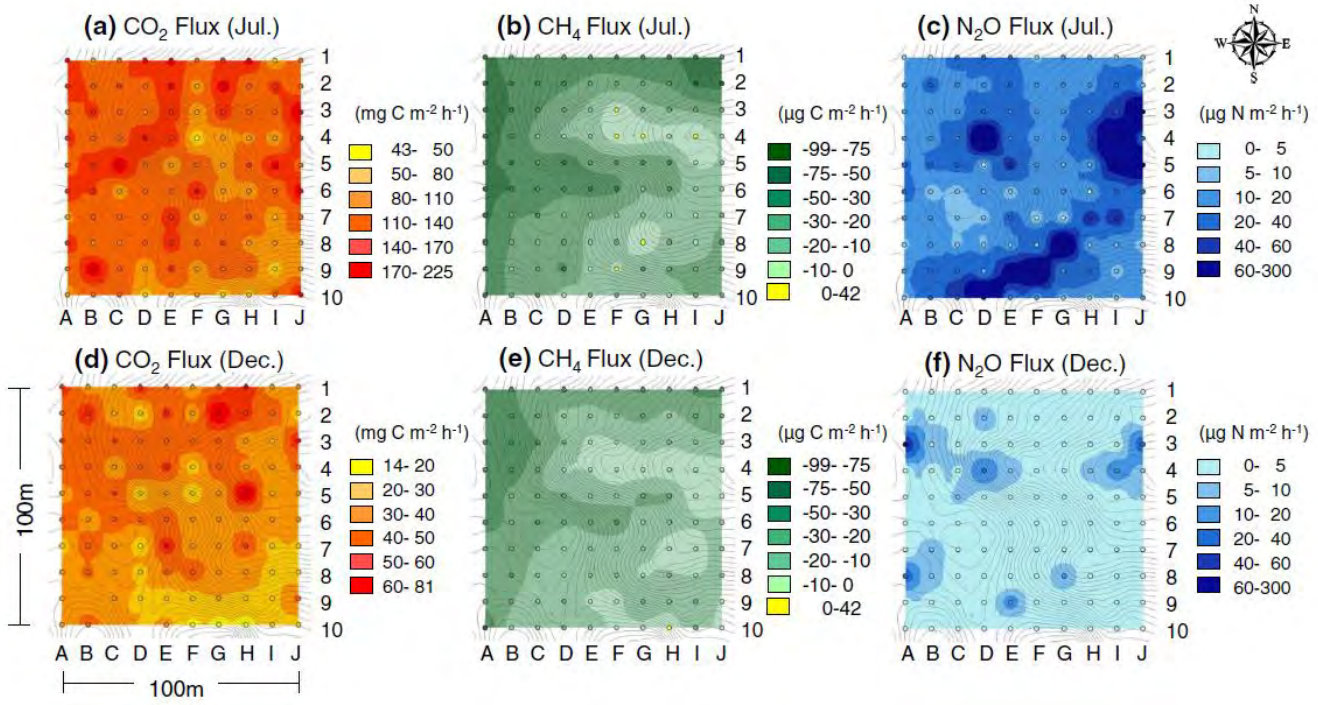
II. Soil is the base for the ecosystem services
Highly variable: Why?



(Hillel 2001)

II. Soil is the base for the ecosystem services
Highly variable: also in the process





(Bellingrath-Kimura et al. 2015)

II. Soil is the base for the ecosystem services
Highly variable: Also in the process

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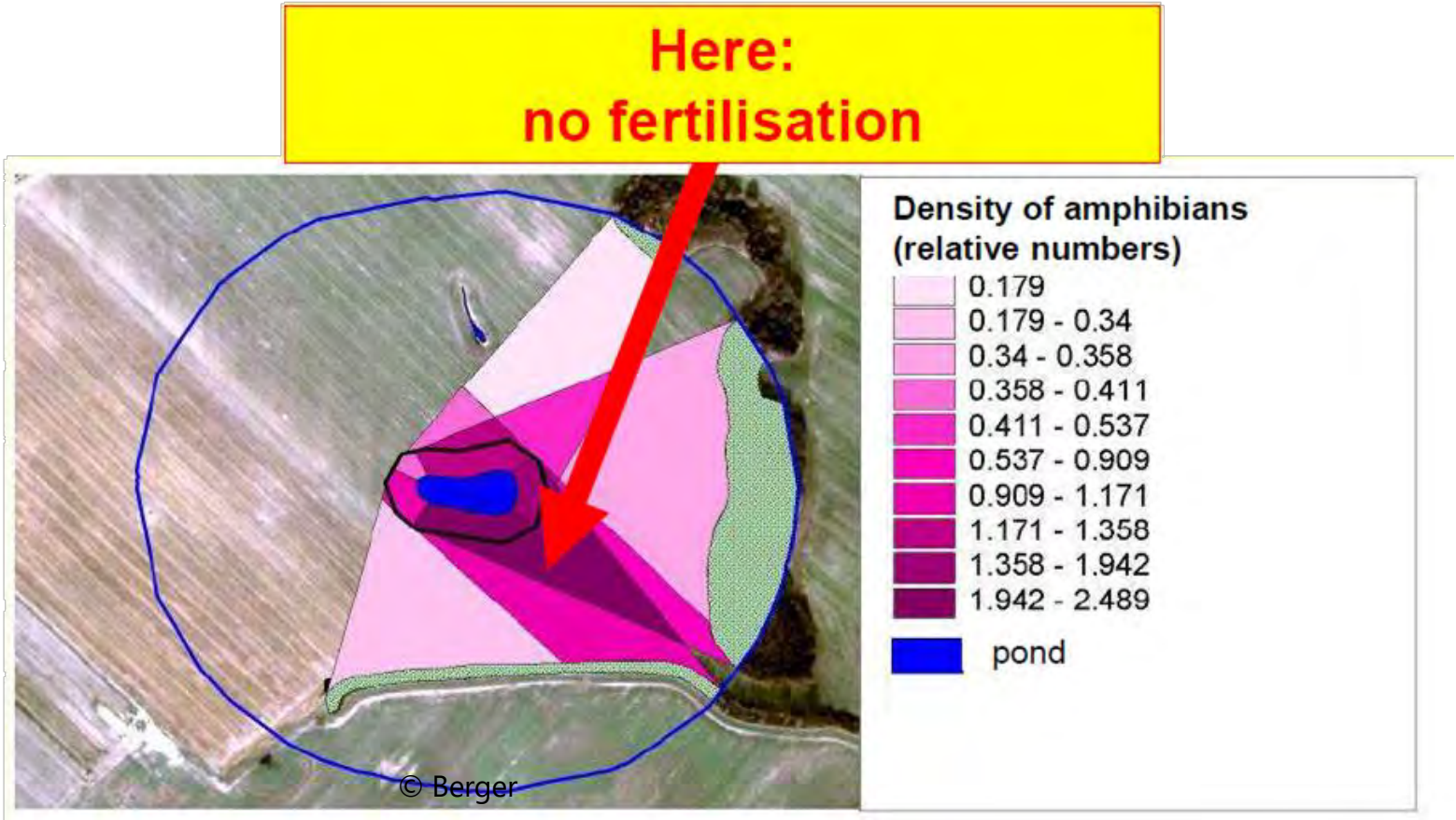
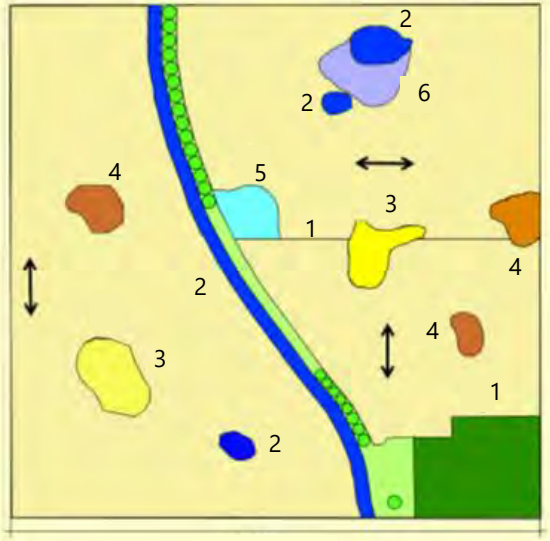
Highly variable: Also in the process



© Berger

II. Soil is the base for the ecosystem services
Highly variable: where to protect?

Ausgangssituation z.B. Ostbrandenburg
Flächen mit hoher Standortheterogenität aber einheitliche Nutzung



Legende
- Acker
- Bearbeitungsrichtung

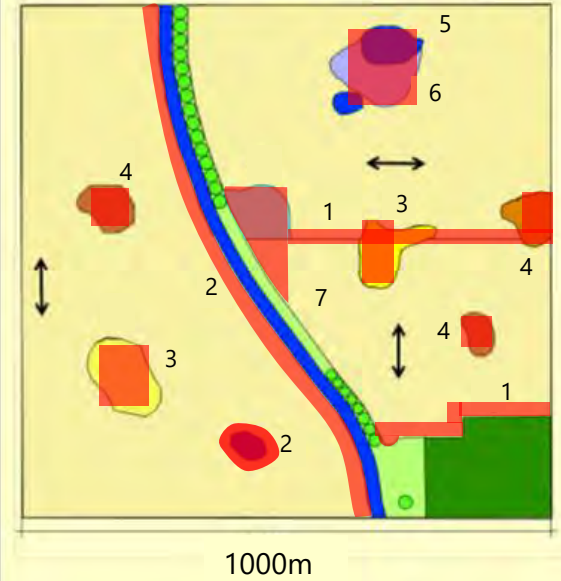
Vorhandene Strukturen
- Fließ- und Kleingewässer
- Gras- und Staudenfluren
- Wald/Forst
- Flurgehölze

Acker-Standorte

1. Schlagrand
2. Gewässerrand
3. Sandfläche
4. Trockenkuppe
5. Nassstelle
6. Überflutungsbereich

NATAPP www.naturschutz-app.de

Within field segregation: 10% of the area for nature protection with site specific small measures



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Vorhandene Strukturen
- Fließ- und Kleingewässer
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- Wald/Forst
- Flurgehölze

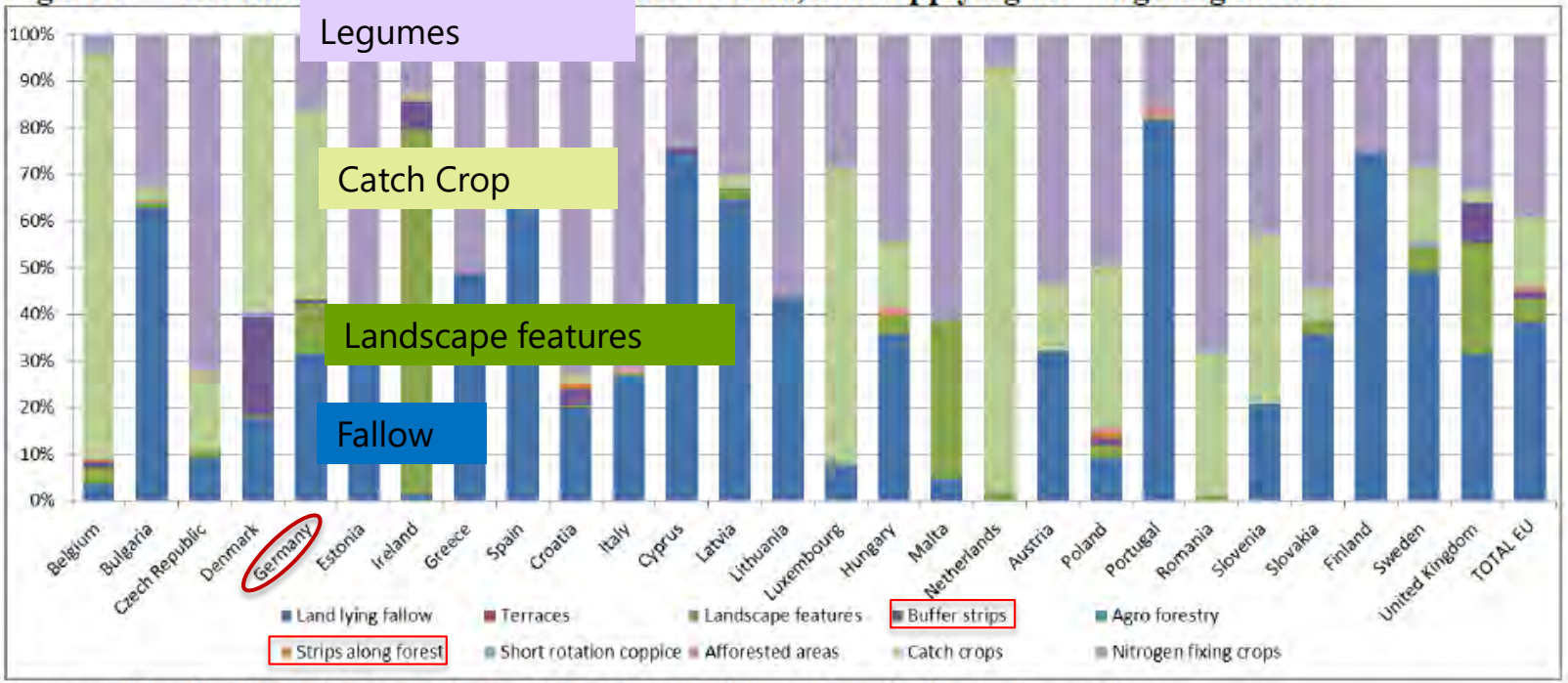
Naturschutzbrachen auf
1. Wald-. Flurgehölz- und Schlagrand mit Vorgewende
2. Gewässerrand mit Abstandsauflagen
3. Sandfläche
4. Trockenkuppe
5. Nassstelle
6. Überflutungsbereich
7. Kleinflächen

NATAPP

www.naturschutz-app.de

III. Digital tools can help detangling the complexity
Why not protect valuable sites?

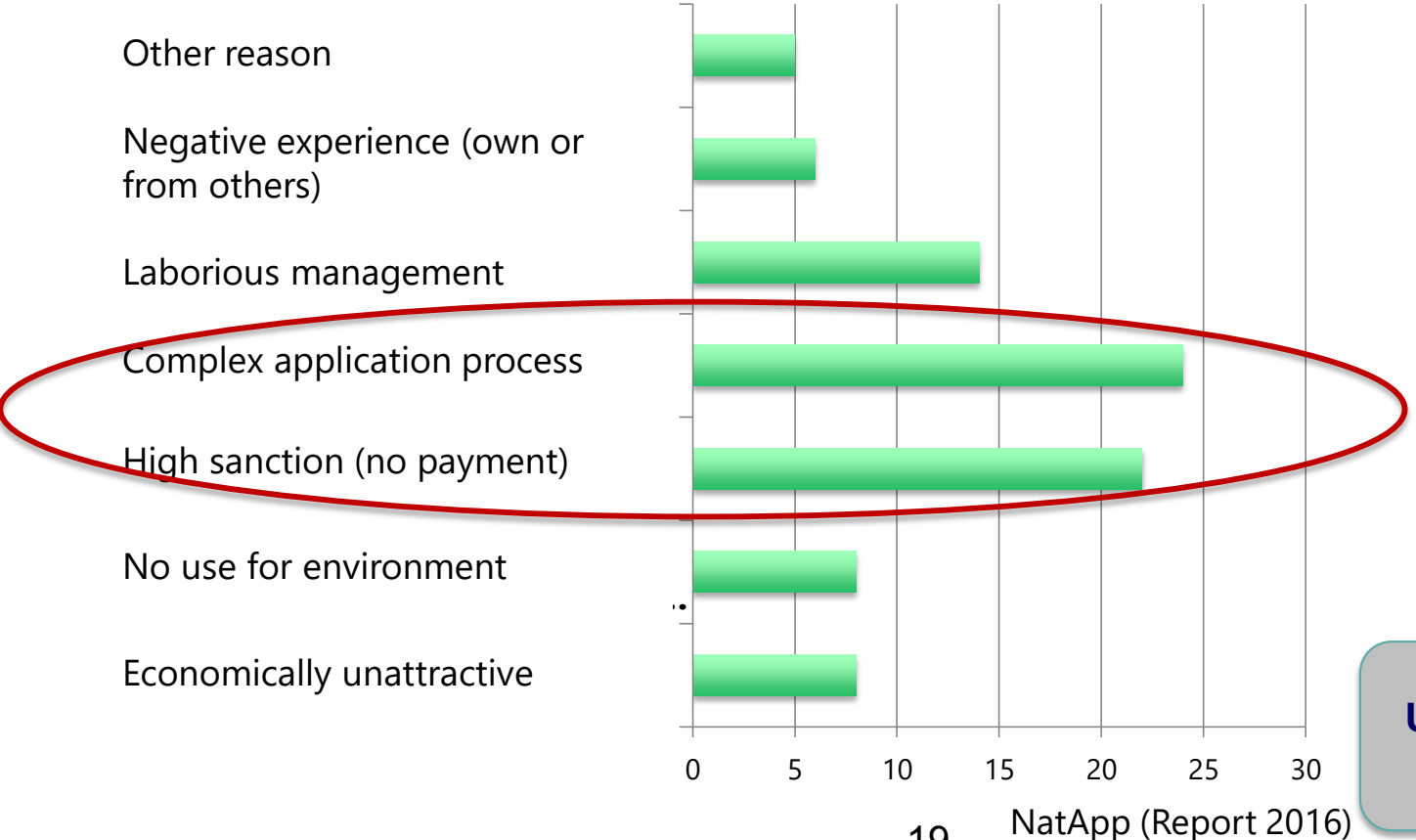
Figure 3 — Breakdown of the main types of EFA area, after applying the weighting factors



Source: Member States' uptake data, 2015 (EU-27, data not available for France)

(European Commission 2019)

nur wenig: Buffer strips
Strips along forest



Problem

Realization by the farmer

and

Controllable for the administration

Use of Digitalisation (ICT)!

III. Digital tools can help detangling the complexity
Challenges and chances

Global Change

Chance

Challenge

New market values

- Integrating ecosystem services, biodiversity and resource efficiency

New sensors and models

- Documentation, forecasting and controlling of site-specific effects of agricultural activities

New small-scale and site-specific management systems

- Optimization by small robots

New operating models

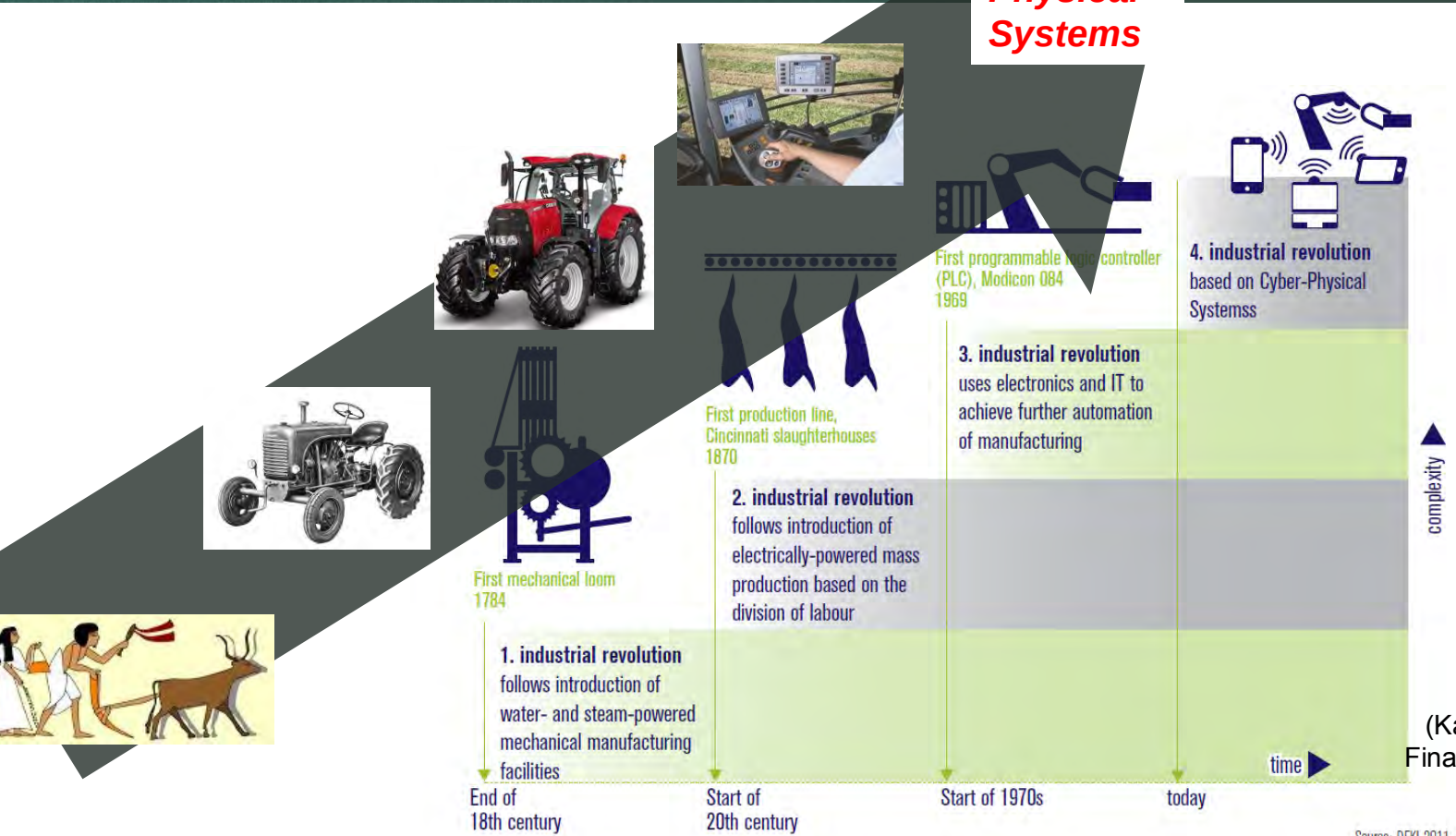
- Develop new orientation goals in operational planning and support complex decisions

New cooperation

- Creation of new communication channels between farmers, consumers and society

Zeichner: Heyko Stöber

III. Digital tools can help detangling the complexity
Industry 4.0 v.s. Agriculture 4.0



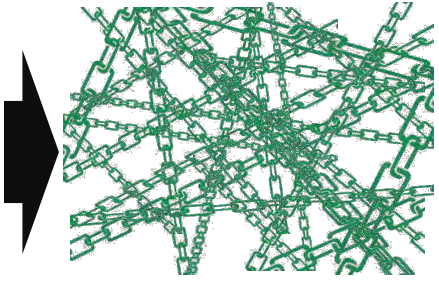
(Kagemann et al. 2013: Final report Industrie 4.0)

III. Digital tools can help detangling the complexity
Industry 4.0 v.s. Agriculture 4.0

- Plant, animal and environment interact each other
- Plant and animal are living organisms and react individually
- Production are highly diverse (Wheat → bread/bran/biomass)
- Long time period are to be considered (one cycle is one or several years, the use of soil last for decades)
- Agricultural activities are conducted in an open system and impacts on ecosystem
- Indicators and concepts to integrate ecosystem services in the value chain are lacking

Production

Value Chain



Biogas

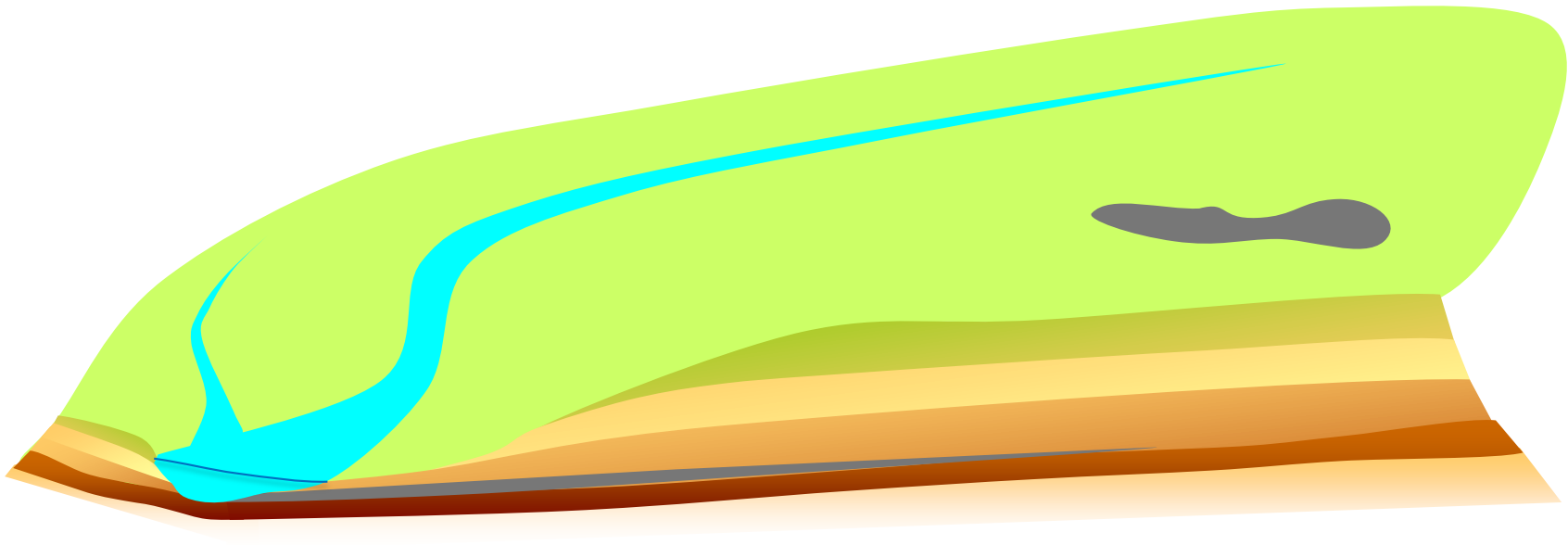
Feed

Food

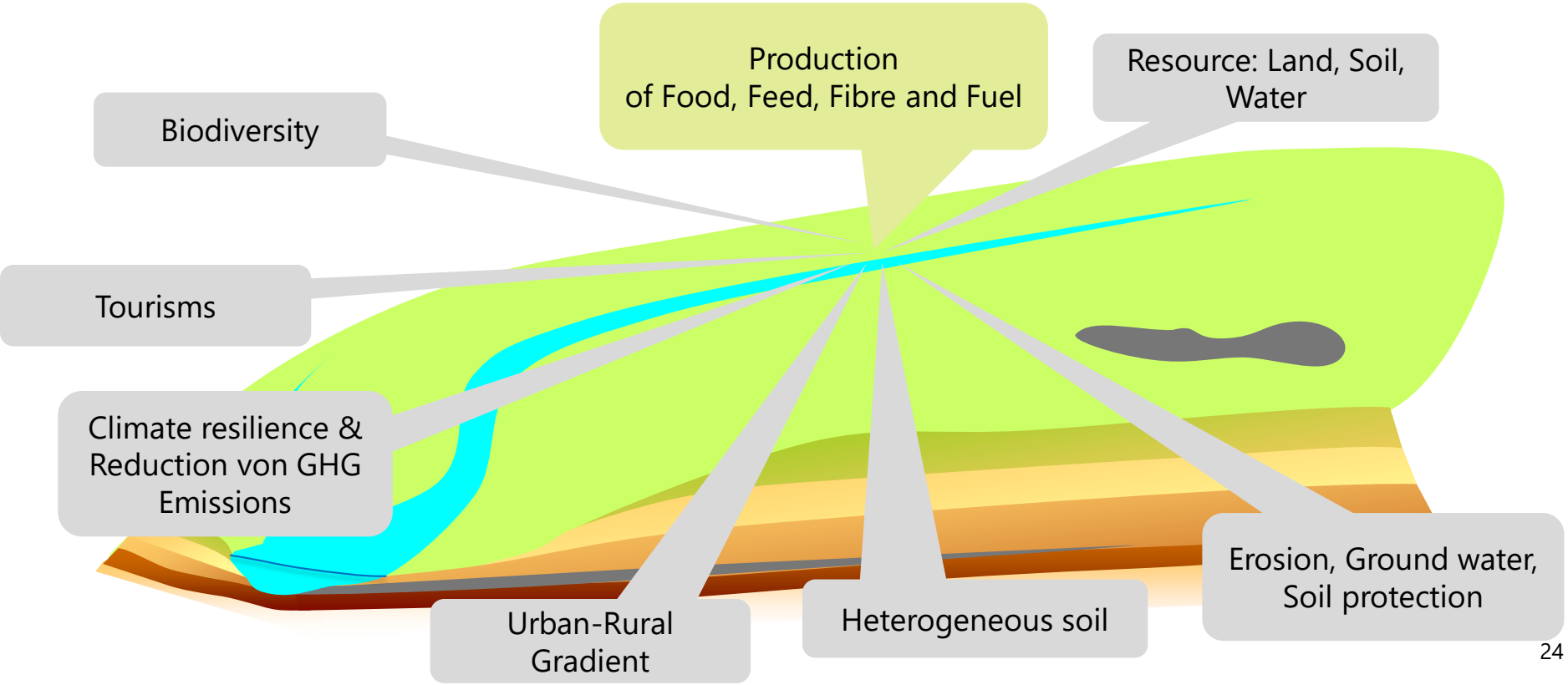
End-User

III. Digital tools can help detangling the complexity
Projects: Agricultural Systems of the future

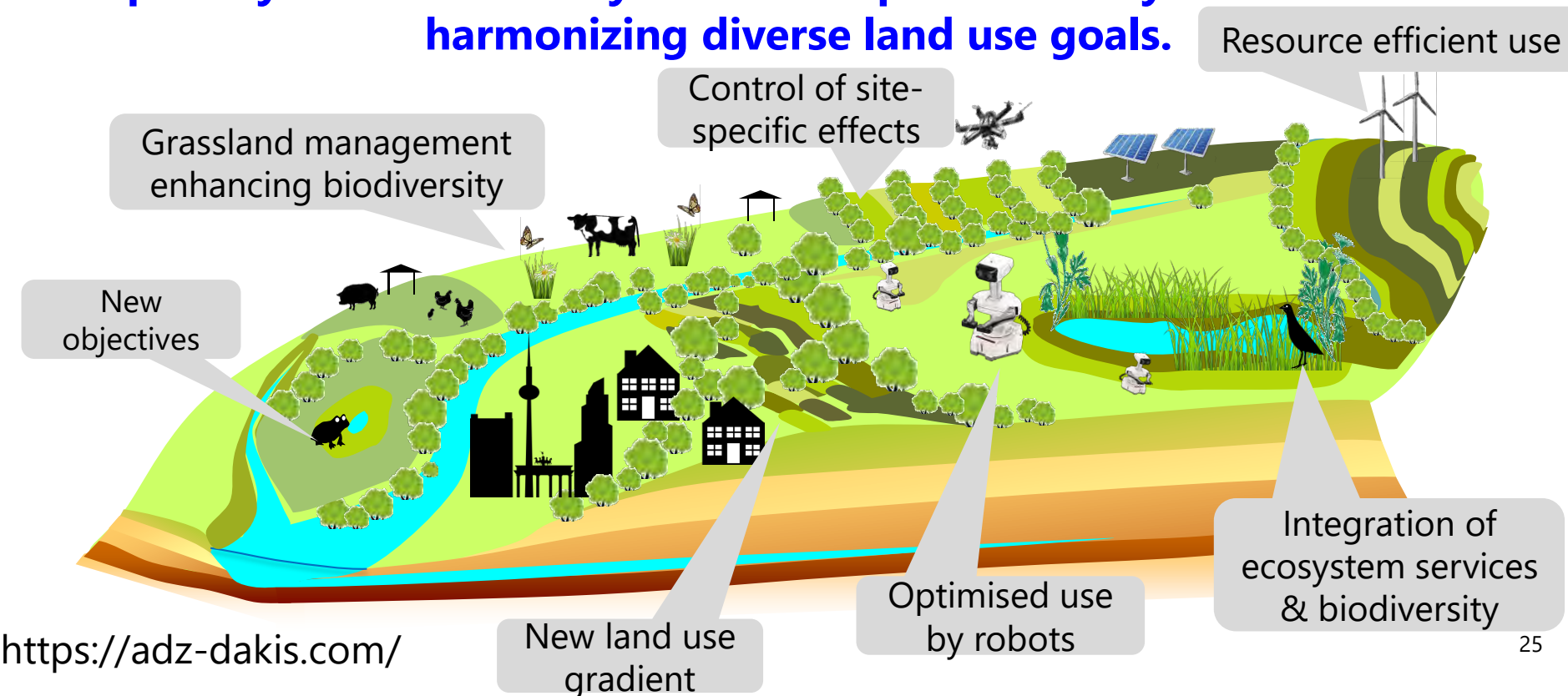
https://www.agrarsysteme-der-zukunft.de/en/home



III. Digital tools can help detangling the complexity Demand in agricultural landscapes



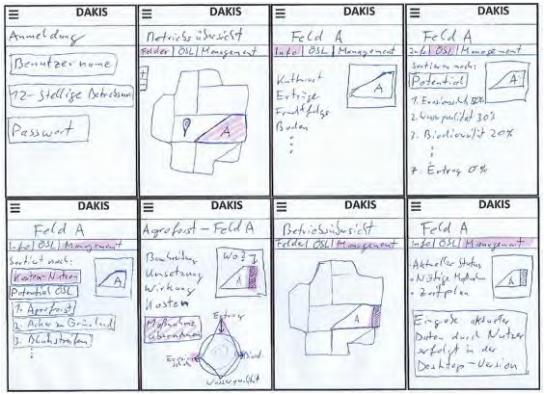
Spatially and functionally diversified production systems will allow harmonizing diverse land use goals.



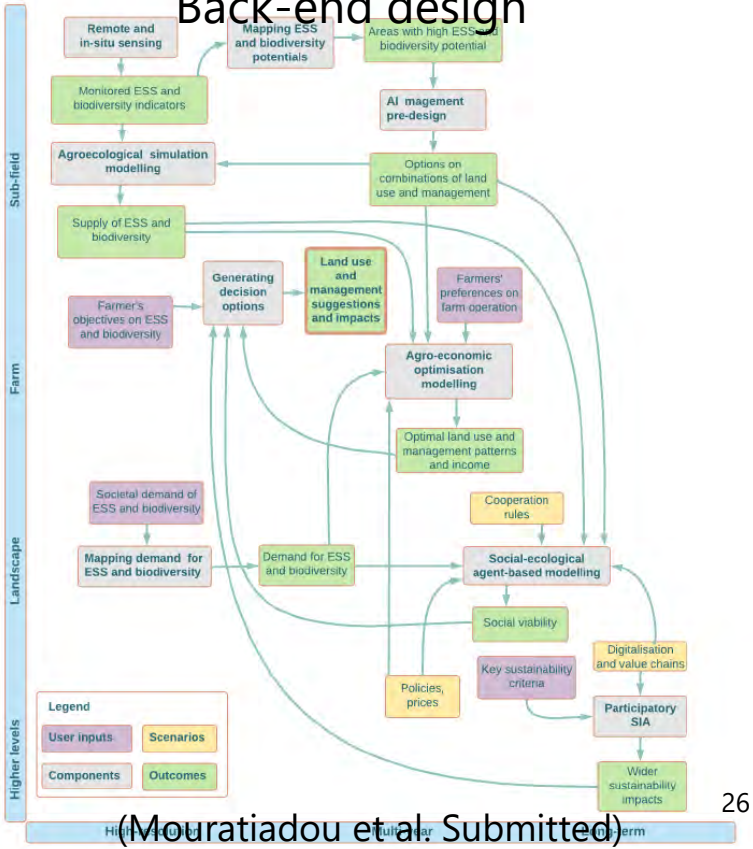
https://adz-dakis.com/

2. Integration: The DAKIS Prototype

Front-end design



Back-end design



(Mouratiadou et al. Submitted)

III. Digital tools can help detangling the complexity
Technology of today

Tractor Cockpit:
Motor + GPS + Tillage/Fertilization

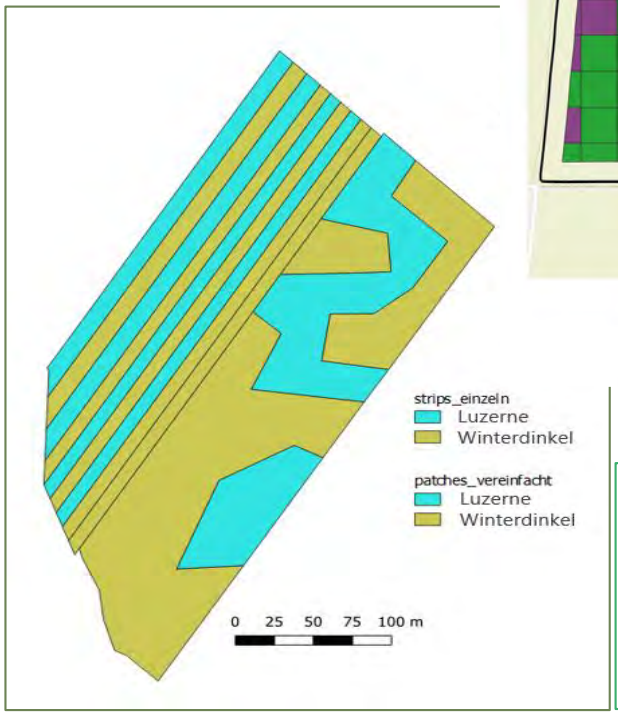
3D tillage sensor (Einböck)

III. Digital tools can help detangling the complexity
Technology in the future: Swarm Robots

ICT does not mean automatically bigger fields!

Scalability via the Number of machines (small farms, small No. of machines)

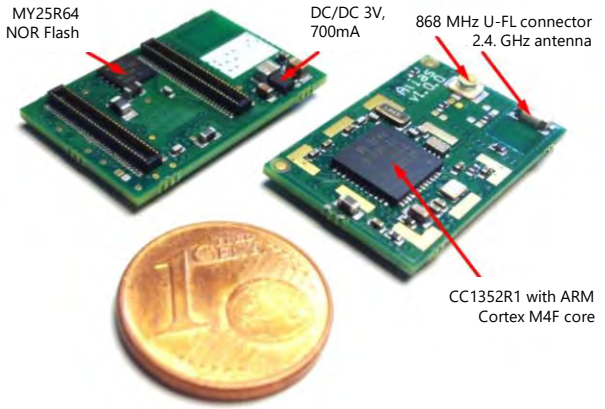
III. Digital tools can help detangling the complexity
Digital agricultural knowledge and information systems



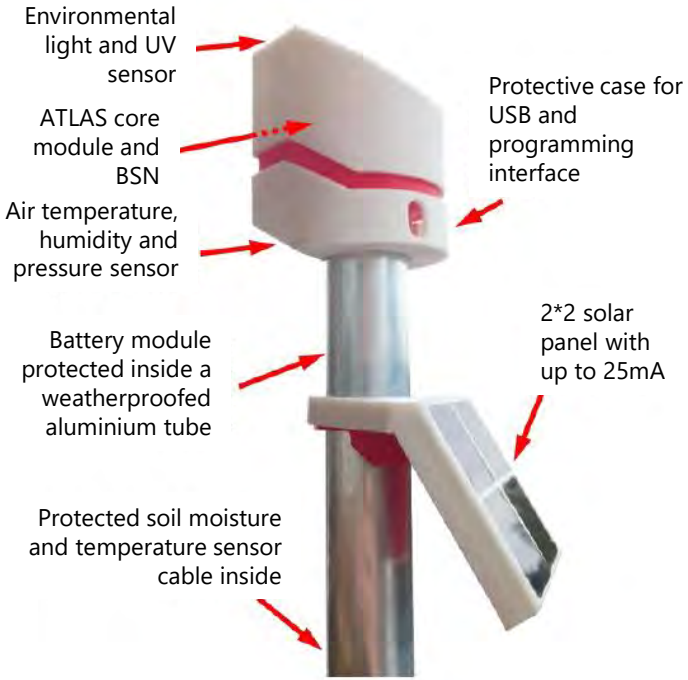
- Identifying the spatial heterogeneity of field
- Creating a **Patch-Cropping-Map**
  - Minimal size (direct payment 0.3ha)
  - Machinery working width
  - **Future (Robots) and current technology** (organic form or rectangular Polygons)

Donat, M. et al. (2022): Patch cropping- a new methodological approach to determine new field arrangements that increase the multifunctionality of agricultural landscapes – In: Computers and Electronics in Agriculture. Volume 197. 106894. https://doi.org/10.1016/j.compag.2022.106894.

III. Digital tools can help detangling the complexity
Digital agricultural knowledge and information systems



Core-Modul (called: ATLAS), where all important components are integrated. Cassic sensor-net tasks: MCU, RF-Frontend, storage and Spannungswandler)
© Max Frohberg, IHP



Acoustic sensor prototype

III. Digital tools can help detangling the complexity
Risks and necessary steps

Diskussionspaper: https://bit.ly/3scYXAJ
Technoliegebericht: https://bit.ly/3vJ956E

- Intensification of agriculture
- Homogenization of farming systems
- Impact on genetic engineering
- Intensification and expansion of livestock farming

→ Clear goals/indicators for "sustainable use

→ Valorization of Ecosystem services and Biodiversity

- Socio-economic risks (small farms, technology-heavy)

→ Develop IT competence

- Material and energy consumption (recycled only 1/3 (Eurostat, 2020)
- Risk of data management
- Monopolization (platform companies, machinery manufacturers (3 groups: 50%), agrochemicals (3 groups 70%)

→ Data sovereignty

→ Technological impact assessment & management

→ Governance

III. Digital tools can help detangling the complexity
Valorization of the environmental cost

https://www.landwirtschaft-artenvielfalt.de/

III. Digital tools can help detangling the complexity
Valorization of ecosystem services and biodiversity

agora natura

https://agora-natura.de/

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II. Soil is the base for ecosystem services

- Site specific and temporal variable

III. Digital tools can help detangling the complexity

- Sustainable bioeconmy should consider ecosystem services and biodiversity

Thank you for your attention.

Leibniz Centre for
Agricultural Landscape Research
(ZALF)

Biopioniere
https://www.youtube.com/watch?v=BaUxl62Upi8

Contact: