Leibniz Centre for **Agricultural Landscape Research** (ZALF)

Land Use & Governance

Potential of autonomous field robots to improve soil health in diversified cropping systems: a promising tool to boost sustainable intensification of agriculture?

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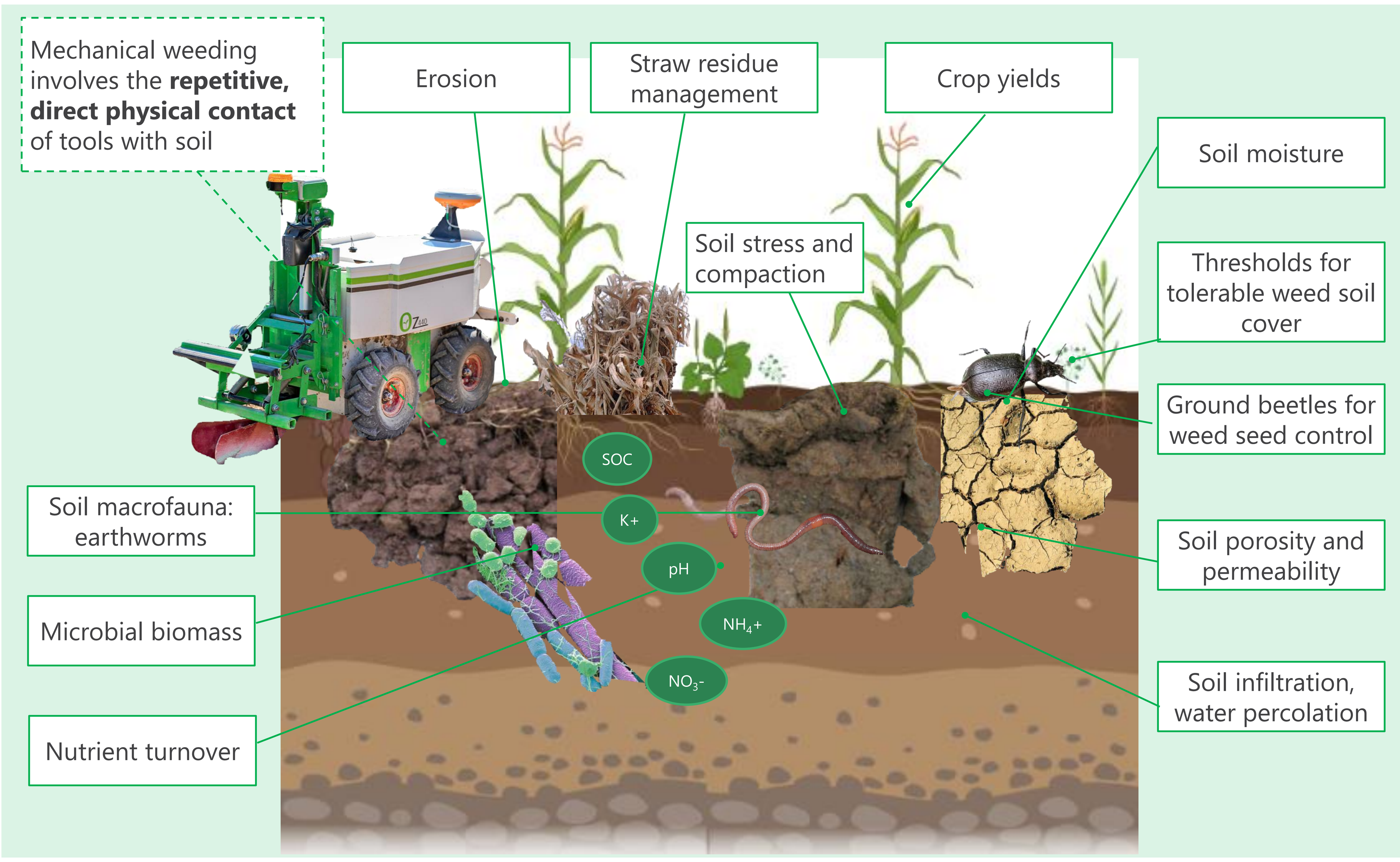
Objective

Conceptualization: Summary, connection and application of existing knowledge of soil property impacts by conventional machinery into agricultural robotic settings

Research area examination: Evaluation of the existing knowledge about effects of autonomous field robots on specific soil properties, such as compaction, soil structural changes and aggregate composition



Impact on soil properties and processes through field robots in arable farming

Available studies

- ROBOTTI 150D *(Calleja-Huerta et al., 2023 in Denmark)*
  - limit the number of passes from lightweight robots to reduce negative impact on physical soil properties and topsoil functionality
- Farmdroid FD20 *(Bruciene et al., 2022 in Lithuania)*
  - Robotic weeding increased soil bulk density by 0.16 g cm^3; but only marginal increase of penetration resistance in topsoil
- Many review and opinion articles (>17 since 2014) about agricultural field robots without research/field data

Outlook

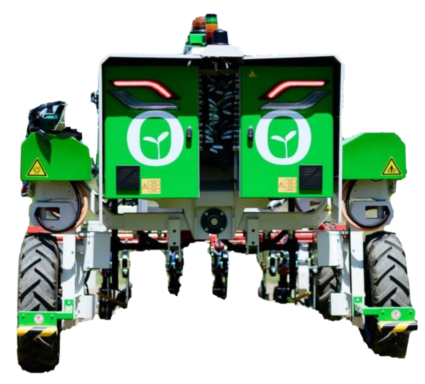
- BMBF funded junior research group **SoilRob**
  - "Towards healthy soils by using autonomous field robots in diversified agricultural landscapes"
  - Start: October 2023
  - Duration: 5 years
  - Group size: 5 persons
- Challenge: soil-smart control of *unstructured objects* (CROPS) *in unstructured environments* (FIELDS) to solve environmental challenges
- Aim: strengthen the potential of field robots in newly arranged, diversified cropping systems of the future, and thus *redefine* sustainable intensification

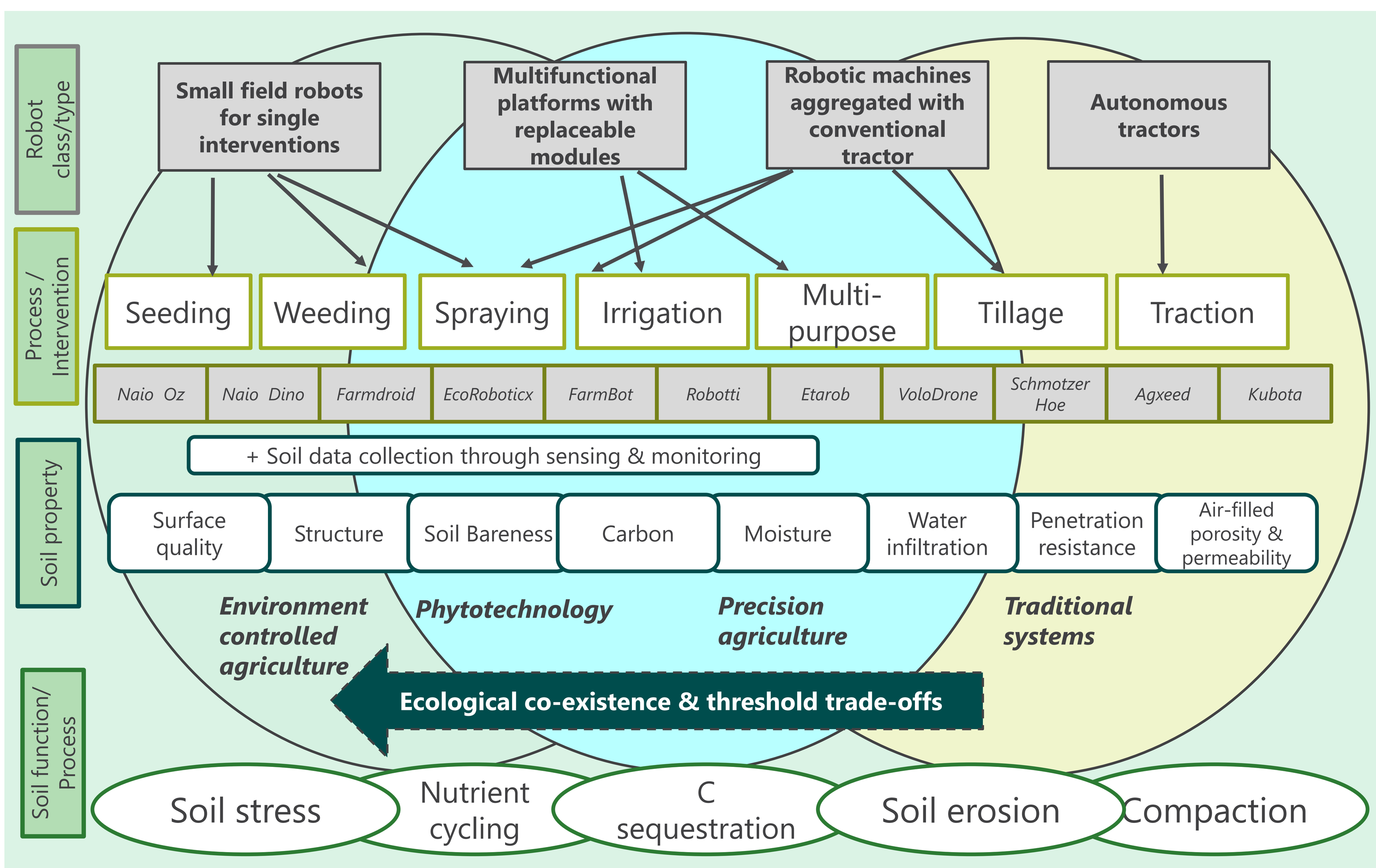
Main differences

Factor	(Autonomous) Field Robots	Conventional (large) agricultural machinery
Size	Lighter weight, small size	Higher weight, bigger machines
Mobility	Highly mobile, slower speeds	Less agile, fast traction, GPS operation
Automation	(Fully) autonomous	Require human operators
Versatility	Higher work rates, modular farm mechanization, scalable	Operator-dependent, modular tractors, large-scale
Precision	Accurate and targeted operations at the plant level; repetitive labour possible	Sub-field scale (with precision farming practices)
Energy source	Often electric/renewable energy and energy savings	Non-renewable fuel and higher energy usage
Purchase costs	Weeding robots: up to € 700k Spot spraying robots: max. of € 65k	Very capital-intensive for the small and medium-sized farm
Labour	Reduced manual control labour, increased supervision intensity	Risk of monotonous and labour-intensive tasks
Data collection	Equipped with sensors for automated estimation of biophysical and biochemical properties at the crop-scale	Ubiquitous sensing at the meter-scale
Accessibility	Mostly in industrialized countries, GPS/RTK signal or internet access needed	Not restricted
Training	Special training required, high affinity with digital technologies and computation	Agricultural education and license

Systematization

Roadmap for comprehensive research on soil chemical, structural and biological changes caused by field robotics





Conceptualization of different levels of agricultural robot types, their corresponding field intervention and its effects on soil-related properties and processes embedded in progressing agricultural production settings

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