LoRaWAN, NB-IoT and other radio networks for agricultural applications

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Agenda

1. Radio networks for IoT and/or agriculture
2. Agricultural use cases
3. Experimental results for soil compaction prediction
4. Outlook / future work

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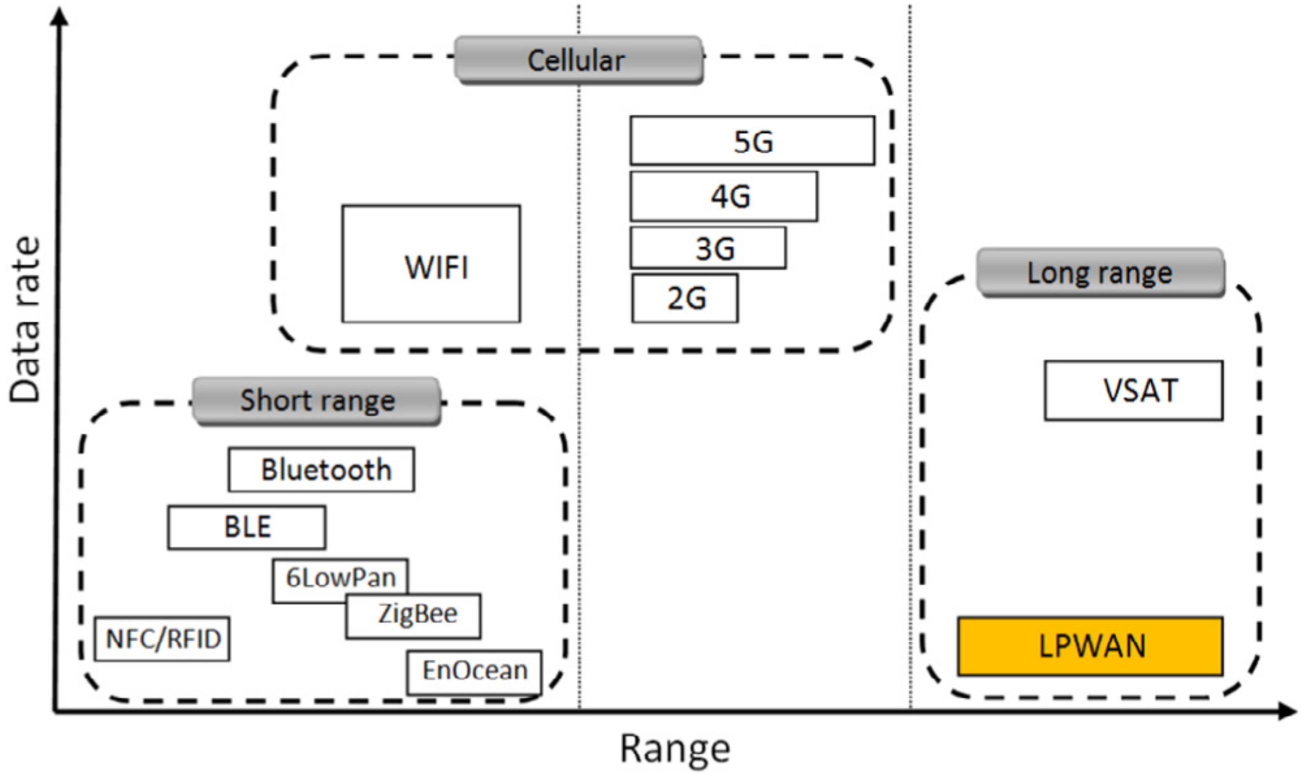
Positioning of Low Power Wide Area Networks (LPWAN)



Source: Mekki, K., Bajic, E., Chaxel, F., Meyer, F.: “A comparative study of LPWAN technologies for large-scale IoT deployment”, ICT Express, Volume 5, Issue 1, 2019, Pages 1-7, ISSN 2405-9595, https://doi.org/10.1016/j.icte.2017.12.005.

Public Mobile Communication Radio Networks for agricultural processes

Parameter	NB-IoT	LTE M	5G
Max. upload data rate	66 kBit/s	1 Mbit/s	Up to 10 Gbit/s
Typical range	15 – 35 km	15 km	500 m
Latency	1.6 – 10 s	10 – 15 ms	1 – 5 ms
Own Infrastructure	No	No	No
Suitable for battery powered devices	Yes	Yes	No

LPWANs for agricultural processes

Parameter	SigFox *)	MIOTY	LoRaWAN
Max. upload data rate	100 Bit/s	407 Bit/s	11 kBit/s
Typical range	10 – 50 km	5 – 15 km	2 – 15 km
Own Infrastructure	No	Yes	Yes
Suitable for battery powered devices	Yes	Yes	Yes

Situation unclear:
https://www.sigfox.com/en/news/unabiz-appointed-new-owner-sigfox-sa-and-sigfox-france-sas-under-receivership-proceeding

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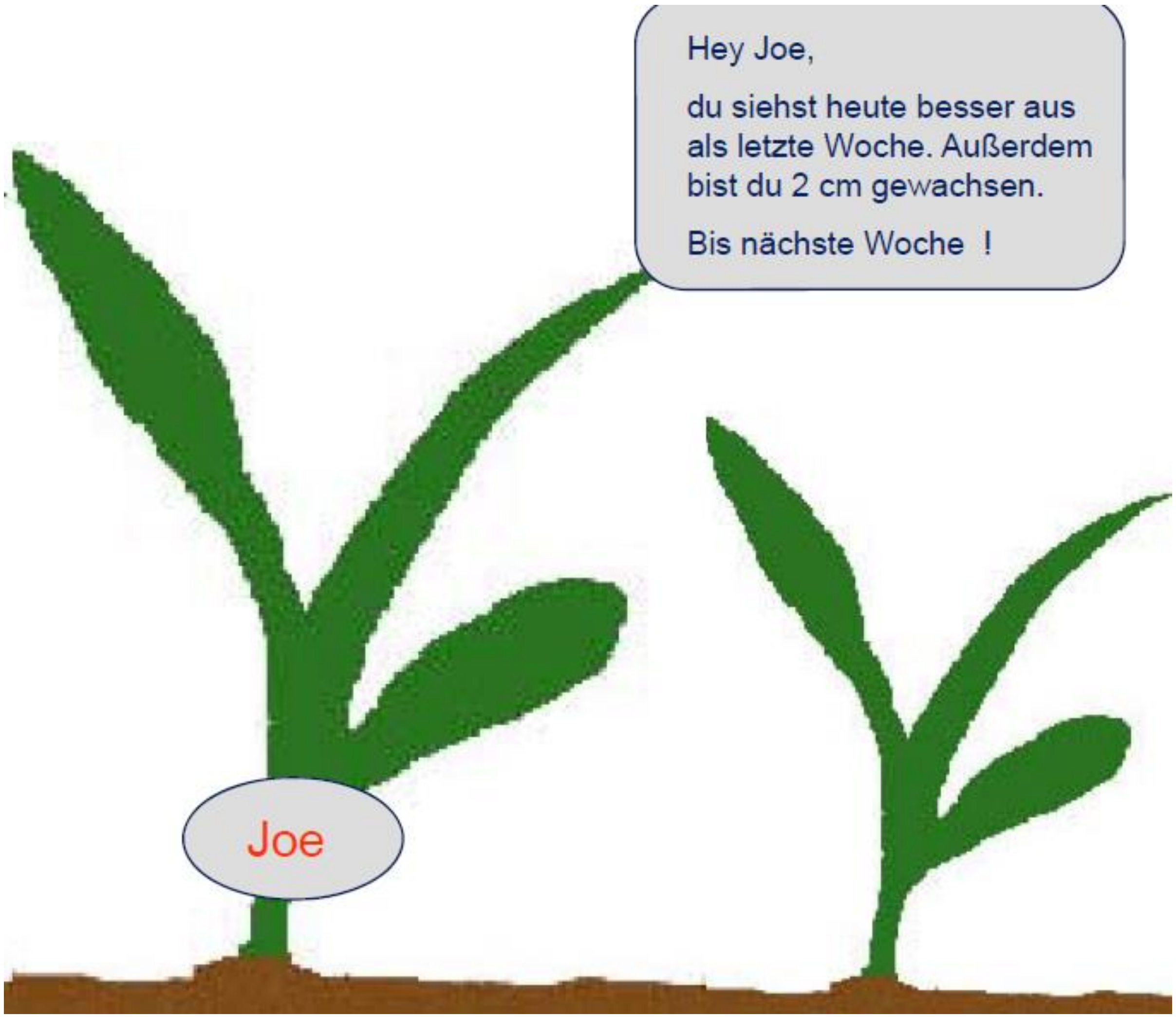
Crop production – single plant view



Source:
Keynote Arno Ruckelshausen
Robot2Business Workshop
Braunschweig 2015

Agricultural use cases – crop production

Maize and wheat production (predominant in NW Germany)

Use Case 1: Semantic environment perception

Goal: Understand the status of each plant and the surrounding soil during the vegetation cycle

- Allow for soil and plant specific preparation, seeding, protection and fertilization (Precision Farming)
- Understand negative effects from weed (Bei-/Unkraut) and over/under fertilization
- Benefits: better yield, less pesticides/fertilizers
  "Achieve more with less"

EXPERIMENTIERFELD AGRO-NORDWEST

https://www.agro-nordwest.de

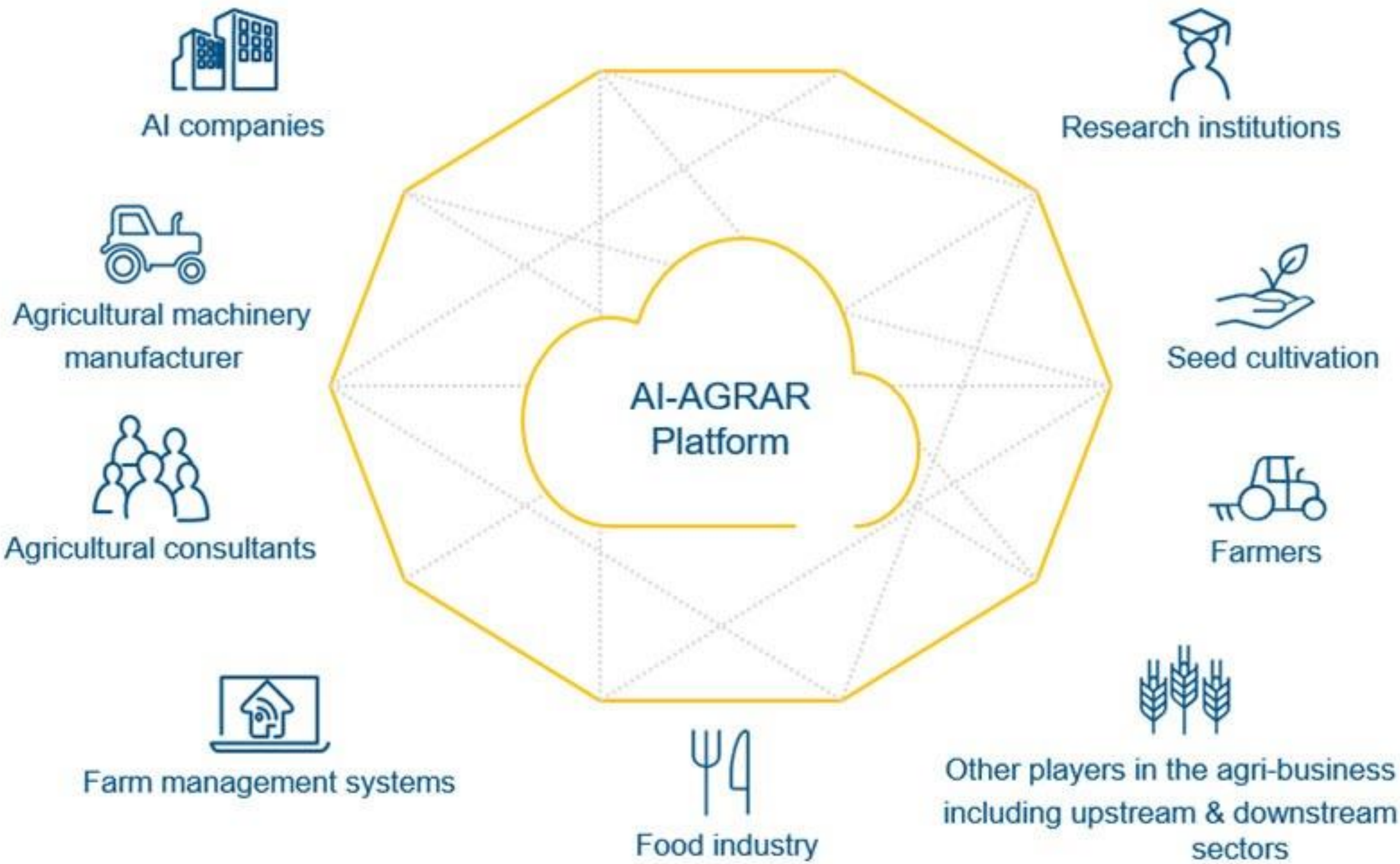
Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages

AGRIGAIA

https://www.agri-gaia.de

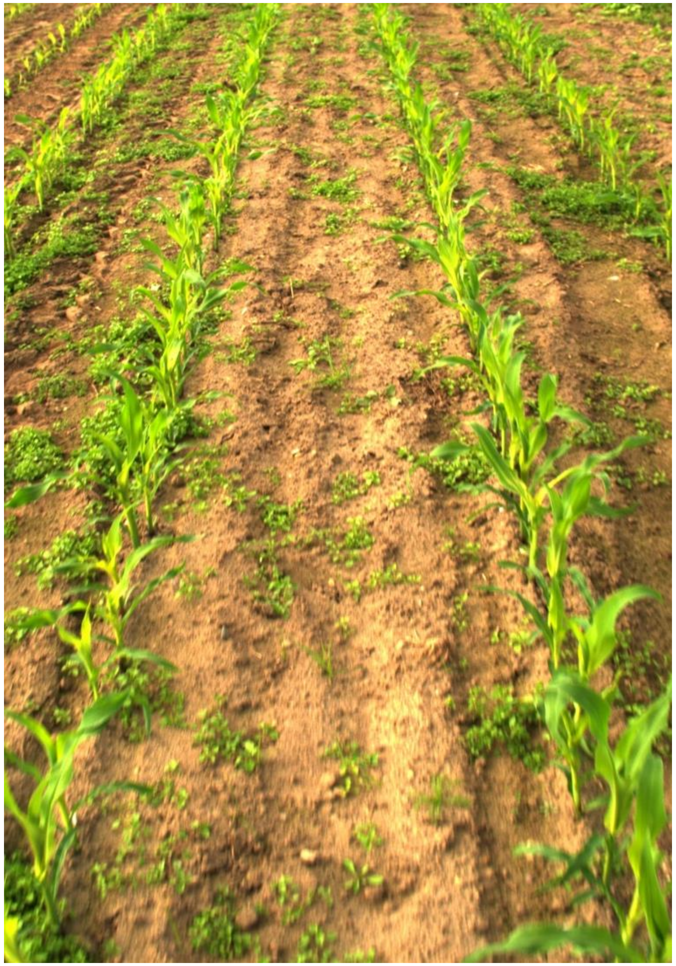
Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Motivation



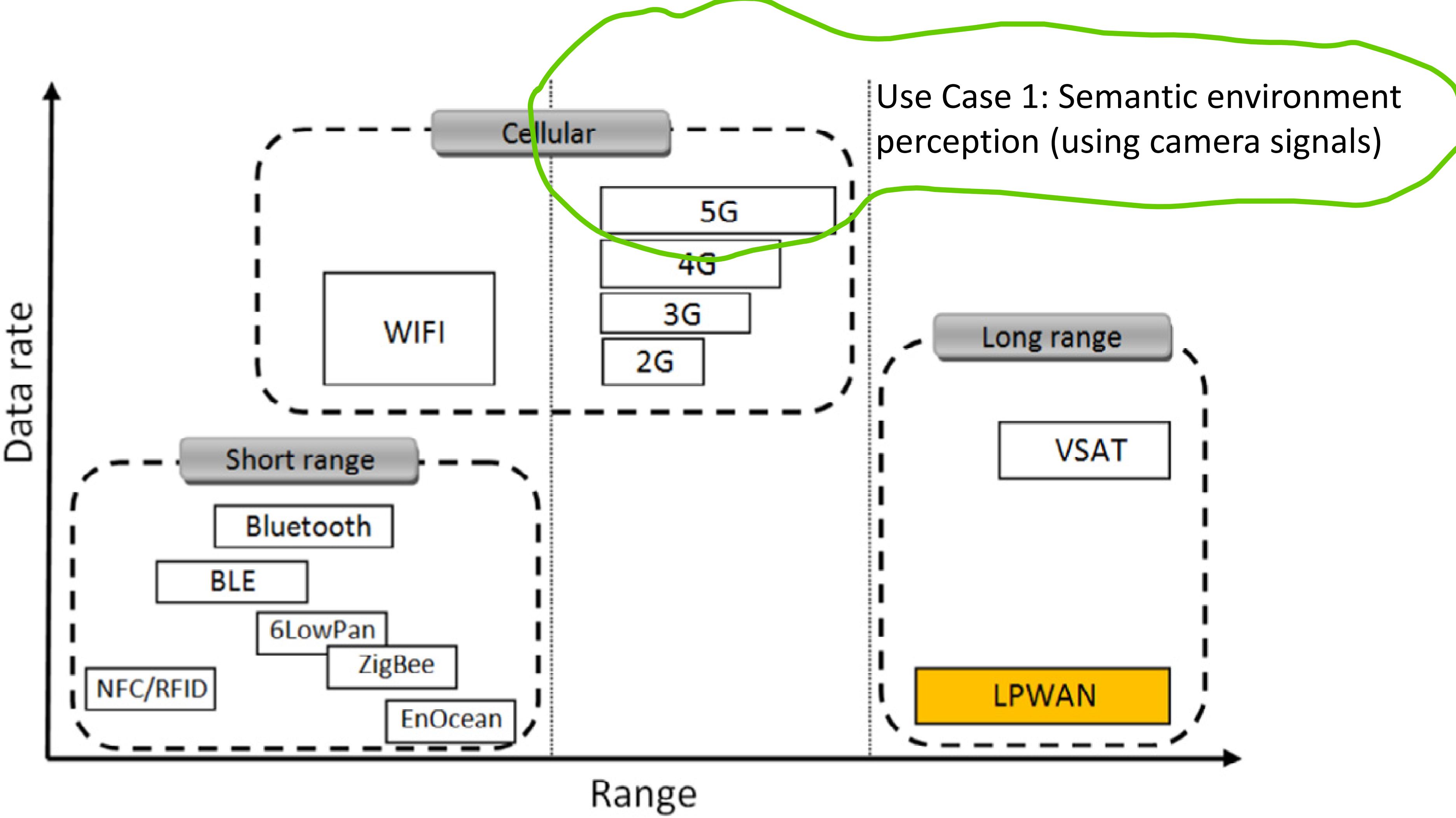
https://www.agri-gaia.de

Plant monitoring in maize using standard and IR filtered B/W camera signals



Source: Amazonen-Werke

Positioning of LPWAN



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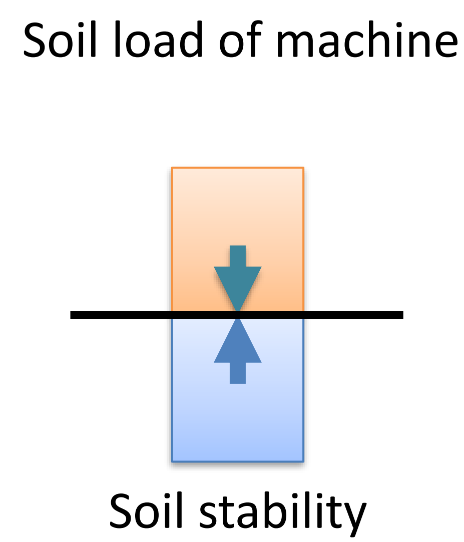
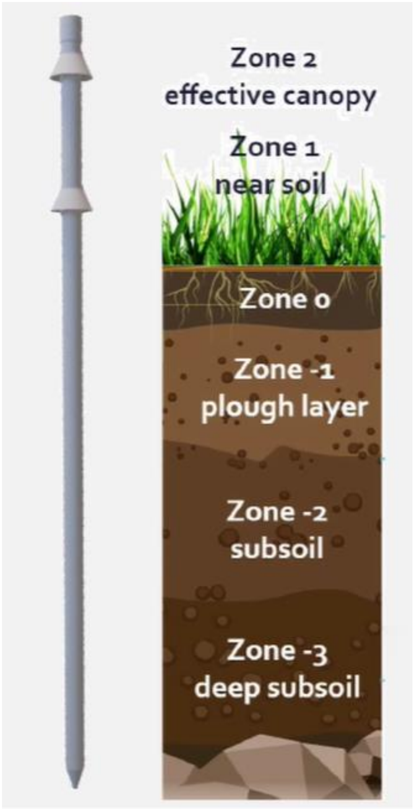
Use Case 2: Soil compaction prediction

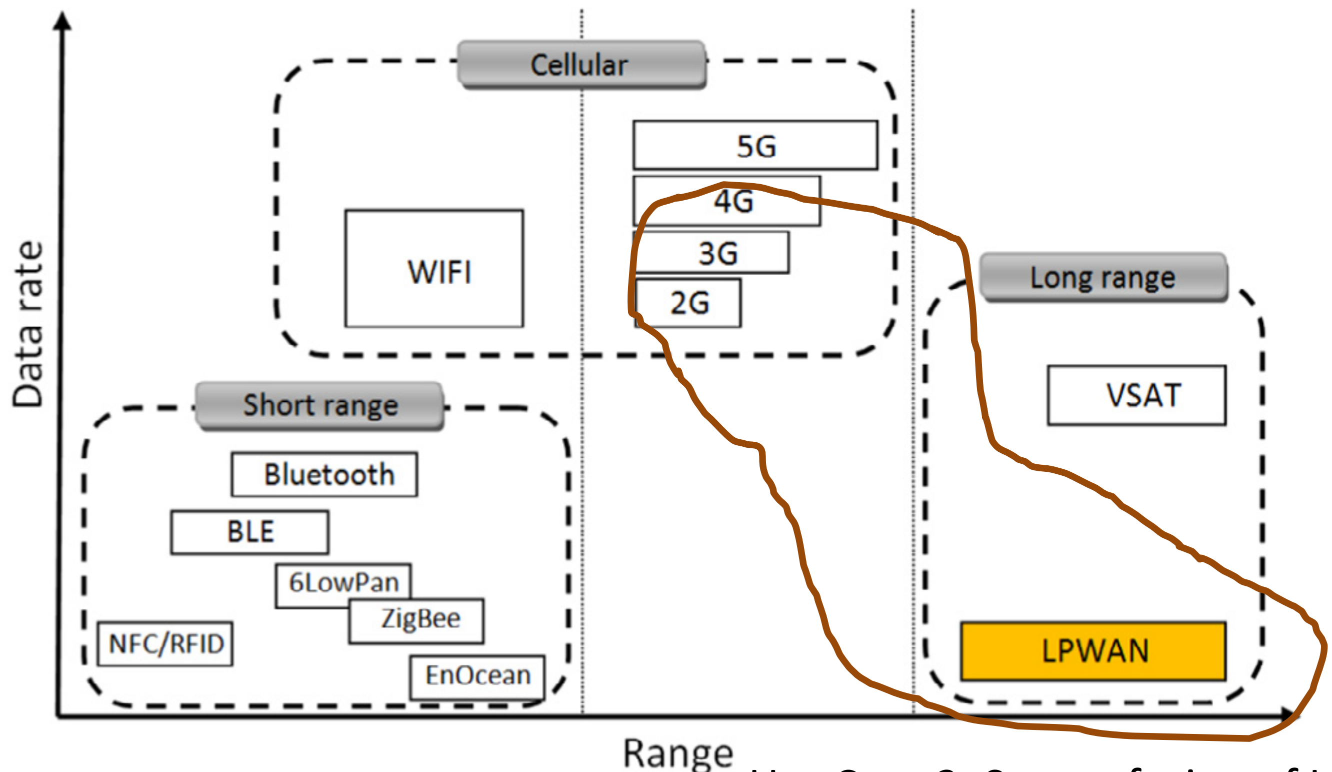
- Sensor fusion of In situ-sensors, microclimate and public weather information e.g. from DWD
- Same environment, but focus on soil: Timing and decision support for driving machinery on the field, challenges:
  - Heavy machinery compacts the soil and harms ideal water flow and plant growth.
  - If soil is too wet, machines can get stuck.



Experiment: Applying In situ sensors with RTK precision geo references



Positioning of LPWAN



Use Case 2: Sensor fusion of In situ soil/microclimate sensors and weather data

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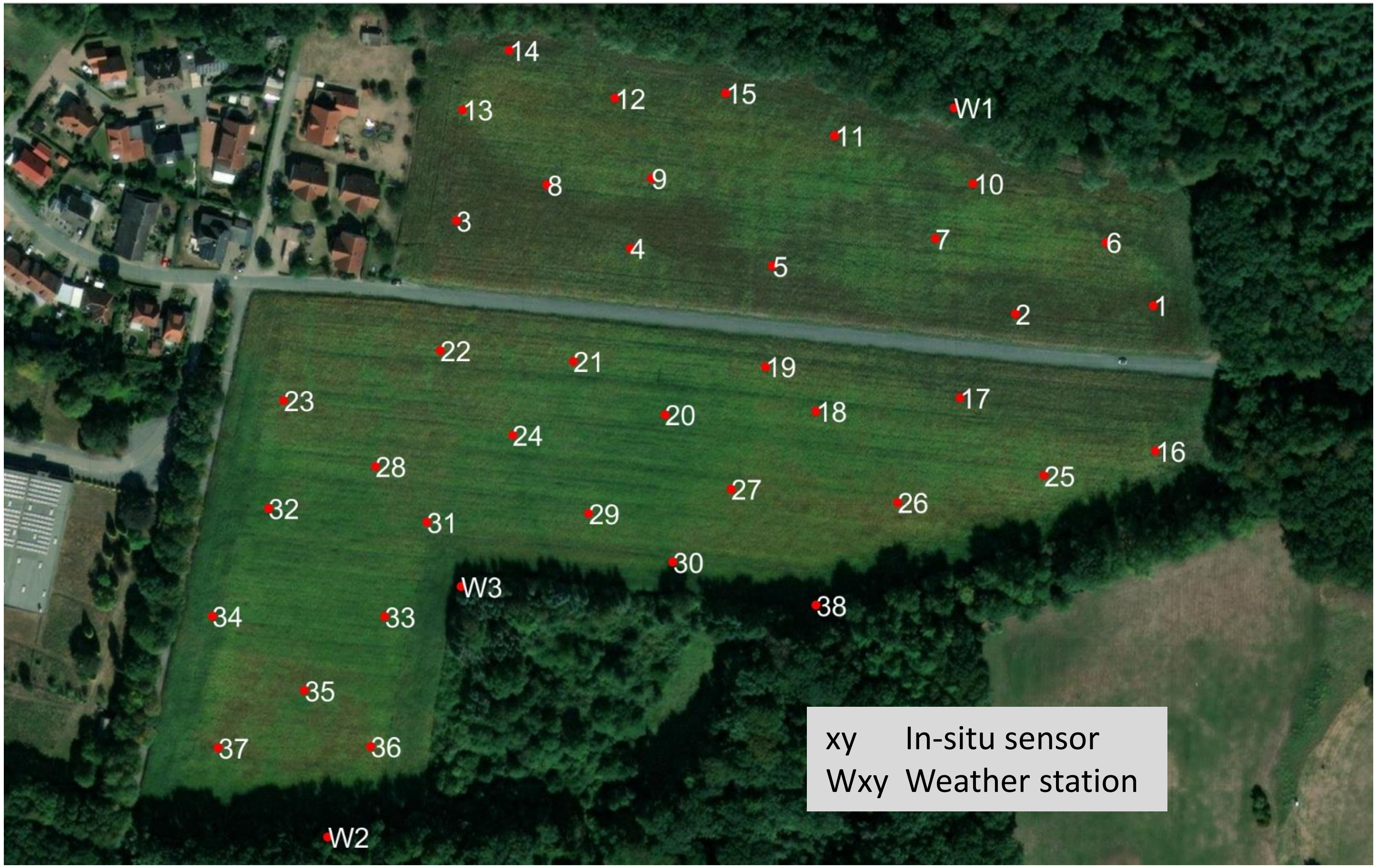
Sensor locations Experiment 1



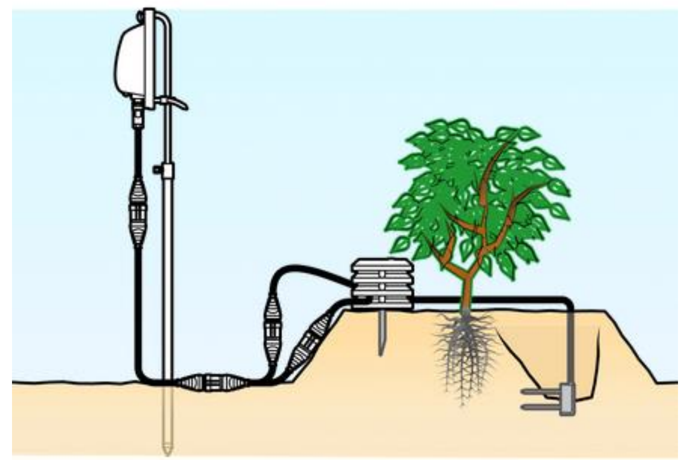
In-Situ sensor data 2021 weekly results

Result period limited to some weeks due to

- Software unready
- Sampling rate inadequate =>
- Overload in TTN Duty Cycles
- Energy consumption too high (for small solar panels)

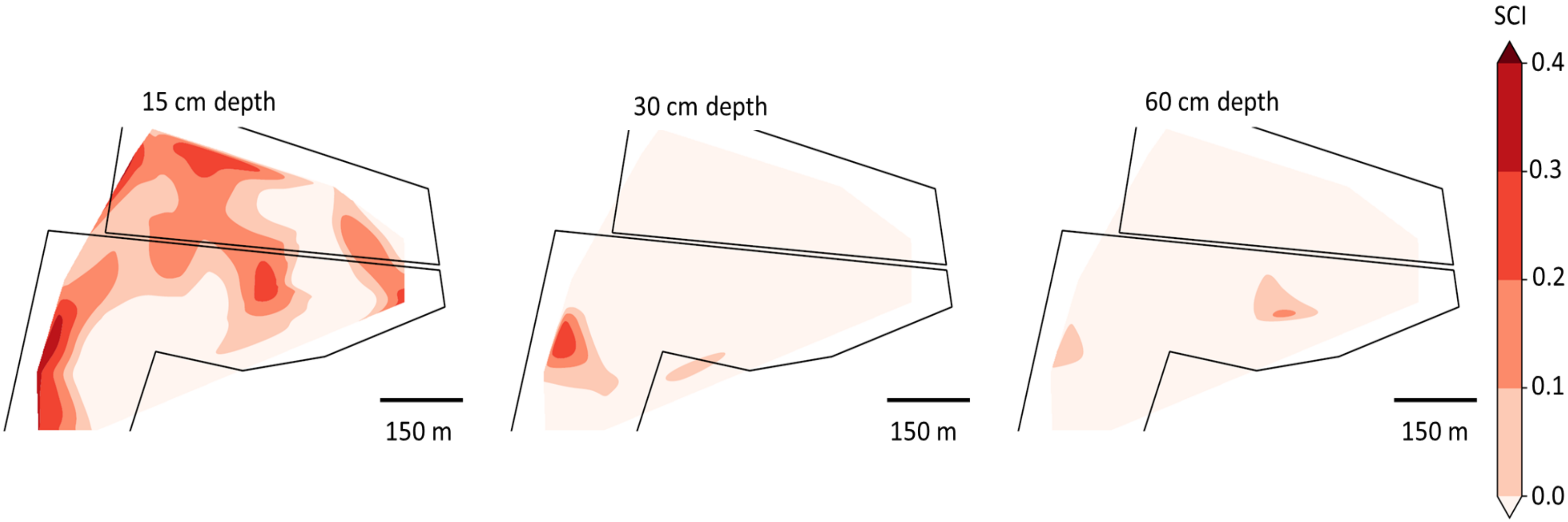
Soil compaction prediction
2022: Additional In-Situ sensors

https://www.deepfield-connect.com/de/produkte/feld-monitoring
Networks: LoRaWAN / NB-IoT / LTE-M / EGPRS
NB-IoT Bands: B1 B3 B8 B5 B20 B28 @H-FDD



https://de.farm21.com/sensors
NB-IoT

Experiment in AGRI-GAIA: Soil compaction prediction



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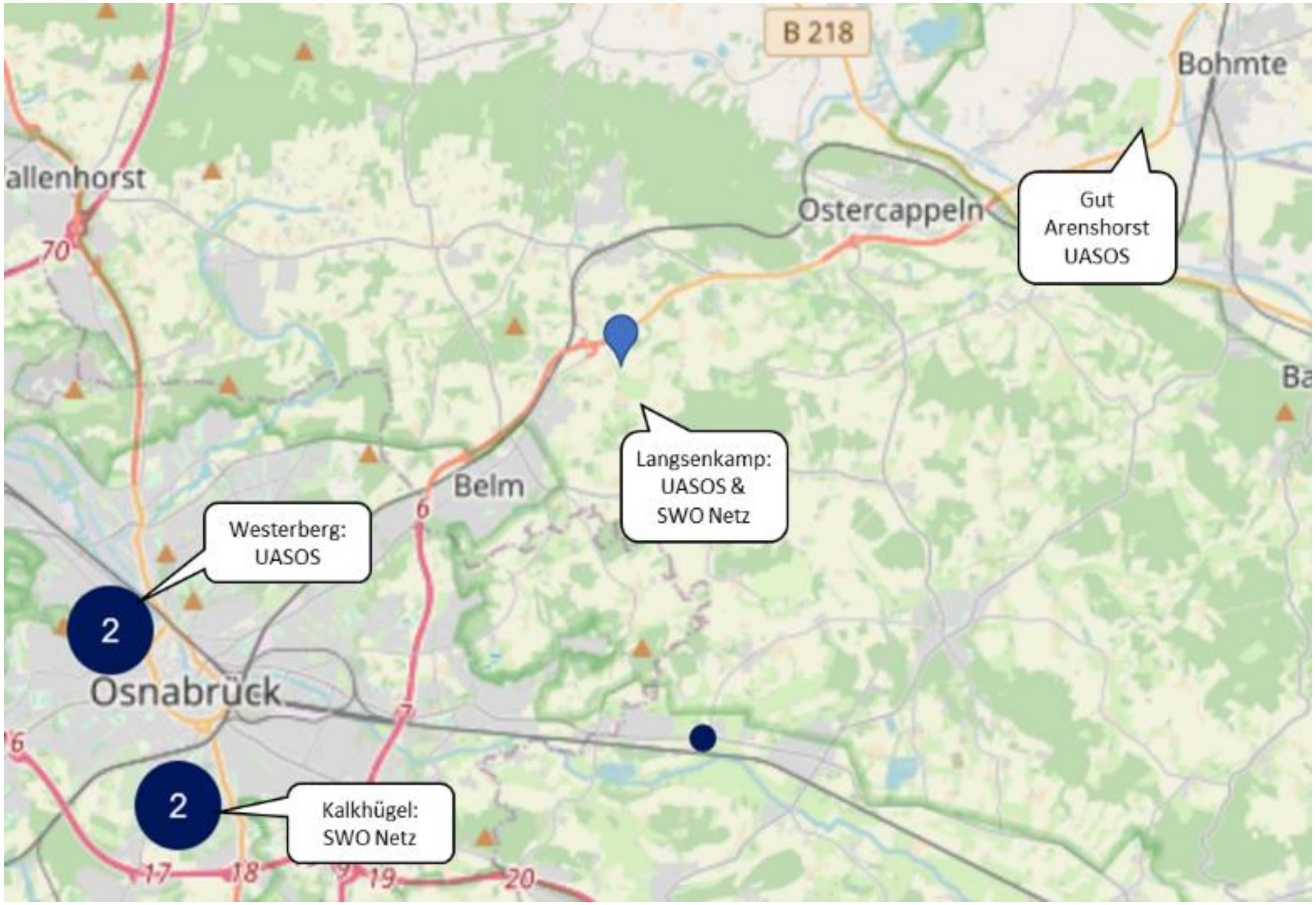
Experiment and gateway locations (TTN)



Things Network (TTN) map https://www.thethingsnetwork.org/community

Outlook / future work

- Extend crop growth and yield estimation
- Provide navigation support during machine operation
- Analysis of hybrid network and application management
- Re use of network and application functions between different networks (non terrestrial, LPWAN, 2G-5G)