SELFSUSTAINED CROSS-BORDER CUSTOMIZED
CYBERPHYSICAL SYSTEM EXPERIMENTS
FOR CAPACITY BUILDING AMONG EUROPEAN STAKEHOLDERS

Economic, environmental and social impacts (part 1)

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Content

- **Introduction to economic, environmental and social impacts of smart farming**
  - Ontology of smart farming technologies and successful innovation processes for their commercialization
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Introduction

- The term 'Smart Farming' covers three main topics: Farm Management Information Systems (FMIS), Precision Agriculture (PA) and Automation and Robotics within the agricultural sector.
- Application of robotics in arable farming is still in its very early stages, but robotics is eventually likely to apply PA principles.
- With decision support systems, PA combines advanced software-based information technology and farm management with physical observations and planning in the field to formulate geographically specific action plans.
- Assessing the economic and environmental benefits from applying SFT requires that the application of information and communication systems provide added value to the agricultural system.

Ontology of smart farming technologies and successful innovation processes for their commercialization

- **Smart farming technologies and their practical value -** Currently available SFTs are not easily adopted by practitioners due to numerous reasons, such as small farm size, low income and possibility of financing. The main impact/benefit that each type of SFT can provide and the main SFT companies providing them are given below.
- **Soil recording and mapping smart farming technologies**
  - Soil apparent electrical conductivity
  - VIS/NIR spectroscopy
  - Gamma-ray spectroscopy
  - Ground-penetrating radar

Smart farming technologies and their practical value

- **Soil apparent electrical conductivity -** Electrical conductivity (ECa) can indirectly provide a measure of clay content, organic matter content, bulk density and pore size distribution. Suitable systems for agriculture include but are not limited to Dualem 21S, Geonics EM38 and Veris MSP3.
- **VIS/NIR spectroscopy** - Most multispectral systems for visible and near-infrared spectroscopy (VIS/NIR) are designed for plant tissue analysis and not for soils. Measurements can be performed in the field on point basis either handheld or by drone, aeroplane or satellite.

Smart farming technologies and their practical value

- **Gamma-ray spectroscopy -** Gamma-ray spectrometry or radiometry is based on the passive measurement of naturally occurring radioactivity in the Earth's surface with a scintillation crystal. Some instruments are now designed as standalone, with less need for a separate laptop and GPS.
- **Ground-penetrating radar** - Ground-penetrating radar is suitable for measuring sharp texture changes in soil profiles. There are many different GPR systems on the market from various providers. All are designed for different applications, one of which is agriculture where presence, thickness and depth of distinct layers are mapped.

Crop recording and mapping smart farming technologies

- **Canopy reflectance (visual, remote and proximal)**
  - Reflectance of incident light by a crop canopy is mainly used for measuring potential amount of biomass, N content and chlorophyll concentration. Reflectance is commonly measured with cameras on board satellites, aeroplanes and drones or non-imaging devices that are handheld or mounted on tractors.
- **Remote sensing of crop biomass using radar**
  - Satellite-based measurement of canopy reflectance in the optical part of the spectrum is easily disturbed by cloud cover. Low frequency microwaves penetrate cloud cover and allow night time measurements. According to Erickson et al. (2017), satellite imagery in the United States has been used by 3% of U.S. farmers in 2003.

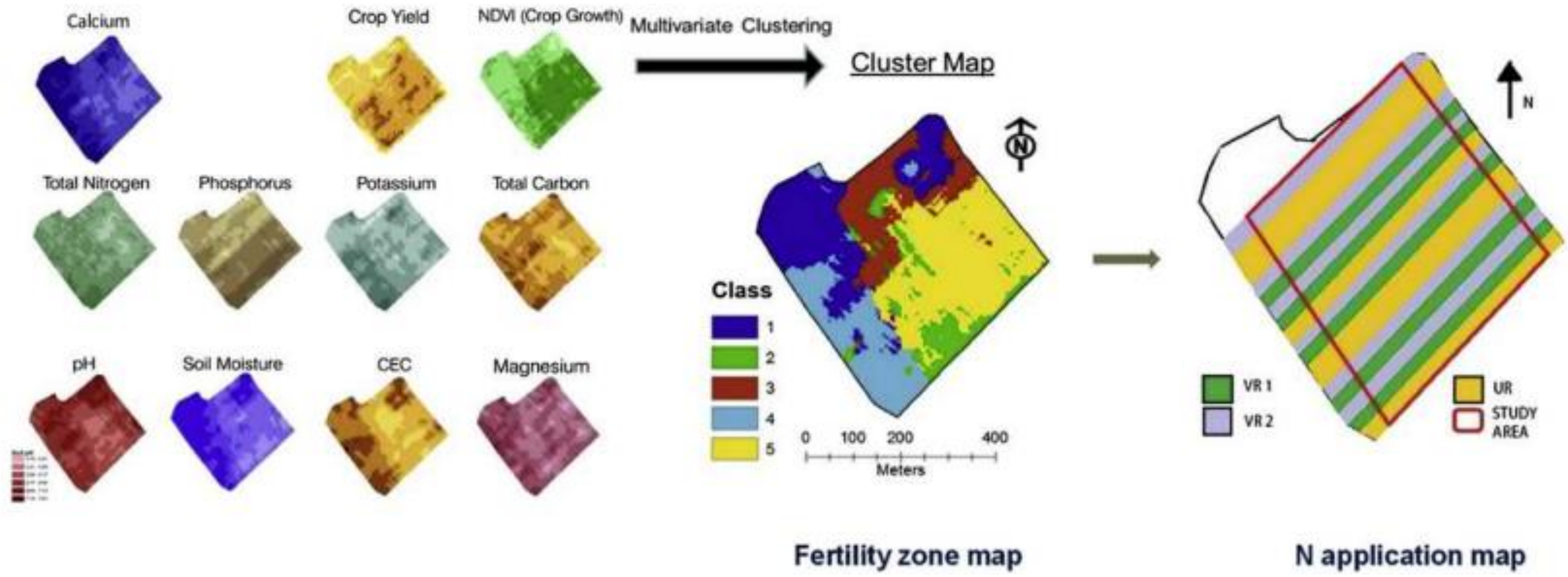
Crop recording and mapping smart farming technologies

- **Actuation (reacting/guiding/robotic) technologies**
  - Variable rate fertilization
  - Variable Rate Lime Application (VRLA)
  - Variable rate pesticide application
  - Variable rate irrigation
  - Autosteer and GPS-based application of seed, chemicals, manure and fertilizer
  - Semiautonomous, nonchemical weed control

Variable rate fertilization

- There are many applications of variable rate fertilization applications around the world. A study has compared two different approaches in a field of 22 ha in Bedfordshire, UK. Different sensors were used to measure total nitrogen, organic carbon, magnesium (Mg), calcium (Ca), potassium (K) and phosphorus (P).
- A cost benefit analysis compared the UR and traditional variable rate (VR1) application with the new approach of VR2 of N fertilization. Results suggest recommending the fusion of data on crop and soil properties with satellite imagery and on-line soil sensors.
- Variable rate N application, using commercial N-Sensor, was tested in Germany, which reported increase in wheat yield by 8% compared with uniform application. A study from Denmark indicates that the estimated theoretical increase in yield from redistribution of N in winter wheat is very small or even close to zero.

Variable rate fertilization



Variable Rate Lime Application (VRLA)

- Variable Rate Lime Application (VRLA) is determined according to the site-specific soil type and 'reaction-number’.
- The application level is often between 1-10 tons per ha depending on the soil variation. A good balanced distribution of lime in PA may increase yield by about 1%e2%.

Variable rate pesticide application

- In recent years, variable rate pesticide application (VRPA) technologies have appeared aiming at differentiating the application rate according to the actual or potential pest stress.
- This should avoid overapplication of plant protection products (PPPs) where it is not needed and reduce overlapping or under coverage.
- Map-based VRPA systems decrease costs mainly due to reduced PPP use but have increased costs due to operations that conventional spraying does not comply.
- More savings are possible from reduced volumes needed per ha, which allow less costs (labour, fuel, machine maintenance).

Variable rate irrigation

- Irrigation has been in use for centuries but water efficiency is not as high as it could be.
- The most frequently used irrigation systems in Europe are self-propelled and micro-irrigation systems.
- Irrigation can provide higher yields and lower pesticide use due to no contact of irrigation water with the crop canopy.
- Most orchards planted within the past 15 years use micro-irrigation for both water and nutrient delivery.
- However, these systems have higher investment costs and are mainly useful for high-value crops. VRI could provide a significant positive impact on would be soil N2O emission.

Autosteer and GPS-based application of seed, chemicals, manure and fertilizer

- Autosteer reduces worker fatigue and avoids overlapping trajectories in the field.
- Less overlap means that less driving is needed and fuel is saved. When automatic route planning is used, 8% energy saving was reported.
- Automatic guidance is also an enabling technology for controlled traffic farming (CTF).

Semiautonomous, nonchemical weed control

- Only a few (semi)autonomous robotic weed control systems have been commercialized.
- They are typically unable to operate on fields containing bed-planted or full-cover crops.
- Current systems are not completely autonomous, as it has been pointed out in a critical review.
- In the Netherlands, new weed control systems are **needed**, for example, in onions.
- Weed control between the rows can be done quite effectively by using harrows and finger and torsion weeders.
- Some organic dairy farmers report that if another solution cannot be found, they will switch back to conventional farming.

Session Q&A