ATB
Leibniz-Institut für
Agrartechnik und Bioökonomie

# How can digital transformation foster sustainability in primary production of biomass?

Digital Transformation of the Agricultural Value Chain – Opportunities, Challenges and the Role of Science

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Leibniz
Association

# Sustainability in Agriculture

- "The Global Environmental Facility (GEF) and Food and Agriculture Organisation of the UN (FAO) … working together to minimize the impact of the agricultural sectors on the environment" …"**embed sustainability in [agriculture] … focus not just on maximising yield, but also on safeguarding and making more efficient use of natural resources**."
- **Zero hunger** and **end to poverty**, require lasting climate solutions and developments for future generations … to "**transform the way we grow food and protect our environment**" … use the potential of "**innovation, technology and youth"** … to make agricultural systems … "**resilient to the impacts of climate change"**
- To leave no one behind means "**capacity building**" … "**access to up-to-date information on sustainable agriculture**" … "agricultural knowledge and entrepreneurial skills, … climate smart practices, … training, funding, practical tools, success stories"

(M.R. Hasan, Rural Youth: Protecting the climate through innovation, http://www.fao.org/fao-stories/article/en/c/1226659/ accessed 21/09/2019)

# Sustainability in Agriculture - How to ?

- Do you know Hararis “Sapiens – A brief history of humankind” ?
  - **- than you know that**
- The agricultural revolution started roughly 12.000 years ago
- Core of the agricultural revolution was that many more people could be fed from a reduced area of land (compared to the hunter-gatherer lifestyle)
  - **- but everything comes at a price:**
- The cultivation lead to a reduction of the menu – to a few main fruits & animals:
  - **Wheat, rice, corn, potatoes, millet, barley**
  - **Goat, horse, pig,** (cow, chicken)
- **“We still feed today like the first farmers.” Harari concludes**
  - **We still apply the same basic principles today – just much more effectively**

- **12.000 years later it is due time for a change!**

# Sustainability in Agriculture
# - How to ?

- The underlining effect of the agricultural revolution was:
- **Increase** of **efficiency** by **reducing diversity => Standardisation**
  - **Efficiency** has become our major economic principle
  - **Economy of scales** = producing more of the same comes at a lower cost
- The downside of **reduced diversity => lack of resilience**
  - This is the reason for a lot of hunger periods over the course of time

    ➔

  - A second agricultural revolution has to turn basic principles upside down:
- **Diversification** instead of **Standardisation**
  - We need to find ways to
- **Manage DIVERSITY with same EFFICIENCY as STANDARDISED systems**
- **To increase Resilience AND Sustainability AND Productivity**

# Management of Diversity with Digital Tools
# Industrial Automation ➔ Industry 4.0

- 4th Industrial Revolution

- 1.0 | 1884 | Mechanisation |


- 2.0 | 1870 | Rationalisation |


- 3.0 | 1969 | Automation |


- **4.0 | Today | Informatisation** |



Digitalisation

Cyber-Physical-Systems

Complexity increases

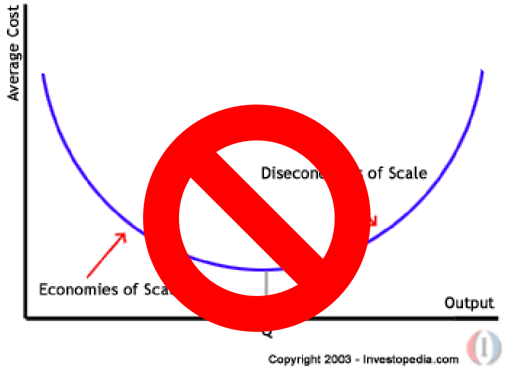
http://www.hps-pigging.com/the-impact-of-industry-4-0/

# What is Industry 4.0 about ?

- **Adaptability** and flexibility for volatile market demands
- **Individualisation**, customisation at mass production conditions
- Invalidates ‘economy of scales’

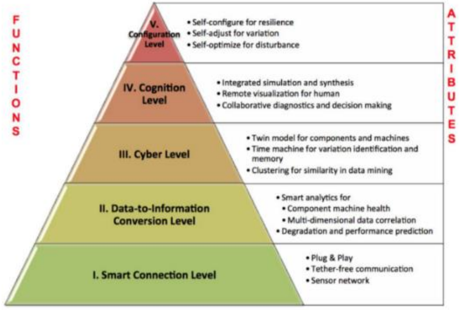
➔ **Economic revolution !**

**Diversification instead of Standardisation**




- **Availability** of digital knowledge anywhere and anytime
- Autnomous, **self-configuring** Cyber-Physical-Systems
- Automated knowledge gain, **cognitive analytics**, artificial intelligence
- **Scenario simulation**, Virtual Reality, digital twins

➔ **Technological revolution !**




Kao et al (2015)

# Digitalization for Environment Controlled Agriculture

## Industry 4.0

- High level of complexity
- Connected information flow **customer to production**
- Enable individualised & **customised production** control
  at mass production conditions
- Impact on: process, material, cost, time, risk

➔ **Flexible management of production process to cope with diversified output requirements in a controlled environment**

## Sustainable Agriculture

- Higher level of complexity
- Connected information flow
  **site specific information**
- Enable individual & specific system control to **adapt cultivation measures to natural heterogeneities**
- **Enable massive production while considering site specific and environmental requirements**

➔ **Manage diversification by adapting production process to natural heterogeneity of environment**

# Digitalization for Environment Controlled Agriculture

## Industry 4.0

**environment**

➔ **Controlled Environment Agriculture**

http://www.algaeindustrymagazine.com/algae-101-part-37/

## Sustainable Agriculture


em
**easures**
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➔ **Environment Controlled Agriculture**

www.cema-agri.org

# Environment Controlled Agriculture – Digital Toolsets

## Agricultural production systems – environment driven processes


Knowledge Base
On-Farm Trials

## Knowledge Gain & Knowledge Management


Data Science, Data Fusion, Knowledge Generation
Decission based on Mass Data (Big Data)
Sharing of Experience Man ⇔Machine

Smart Sensors

**Capacity Building, access to Knowledge & Database**

## Automation of work processes and data acquisition

Smart Sensor Technology, Smart Products, Machine Control Systems, Automation Systems

Knowledge & Data Transfer
Meta Data

## Availability of Information Connectivity for IoT, CPS


Image: http://www.claas-e-systems.com/de/herausforderungen/precision-agriculture/

Digital Data Exchange, Compatibility, Infrastructure, Smart Data, Data Ethics, Data Ownership, Legal Frameworks

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# Challenges of Environment Controlled Agriculture

**Change of paradigm requires management of diversity**

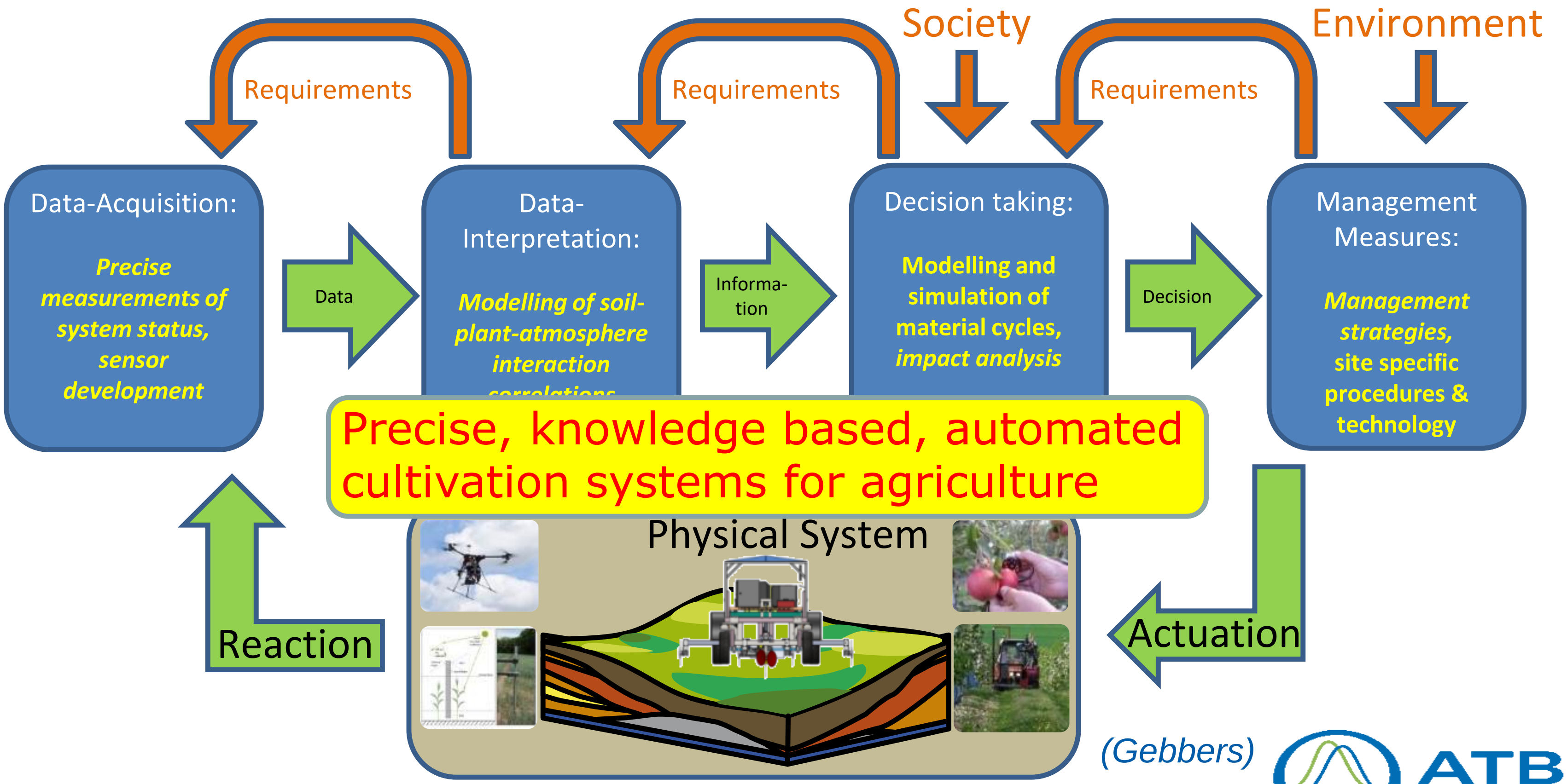
- ➔ Extreme **variability** in **time** and **space**
- ➔ Control systems for **highest complexity**
- ➔ **Environmental parameters** independent of production goals
- ➔ Very **long response times**

Soil

Arable farming

Horticulture

# How to? Closing the Loop on Precision Agriculture



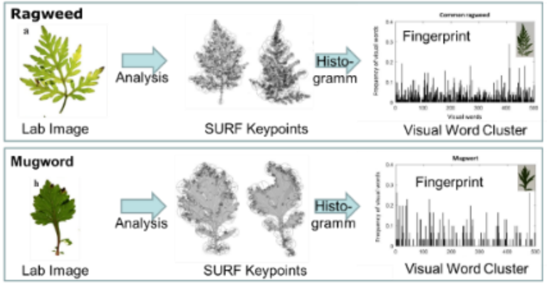
# ATB: Digitized, Knowledge Based, Precision Agriculture

***Intelligent Produce***

*– In situ sensors, Apps, ICT*

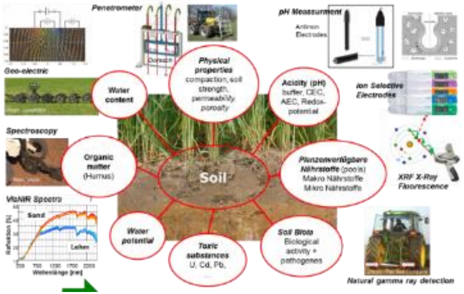
***Smart Plant Protection***

*– Machine learning, sensors*




***Talking Soils***

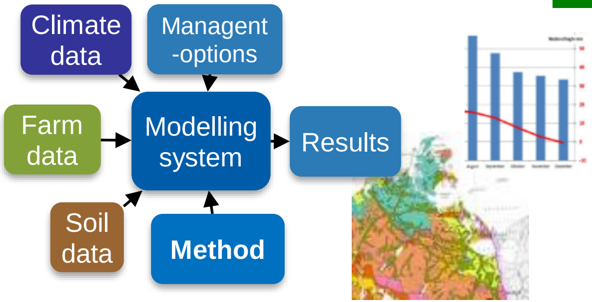
*– Mobile sensors, data fusion*




Precision crop production

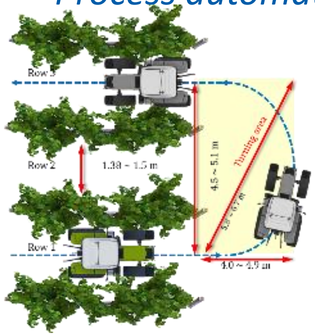
***Production System Assessment***

*- Modelling GHG, water productivity*




***Smart Real Time Applications***

*- Process automation, robotics*




# Challenge:
# Connected Environment

## Environmental-Monitoring

1 Rainfall radar
2 Remote sensing satellite
3 Measurement airplane
4 UAV
5 3D-Lidar
6 Soil sensor network
7 Radiometer
8 Deposition collector
9 Atmospheric profiler
10 Eddy-Covariant-System
11 Groundwater measurement
12 River level
13 Automat. Sample collector
14 Optical sensors
15 Position sensor
16 TDR-probes
17 Tensiometer
18 LAI Sensor
19 Gas exchange sensor


DFG (2014)

# Challenge: Automated Measurement of Indicators for Sustainability in Agriculture

Contribution to „Sustainable Development Goals“


- Provisioning various ecosystem services (Naturkapital Deutschland – TEEB DE 2016)
- Habitat of segetal plants, birds and insects (Binder et al. 2010, Fritsche et al. 2015, BfN 201
- Resource efficiency (Zapf & Schultheiß 2013, Zisc al. 2017)

- *Indicators mostly very simple*
- *not dynamic*
- *not linked to site specific condition*
- *no automated detection systems*

**Evaluation methods**

SAFA (Sustainability Assessment of Food and Agricultural Systems, FAO 2014)

RISE (Response-Inducing Sustainability Evaluation, Grenz et al. 2014)

KSNL (Criteria system for sustainable farming, KTBL 2009)

(Bellingrath-Kimura, DAKIS, https://www.agrarsysteme-der-zukunft.de/en/consortia/dakis)

# Take home Messages

- Sustainability requires resilient production systems
  - Crop rotations, intercropping, preventive measures to improve plant and soil health
- Resilience is increased by diversity of production systems
  - Precision Agriculture, Patch cropping, Spot Farming, Intercropping, …
- Sustainability requires economic drivers (in a capitalistic society)
  - Define values of ecosystem services => Productivity and profitability are key drivers
- Environmental goals for agricultural production increase complexity
  - Only systemic approaches can solve the multi-dimensional ambiguitites
- **A second *agricultural* revolution is required**
  - **Diversification NOT Standardisation as the main production principle**

# Take home Messages

- **Digitalization and Automation are not the solution! But they provide very powerful tools to address very complex problem statements.**
  - Deep Domain knowledge is required to apply data sciences to foster innovation!
    **Deep learning analysis of status quo data will cement the status quo!**
  - Digital agriculture innovations will have to be judged according to the ability to help protect the environment and the climate while producing enough yield to feed the world.
- Access to up-to-date information on sustainable agriculture
  - Capacity building - across the world - is crucial to reach sustainability goals.
  - Provide access to scientific knowledge and data driven information to all –large and especially the small- agricultural players worldwide.
- We have to do it: get started to increase sustainability!
  - Every farm can apply individual steps in practical agriculture today

# Thank you very much for your attention


(Karré 2018)

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