APEC Climate Symposium
Can Tho, Viet Nam,
August 18-20, 2017

Intelligent Agricultural Production System based on Climate, Crop, and Field Information

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OUTLINE

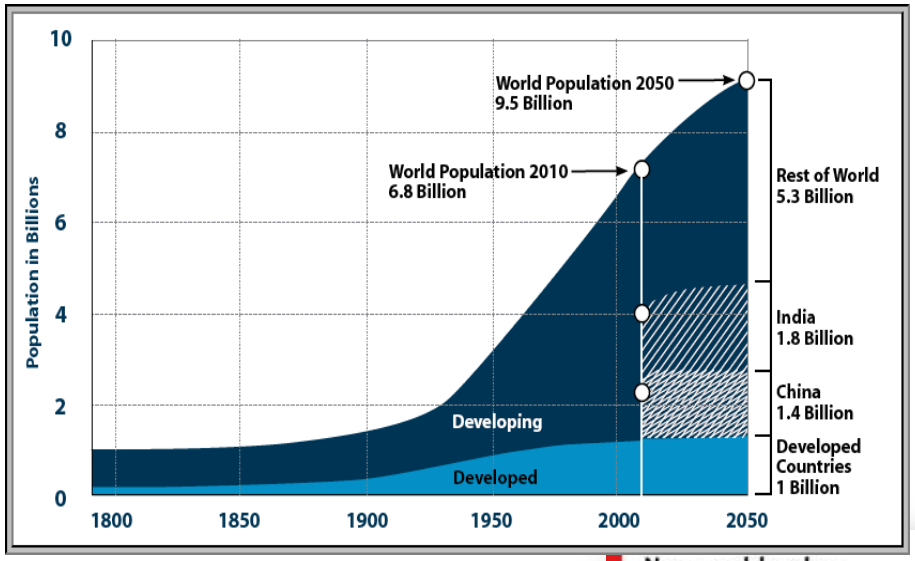
1. Issues in Agriculture
2. Intelligent Agricultural Production System
3. Strategies

01

Issues in Agriculture

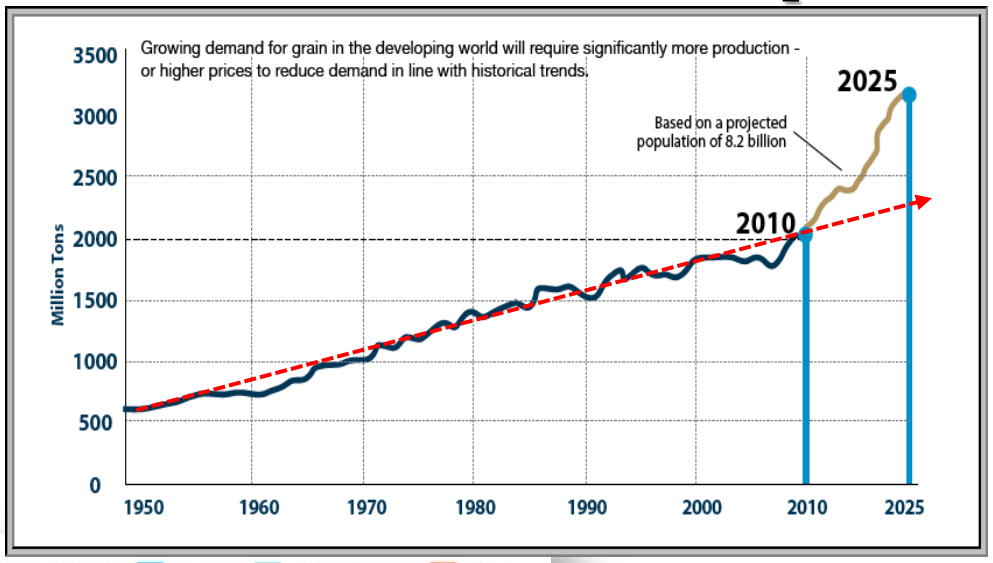
World Population Growth

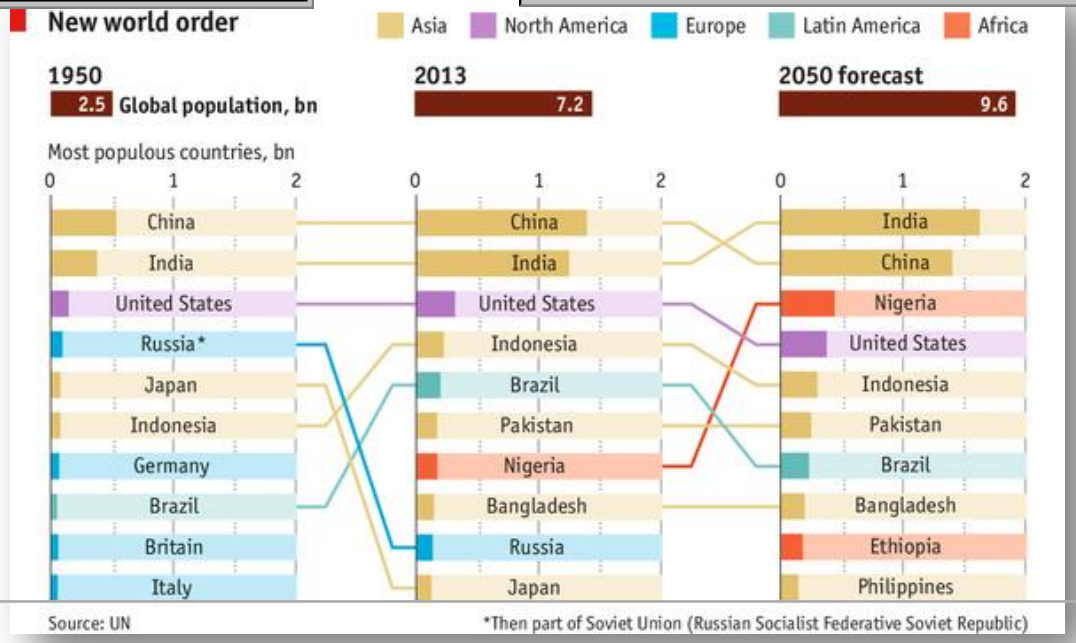
❖ World population growth



(source: writings.basiliochen.com)

❖ Increased demand for food production





(source: www.economist.com)

Food Safety

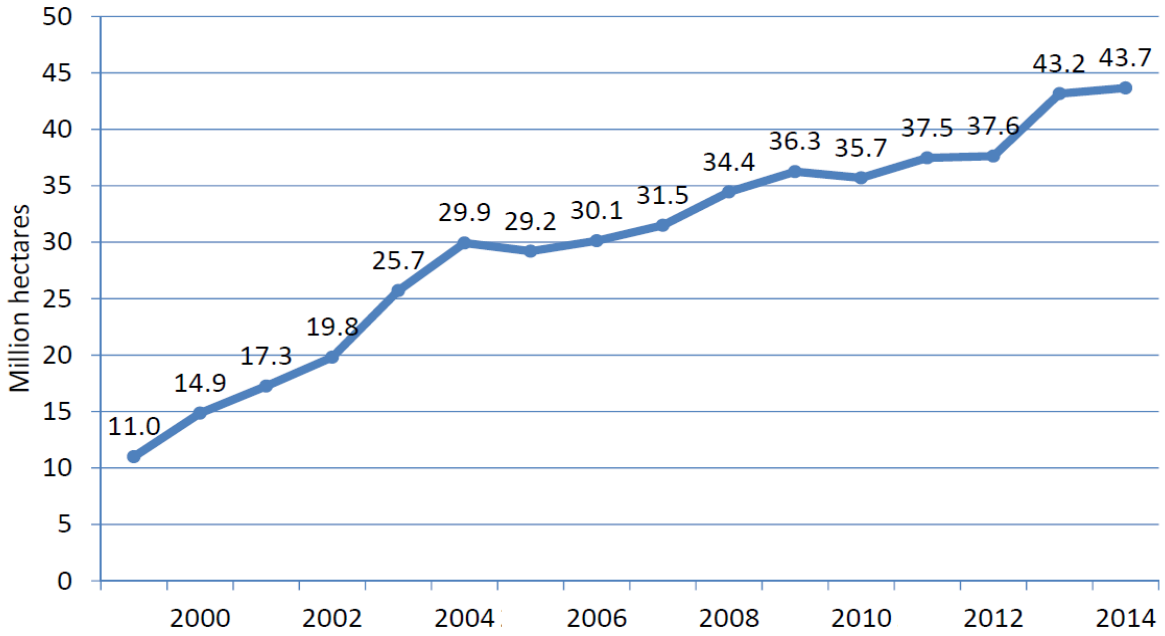
❖ Pesticide residue in foods

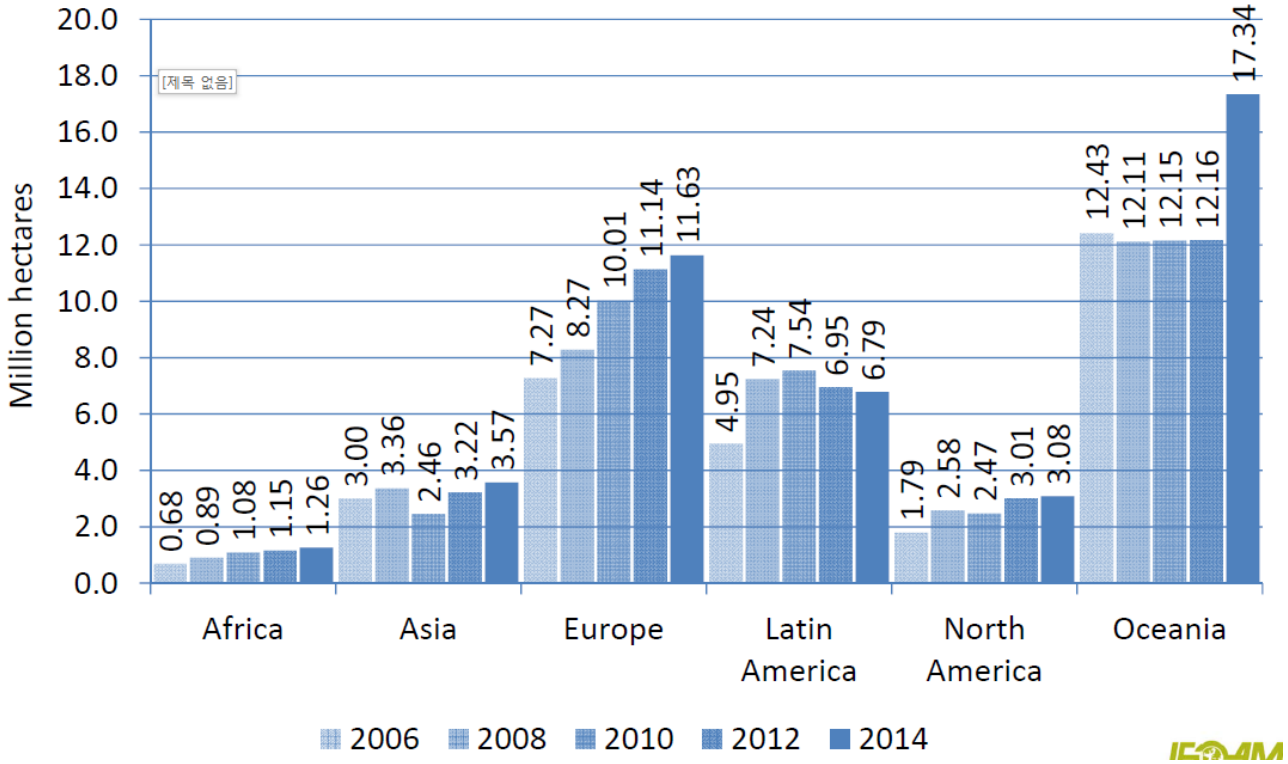
(source: www.dailymail.co.uk)

(source: www.grimsbytelegraph.co.uk)

Demand for Organic Food

❖ Organic agricultural land

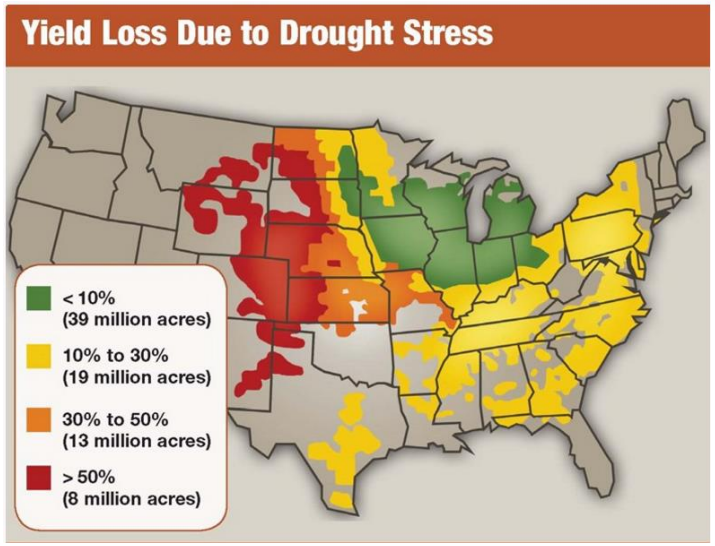


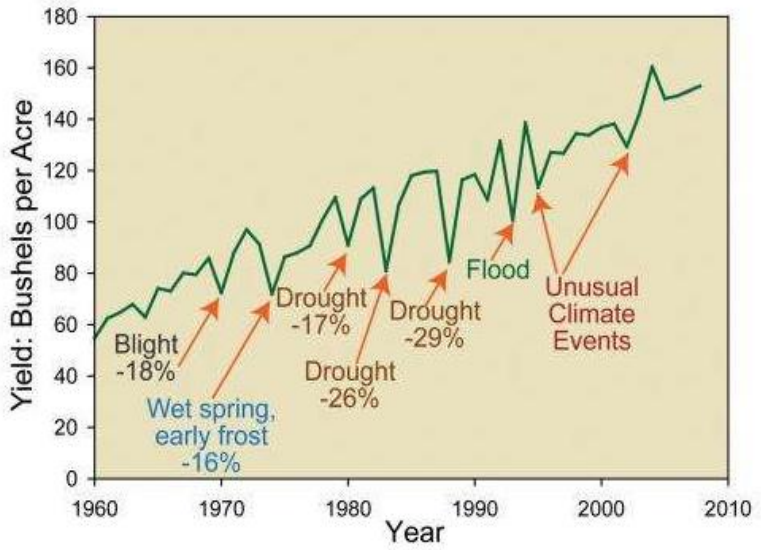


(source: FiBL-IFOAM-SOEL-Survey 1999-2016, www.fibl.org)

Climate Change

❖ Yield loss due to climate change





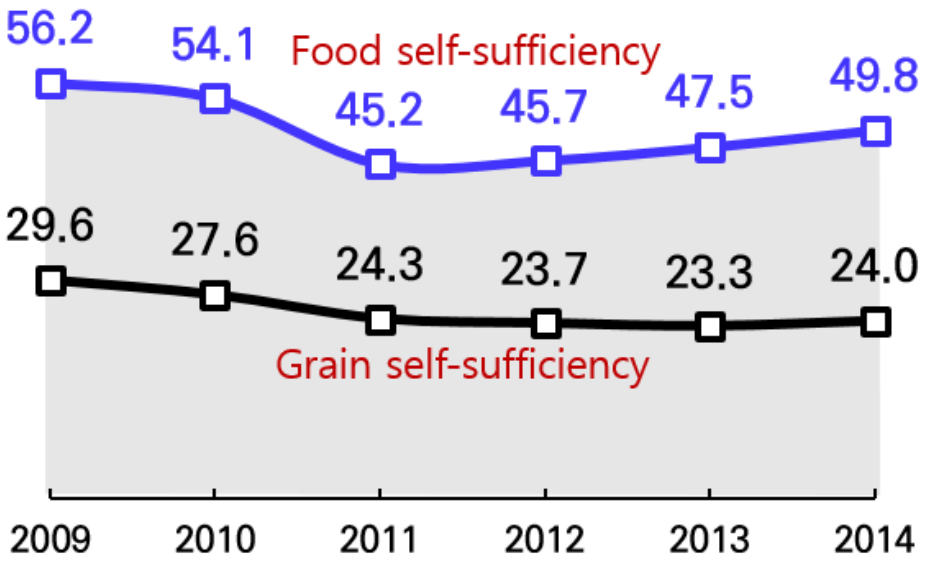
Food Security

❖ 2016 Global food security index

1	United States	86.6
2	Ireland	84.3
3	Singapore	83.9
=4	Australia	82.6
=4	Netherlands	82.6
=6	France	82.5
=6	Germany	82.5
=8	Canada	81.9
=8	United Kingdom	81.9
10	Sweden	81.3
11	New Zealand	81.1
12	Norway	81.0
13	Switzerland	80.9
=14	Denmark	80.0
=14	Portugal	80.0
16	Austria	79.3
=17	Finland	78.9
=17	Israel	78.9
19	Spain	77.7
20	Qatar	77.5
21	Belgium	77.4
=22	Italy	75.9
=22	Japan	75.9
24	Chile	74.4
25	Czech Republic	73.9
26	Oman	73.6
27	Kuwait	73.5
28	South Korea	73.3
29	Poland	72.4
30	United Arab Emirates	71.8
31	Greece	71.5
32	Saudi Arabia	71.1
33	Bahrain	70.1
34	Hungary	69.3
35	Malaysia	69.0
36	Uruguay	68.4
=37	Argentina	68.3
=37	Costa Rica	68.3

(source: A report from the EIU)

❖ Food self-sufficiency in Korea



* Food self-sufficiency: except feed for livestock
* Grain self-sufficiency: including feed for livestock

Challenges in Agriculture

- ❖ Need of increasing food production (quantity)
- ❖ Increased demand for safe food or environment-friendly agriculture (quality)
- ❖ Demand for business model for highly economic return in agriculture
- ❖ Required high global competitiveness in agriculture
- ❖ Improvement of life quality of persons working in agriculture

Innovation of agricultural production system using digital transformation technology

*Digital transformation (4th industrial revolution): highly connected and highly intelligent society based on technology of ICT/IoT, robot/UAV, artificial intelligence, big data, 3D printer etc.

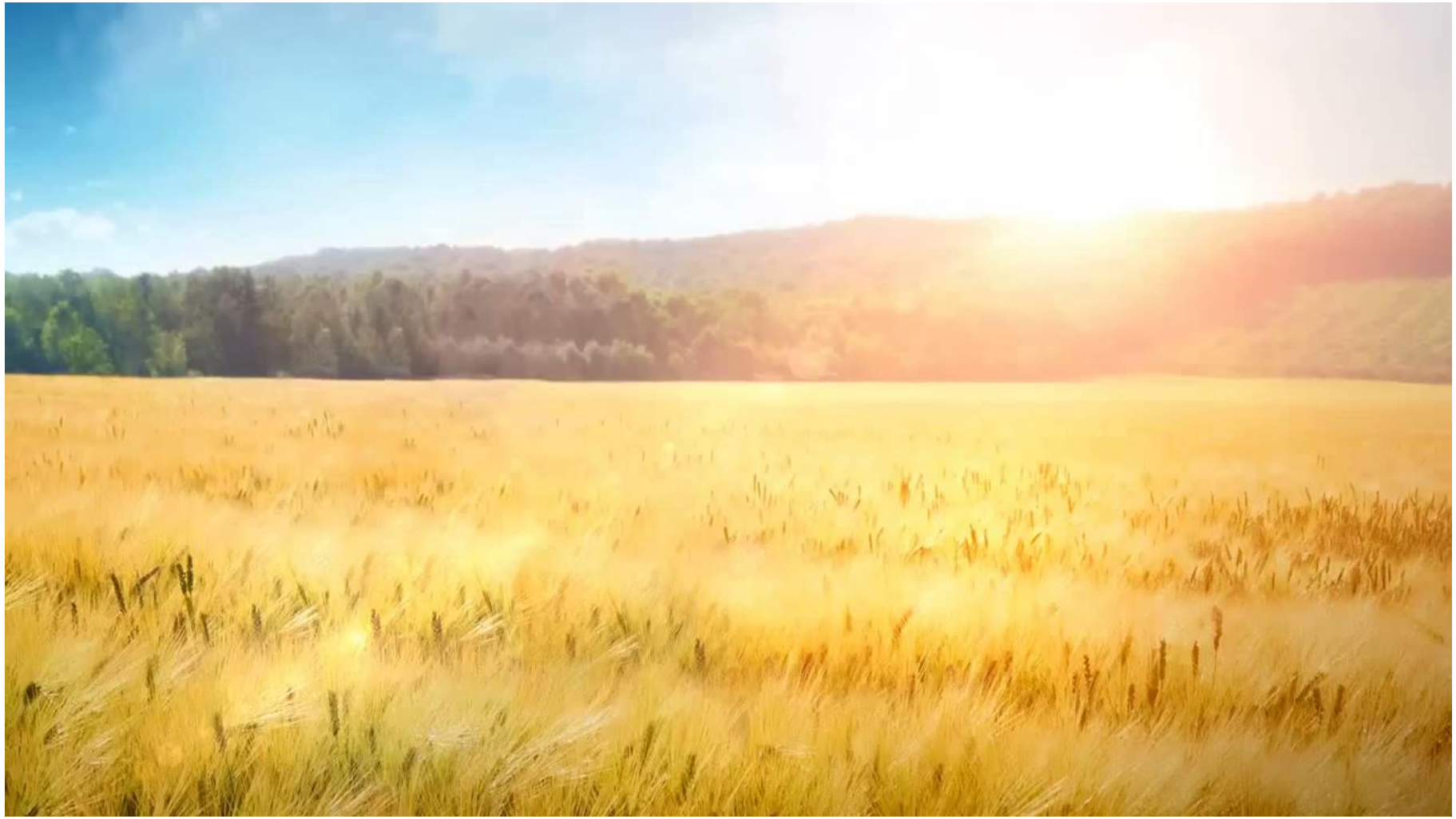
02

Intelligent Agricultural Production System

Intelligent Agricultural Production System

(source: Farm Forward by John Ddere, www.youtube.com)

Intelligent Agricultural Production System



(source: Trimble Connected Farm, www.youtube.com)

Intelligent Agricultural Production System

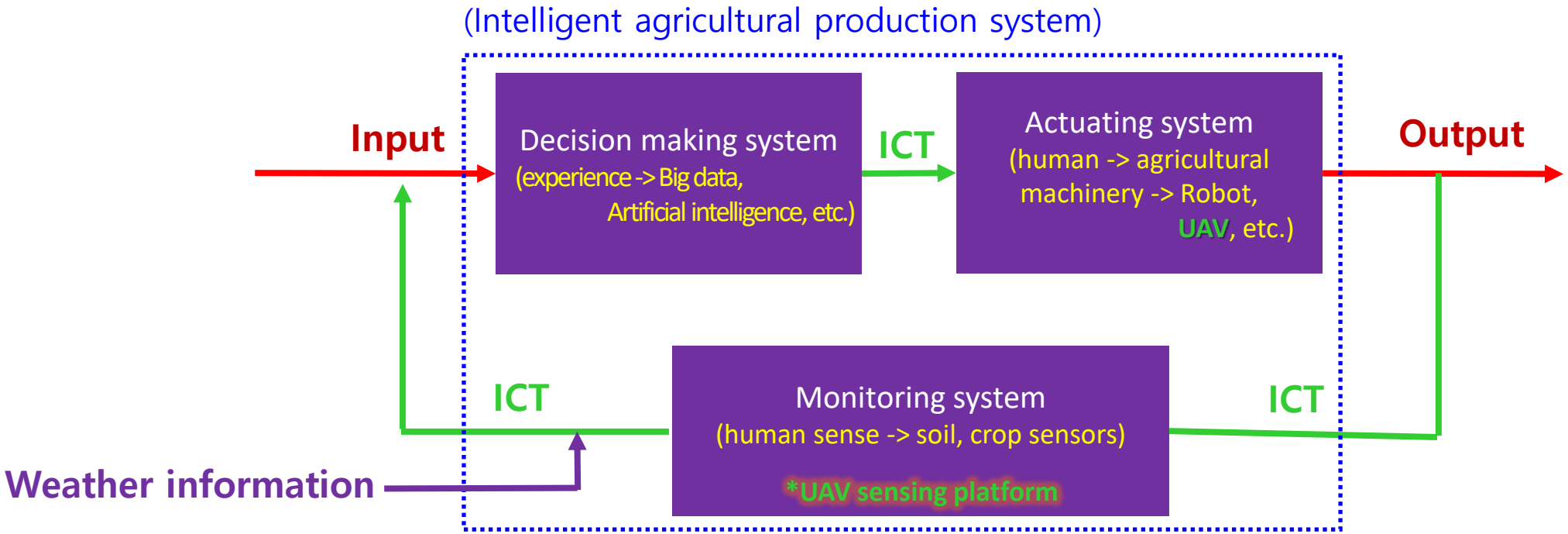
"An intelligent agricultural production system can maximize the efficiency of the system by unsupervised learning with minimum interception of human"

➢ **Input**

:labor, chemicals(fertilizer, pesticide, etc.) water(irrigation), energy, environmental control, etc.

➢ **Output**

:Quantity and quality of agricultural product



Precision Agriculture

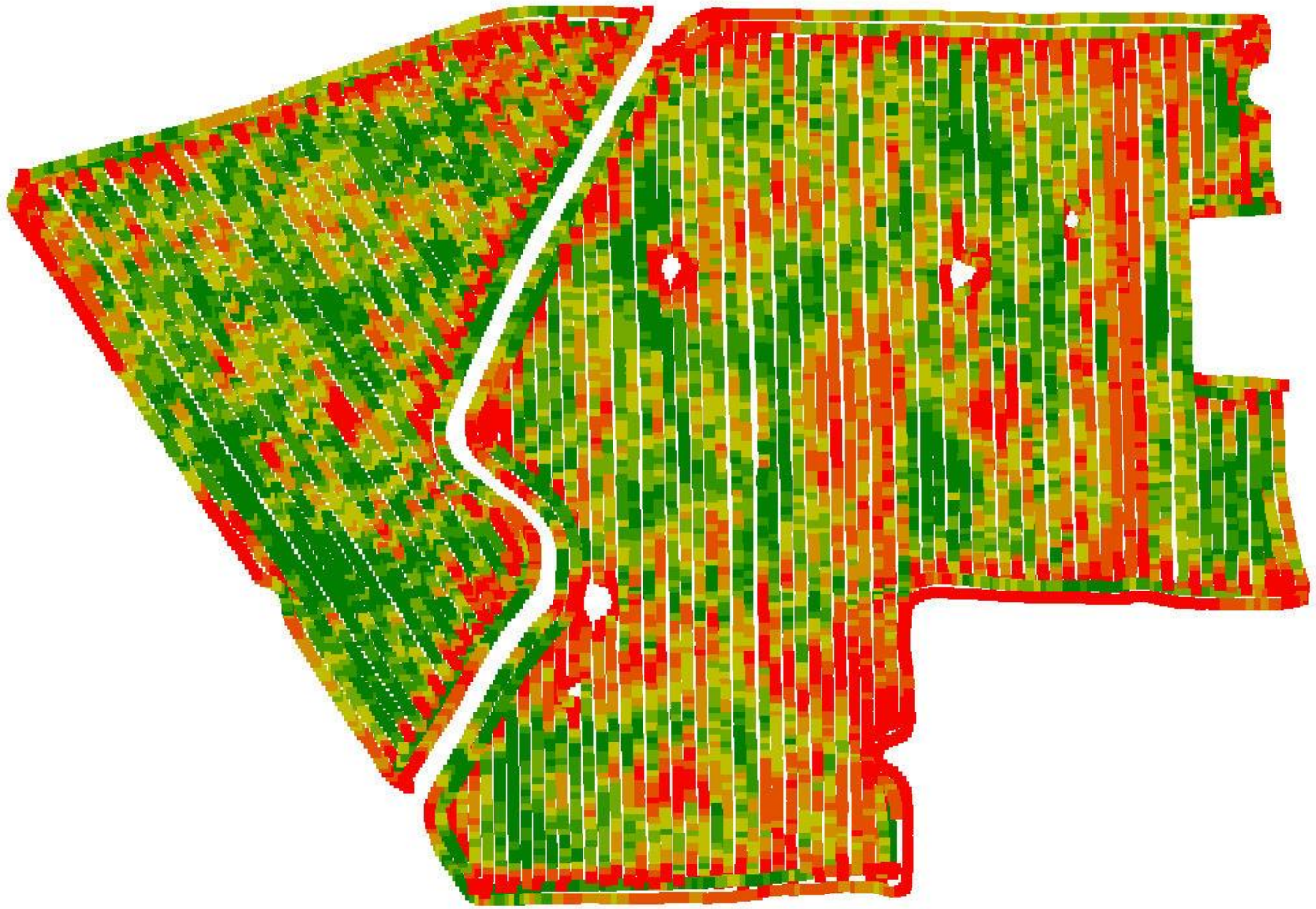
"Site-specific variable technology based on farm field and crop conditions"

Optimum input:

Right time,

Right amount,

Right place



Monitoring System

Satellite

Large covered area (FOV)
Low sensitivity

UAV

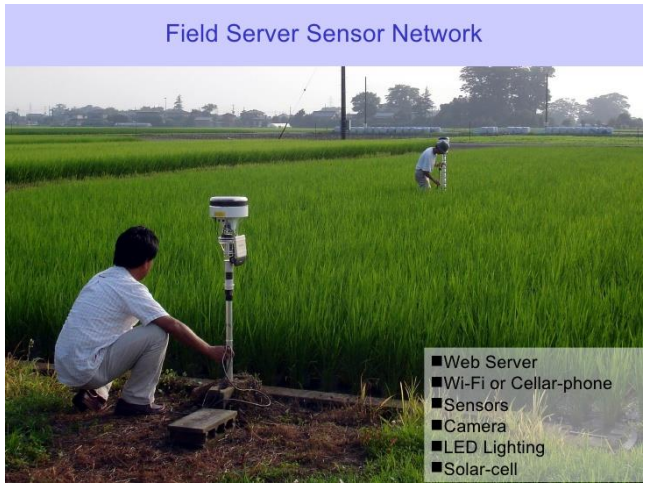
Mobile robot

Small covered area (FOV)
High sensitivity

Biosensor

Monitoring System

❖ Sensor platforms



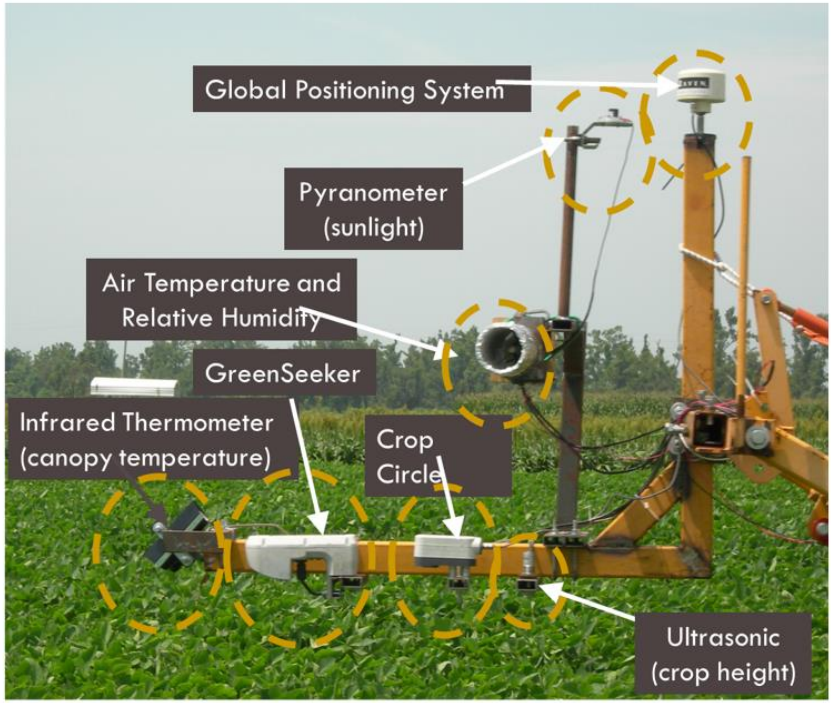
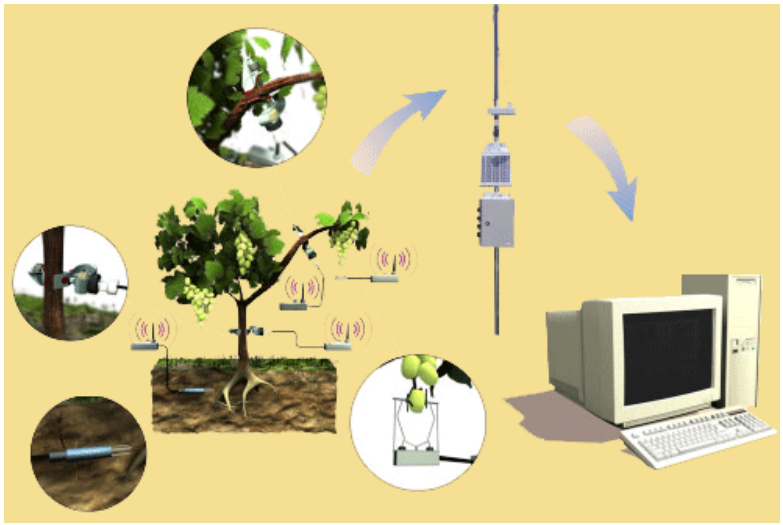


Photo courtesy of Earl Vories, USDA-ARS, Portageville, MO

Monitoring System

❖ Sensors



SICK LMS-291

Mini MCA Tetracam

Sony DSC-V1

Micro-Hyperspec VNIR

Tetracam-ADC

FLIR Thermovision A40M

Monitoring System

❖ Genomics and Phenomics

▶ Genomics

- High throughput analysis of genes and their immediate products, to study the structure and function of genes and genomes

▶ Phenomics

- High throughput analysis of plant growth and physiology, to reveal the role of each gene in the function of the whole plant

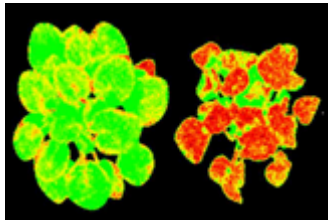
Innovation, Gene discovery

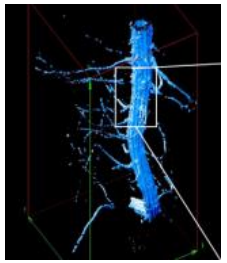
Monitoring System

❖ Phenomics

Phenomics uses imaging techniques to allow researchers to study the inner workings of leaves, roots or whole plants

- Visible imaging – color, morphology
- Infrared & Near–infrared imaging
- Fluorescence imaging
- Magnetic resonance imaging





Monitoring System

❖ Visible imaging

1. Plant color classification
   - Plant health
   - Stress
   - Nutrients
   - Senescence

2. Plant morphology
   - Stem, leaves
   - nodes, length of leaves

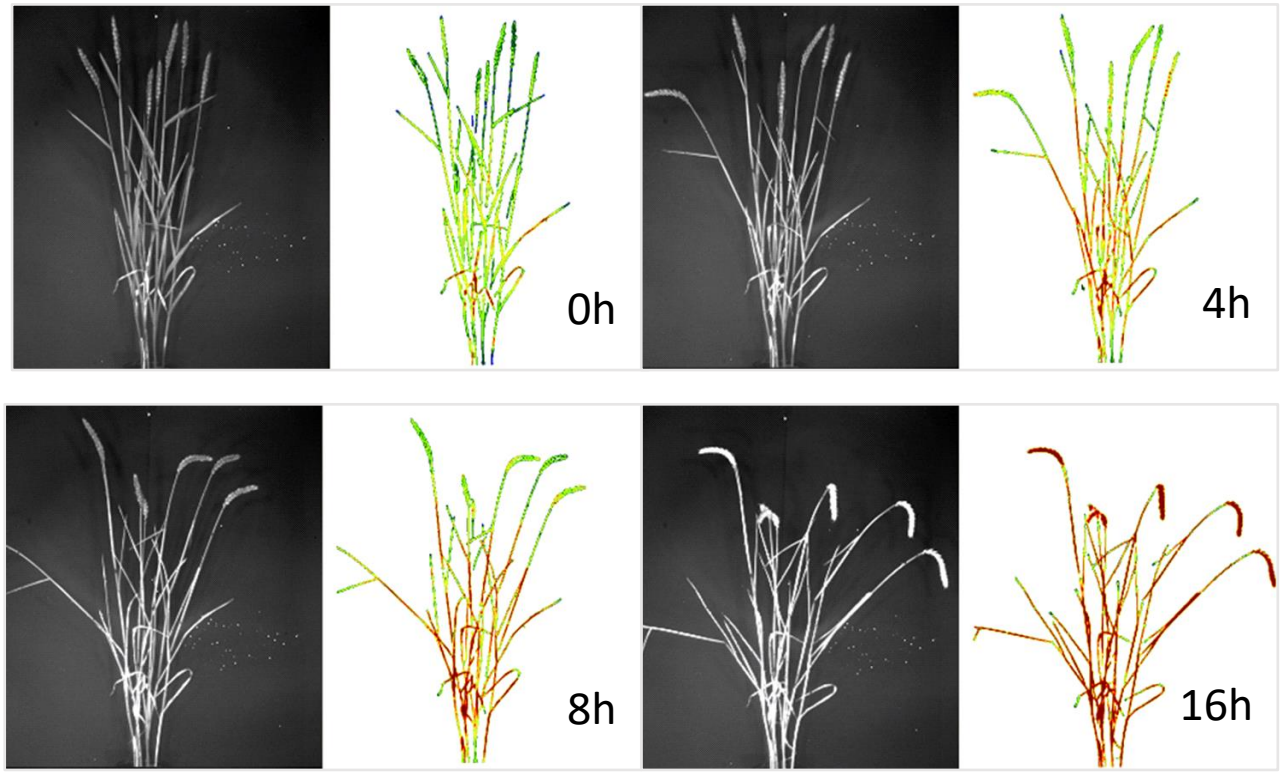
→ Plant growth

Monitoring System

❖ Near infrared (NIR) imaging

Measuring water distribution and dynamics

wheat dried down at elevated temperature

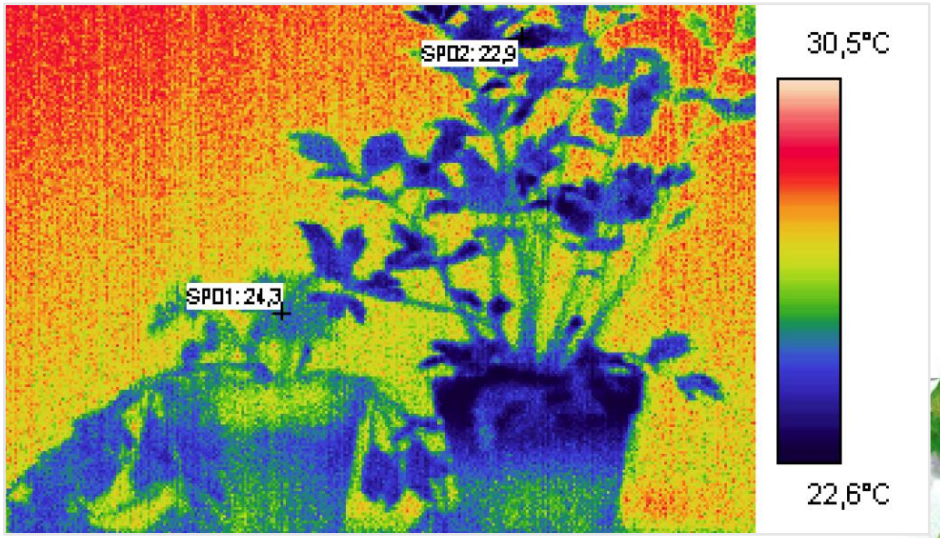


Monitoring System

❖ Infrared (IR) imaging

Quantify temperature differences

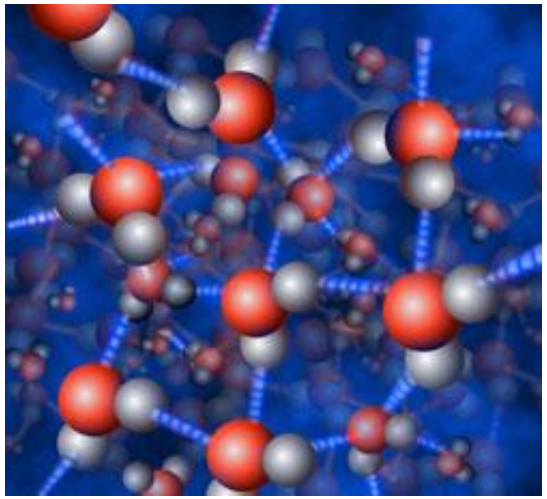
(e. g. within leaves and between plants)



Monitoring System

"Diagnosis of crop stress, disease, nutrient deficiency in an early stage"

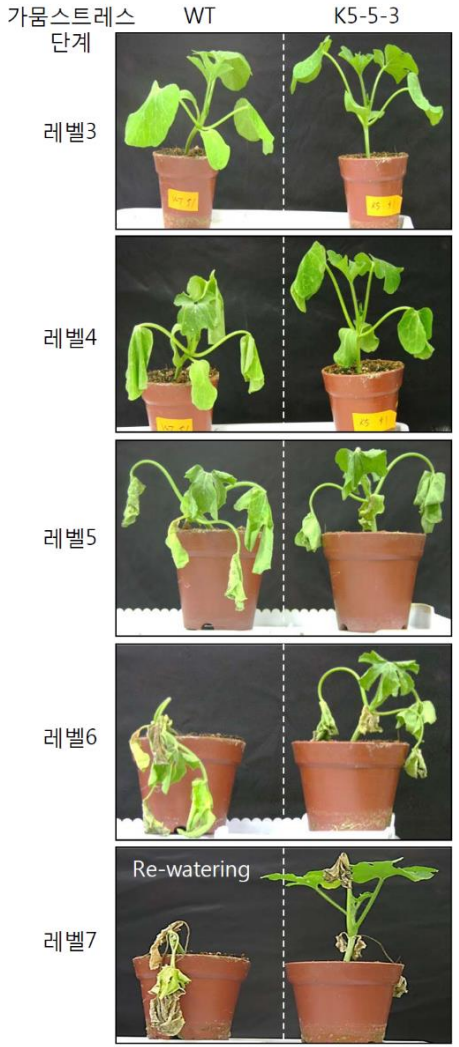
Molecular level
-Micro/nano biosensing technology
-High sensitivity and small FOV
-Possible to diagnose in an early stage
-Direct sensing for crop monitoring

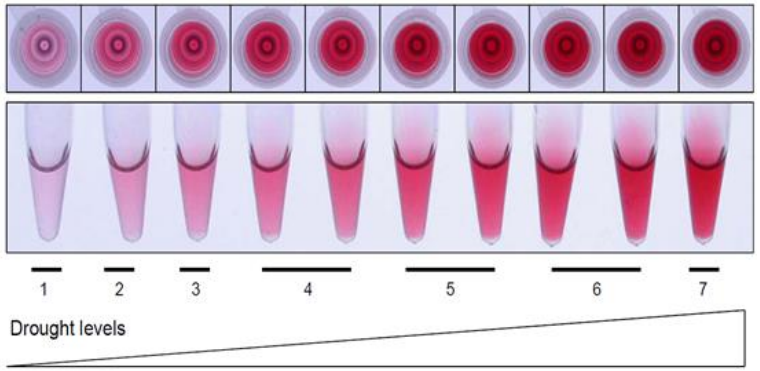


Canopy level
-Spectroscopic, imaging technology
-Low sensitivity and large FOV,
-Not easy to diagnose in an early stage
-Indirect sensing for crop monitoring

Monitoring System

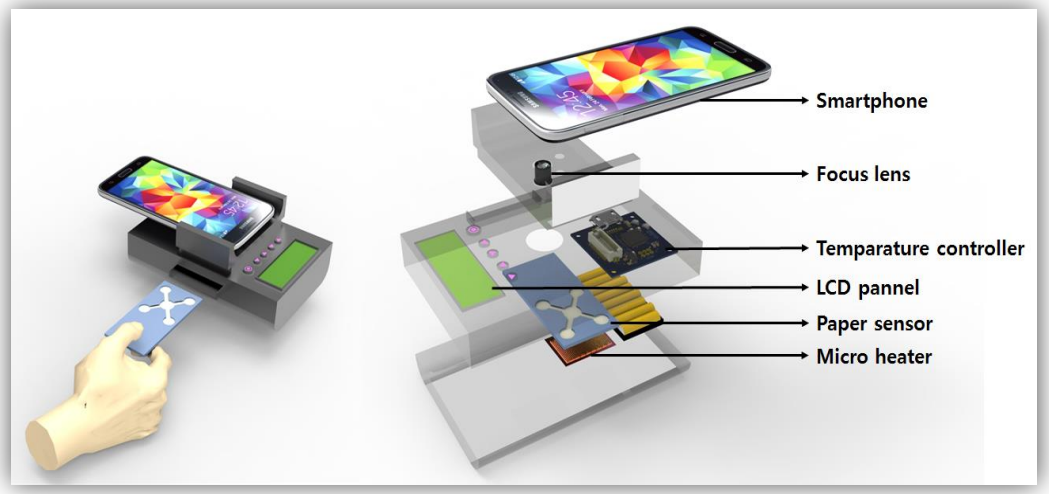
❖ Biosensor for early diagnosis





질병 분석

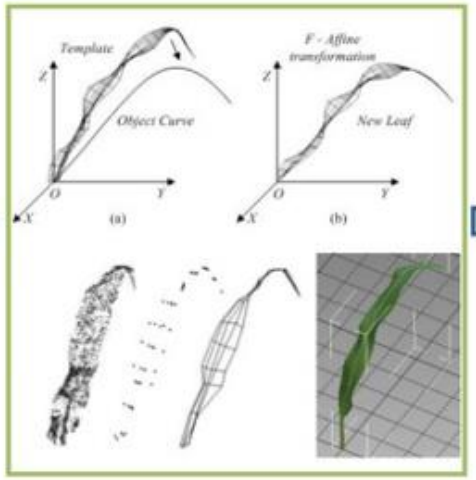
가뭄 분석



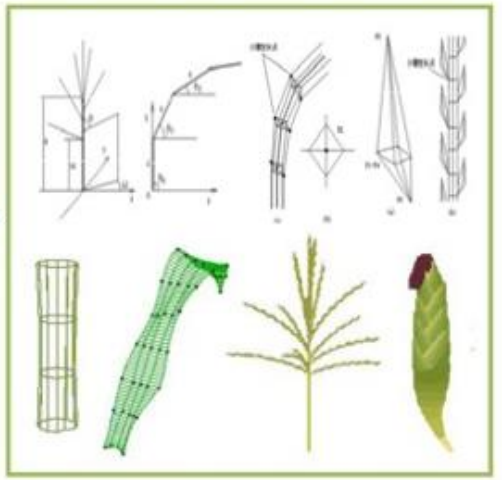
Monitoring System

❖ Sensing for virtual farming

Digitization

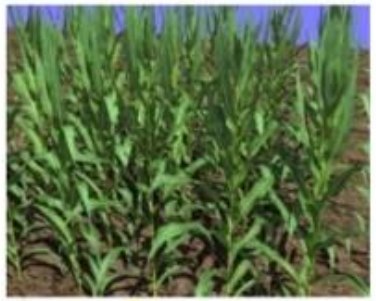


Feature extraction



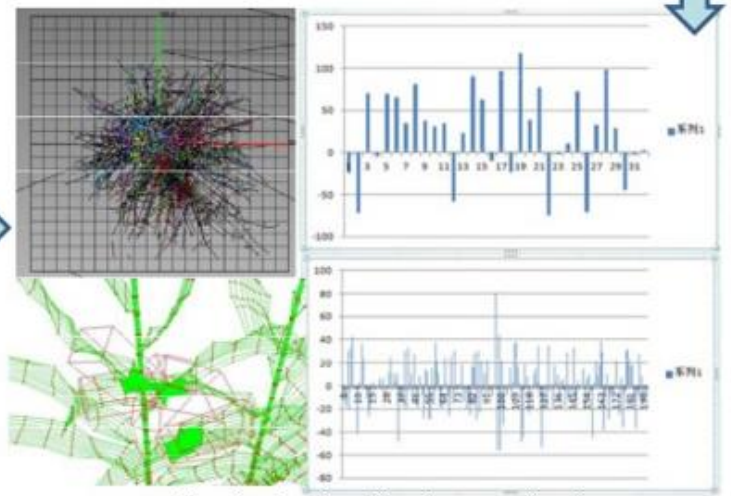
Geometric modeling

Breed variety heredity
Topology
Shape feature
Distribution
Agricultural technologies



Visual canopy model

Crop model & Expert system



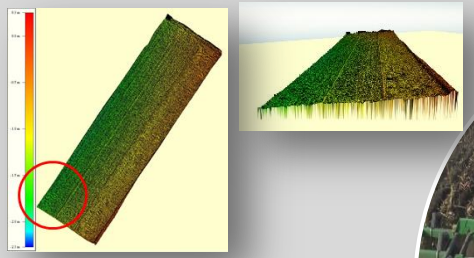
Statistic distribution analysis

Monitoring System

❖ Monitoring rice plant in the whole life cycle using UAV

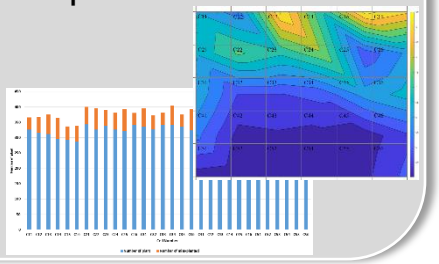
Plowing

- Surface elevation variation
- Uniformity of plowing depth



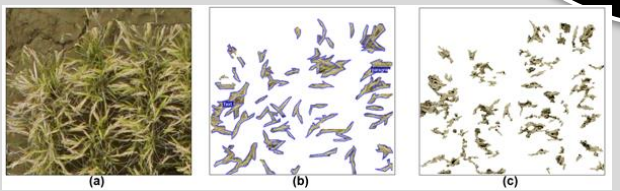
Transplanting

- Planting density(missing plant rate)
- Space between plants
- Coordinate each plant



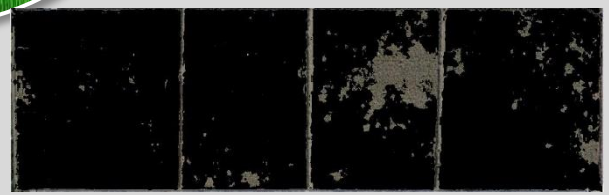
Harvesting

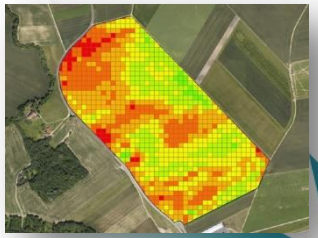
- Yield measurement at each plant
- Yield variation



Disease/Pest management

- Monitoring disease and nutrient deficiency





Field variation

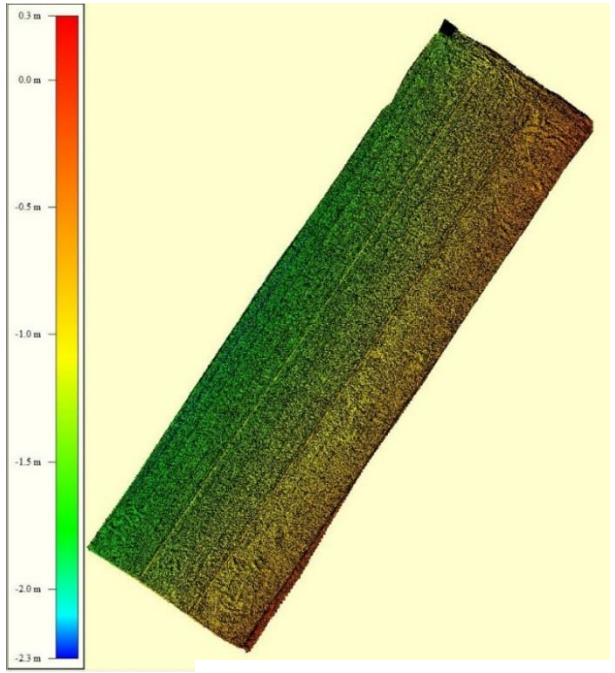
Variable-rate application

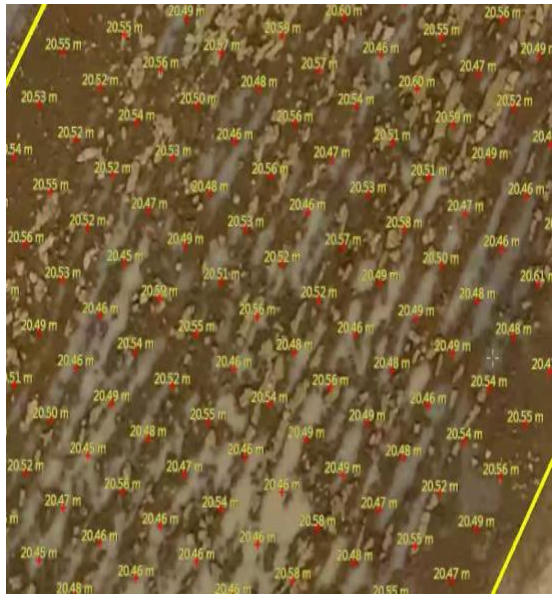
Yield monitoring

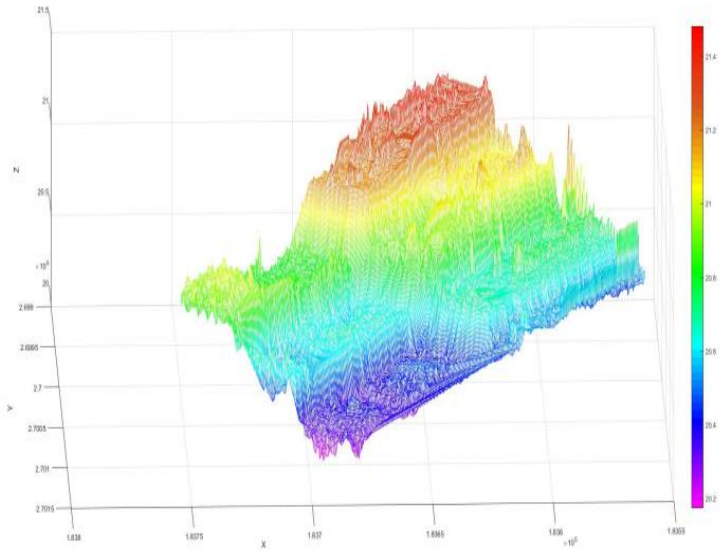
Maximize yield and quality with minimum input

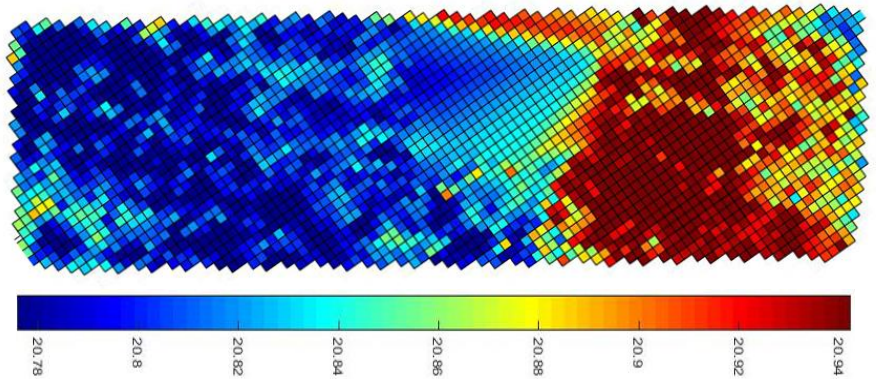
Monitoring System

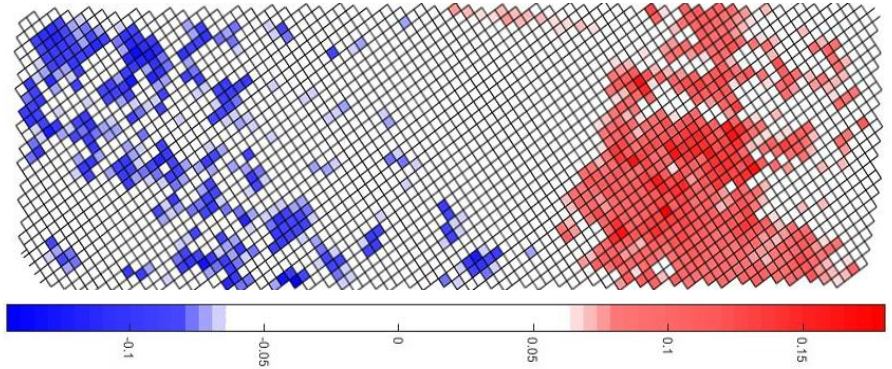
❖ Plowing stage: uniform surface elevation





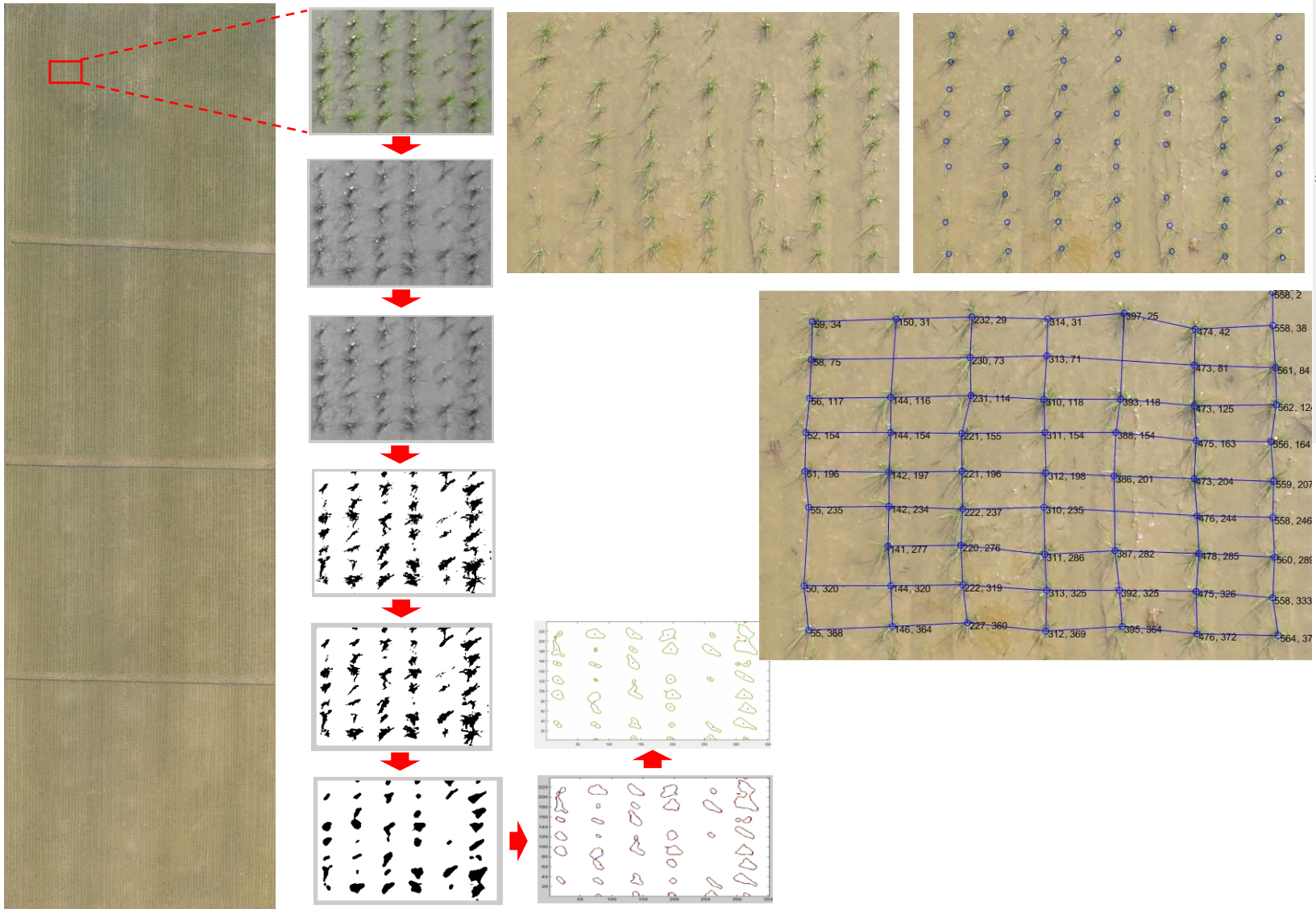


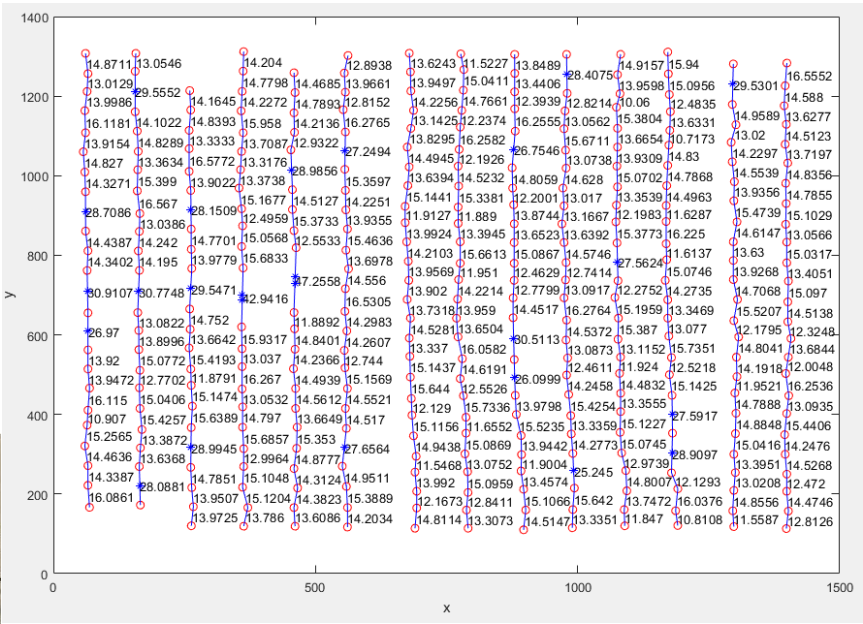


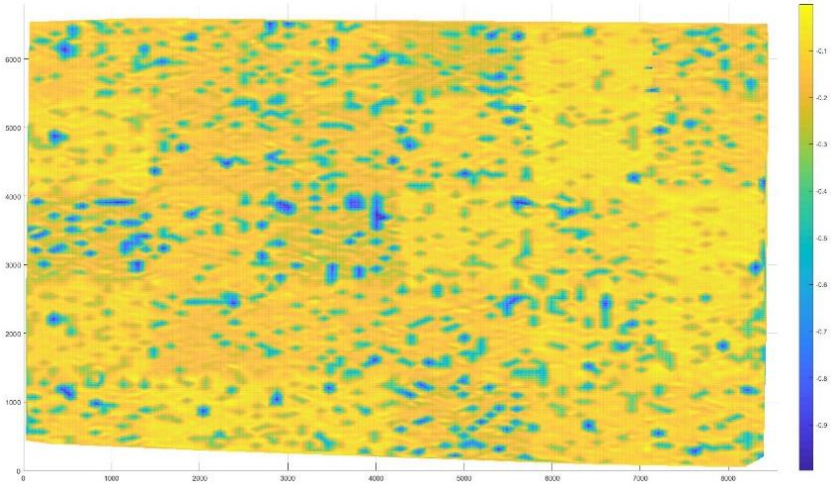


Monitoring System

❖ Transplanting stage: planting density



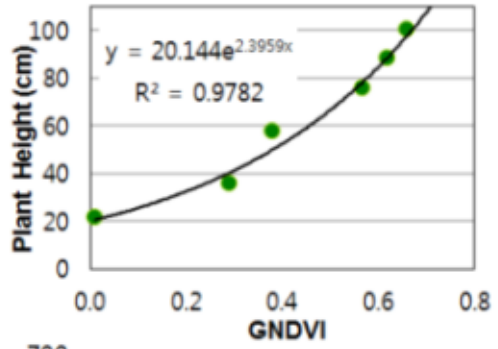


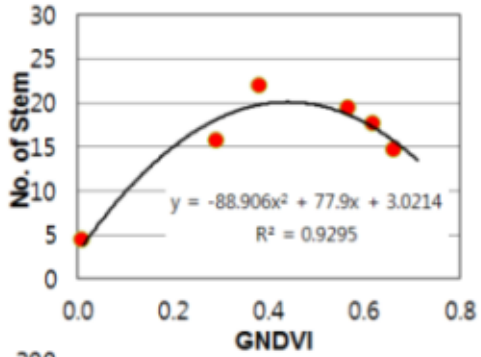


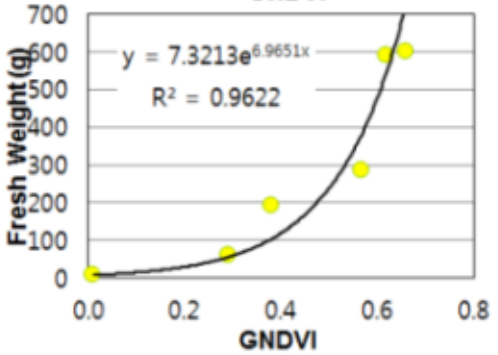
Monitoring System

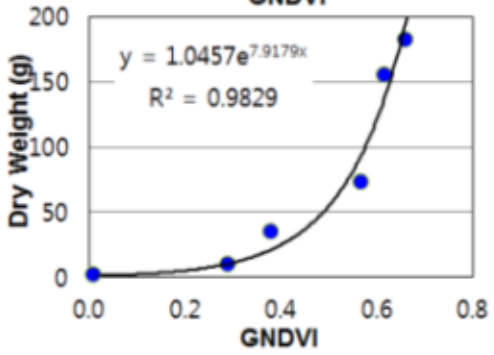
❖ Growing stage: crop growth information based on spectroscopic and morphological analyses

Date of image acquisition	RGB image	NIR image
June 29, 2015 (28 days after)		
July 14, 2015 (49 days after)		
July 25, 2015 (60 days after)		
August 14, 2015 (80 days after)		
September 1, 2015 (98 days after)		
September 11, 2015 (108 days after)		



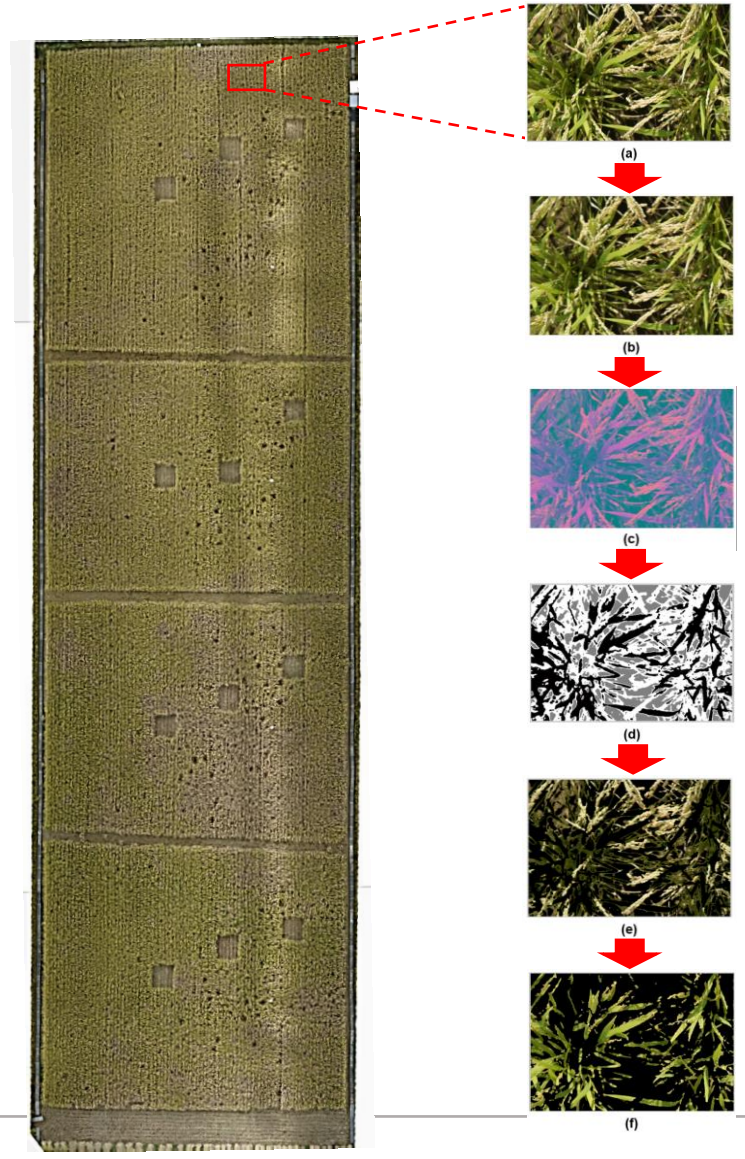


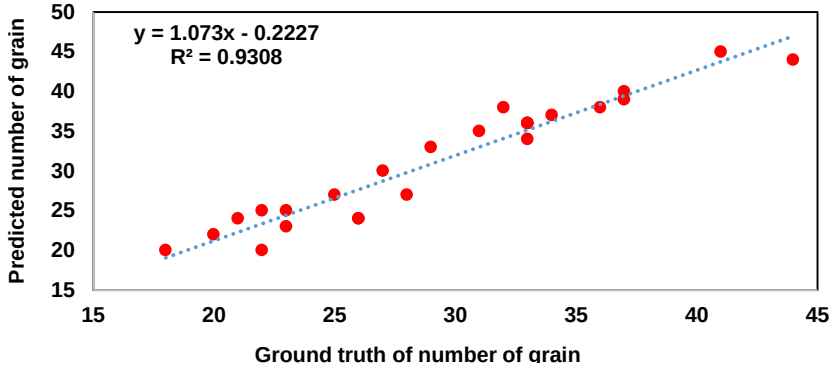


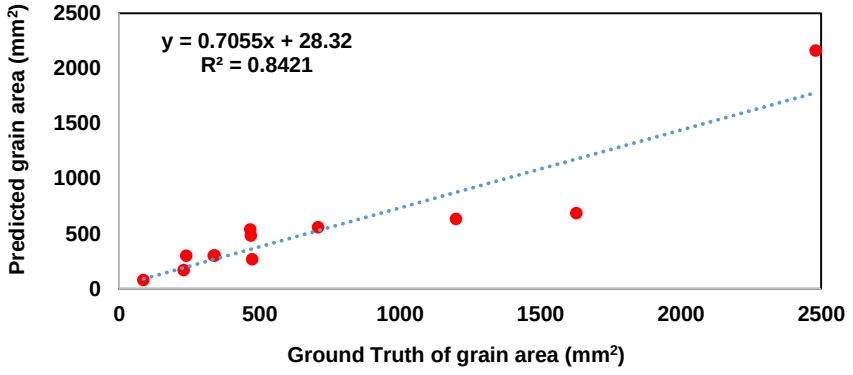


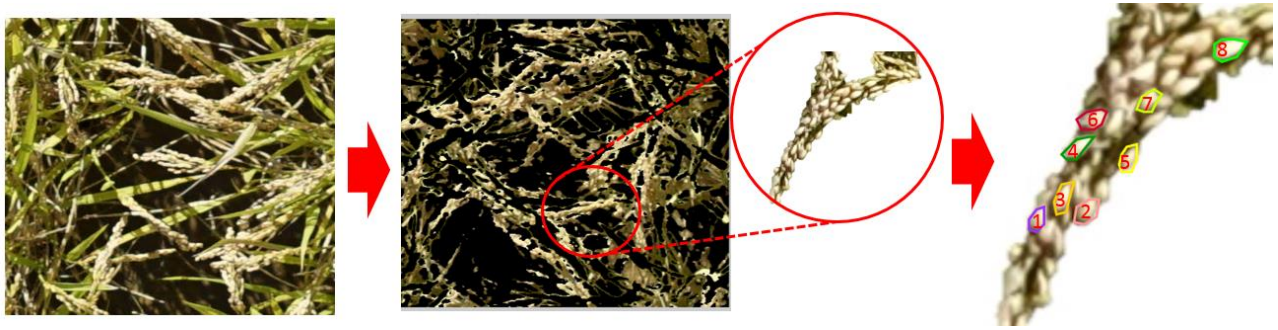
Monitoring System

❖ Harvesting stage: yield monitoring of each plant



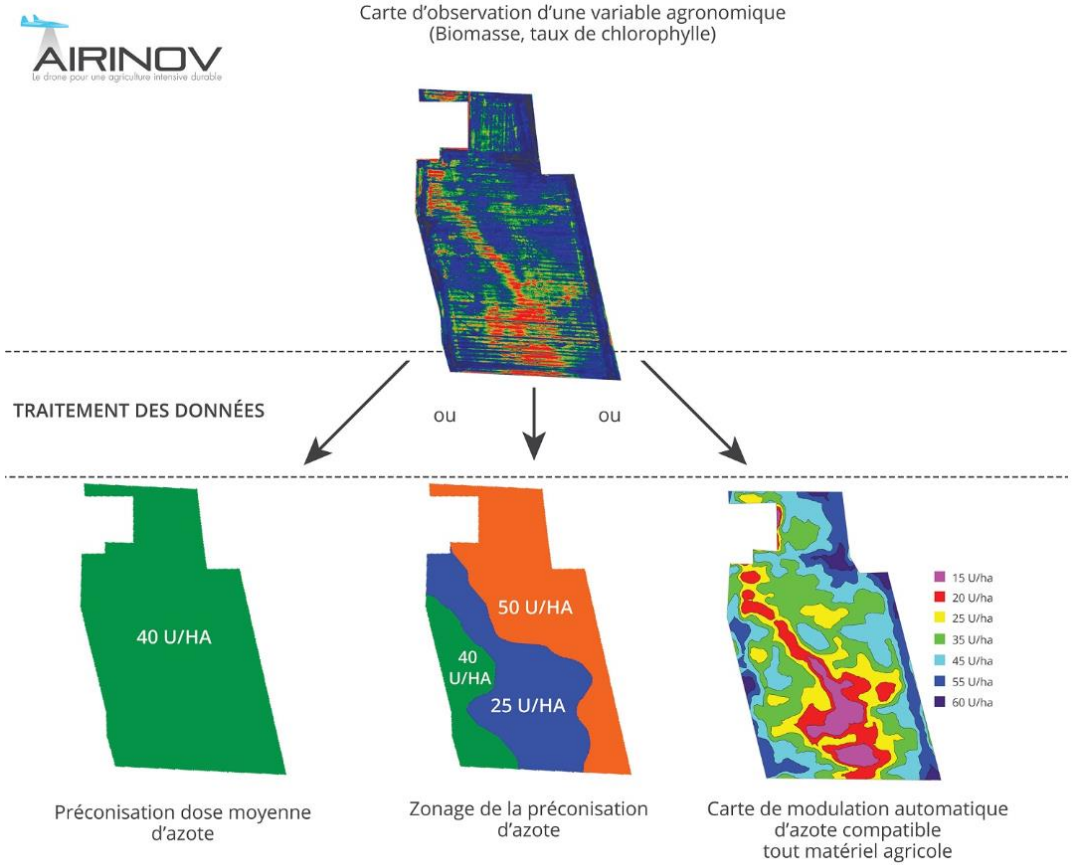




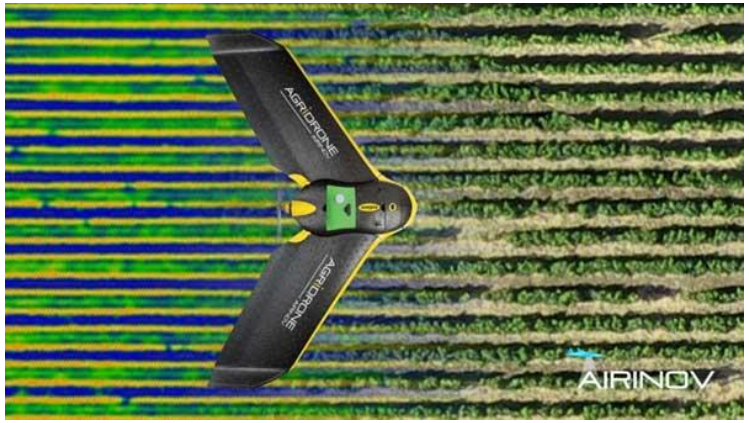


Decision Making System

- ❖ Collecting data of weather, soil, crop in various conditions
- ❖ Big data based optimum model for input of agricultural materials
- ❖ Calibration of the model in various environments

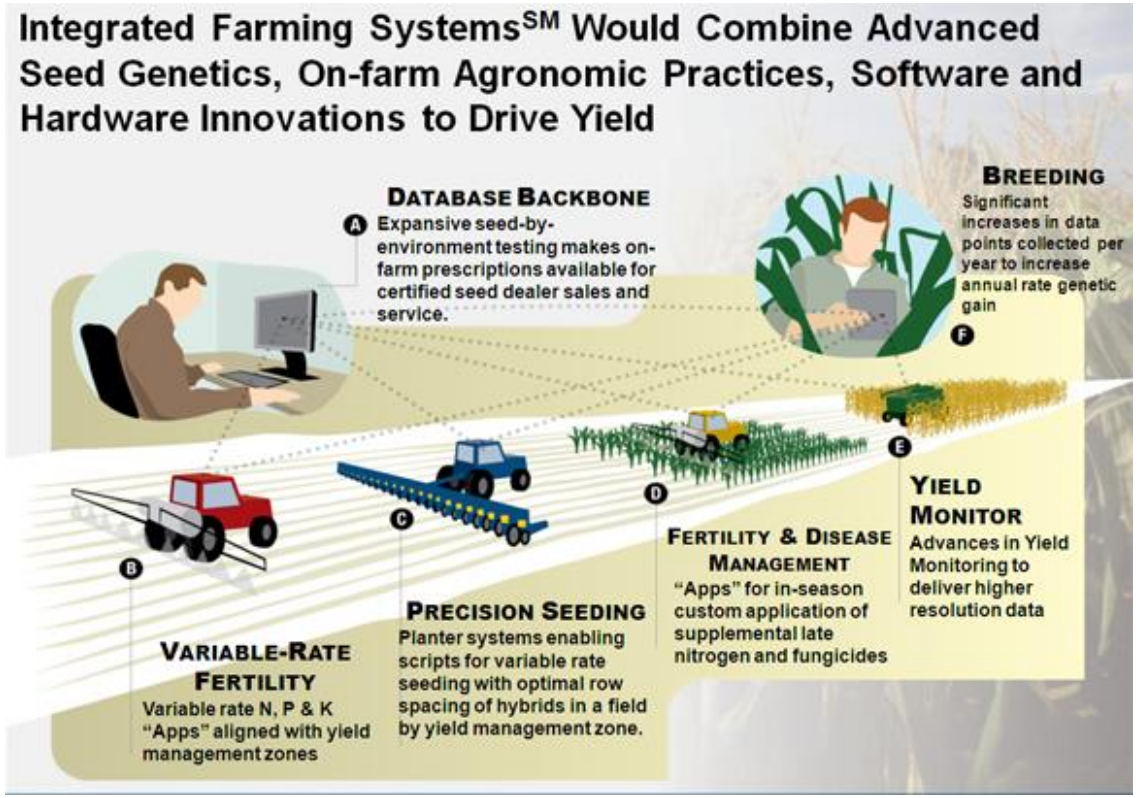


(www.airinov.fr)



Decision Making System

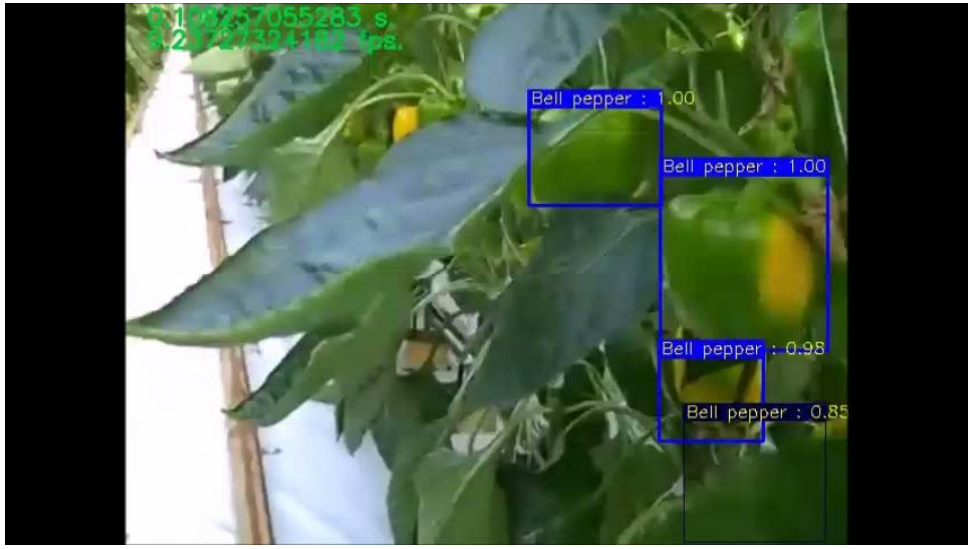
❖ Integrated farming system of Monsanto



(test.monsanto.com)

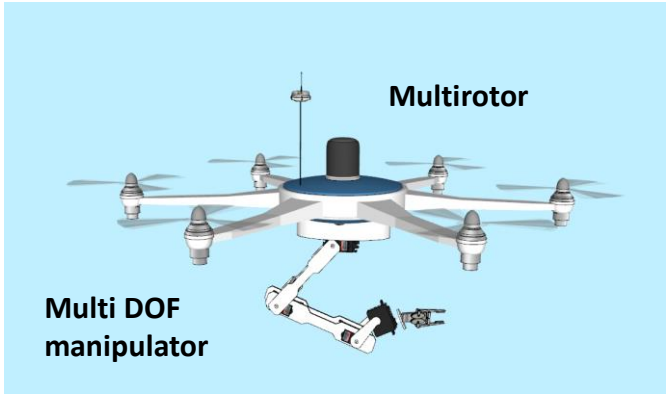
Actuating System

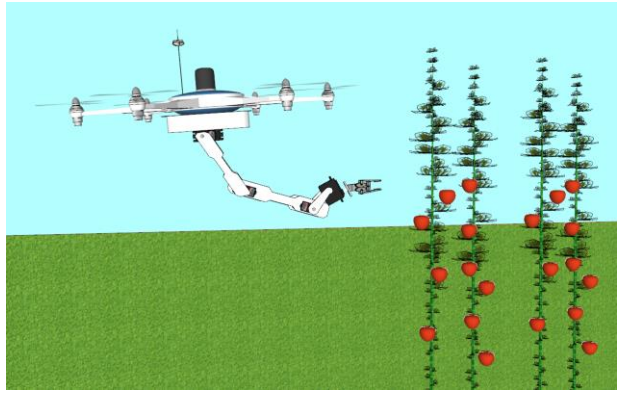
❖ Application of robots: variable-rate actuation

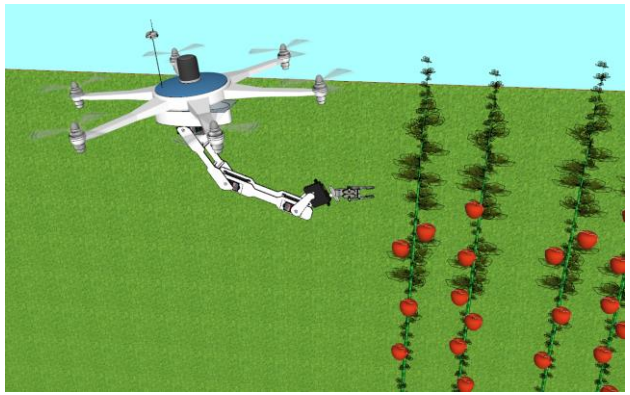


Actuating System

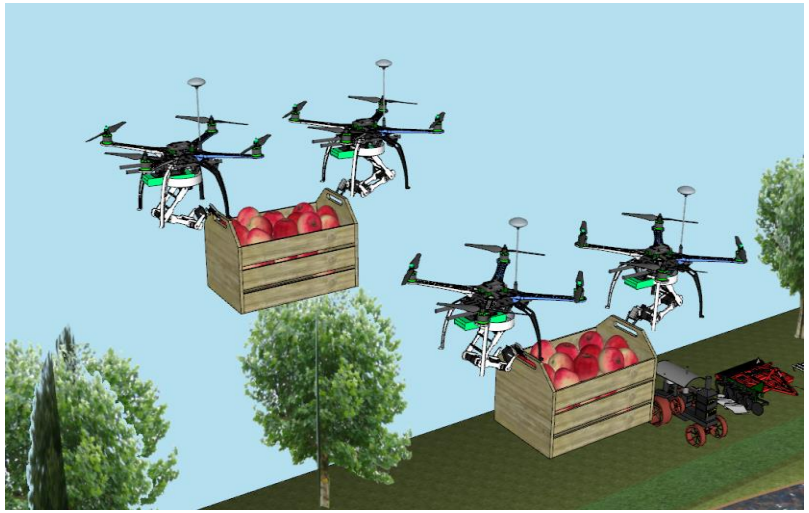
❖ Aerial manipulator for collection and inspection of crops





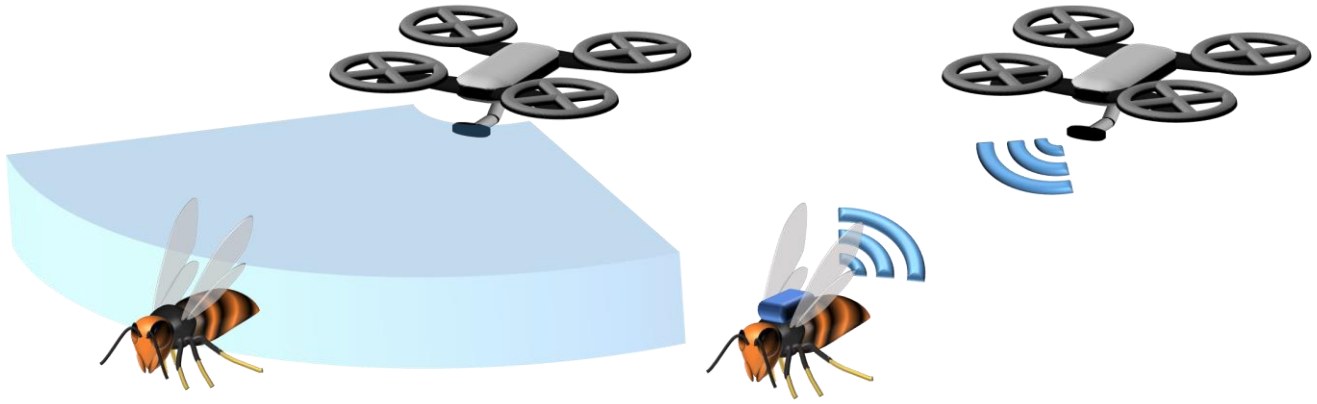


❖ Cooperative control of multi-UAVs for transportation of products

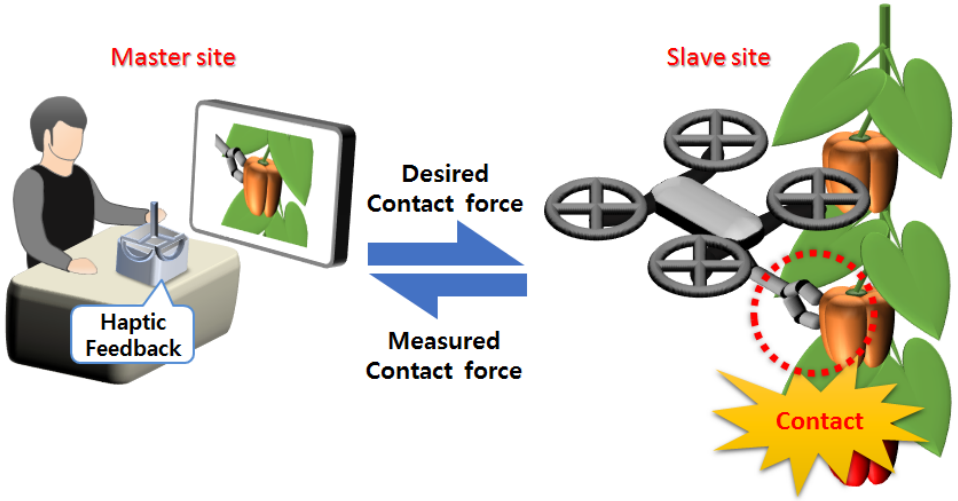


Actuating System

❖ UAV-based tracking of small insect



❖ Haptic teleoperation of aerial manipulator



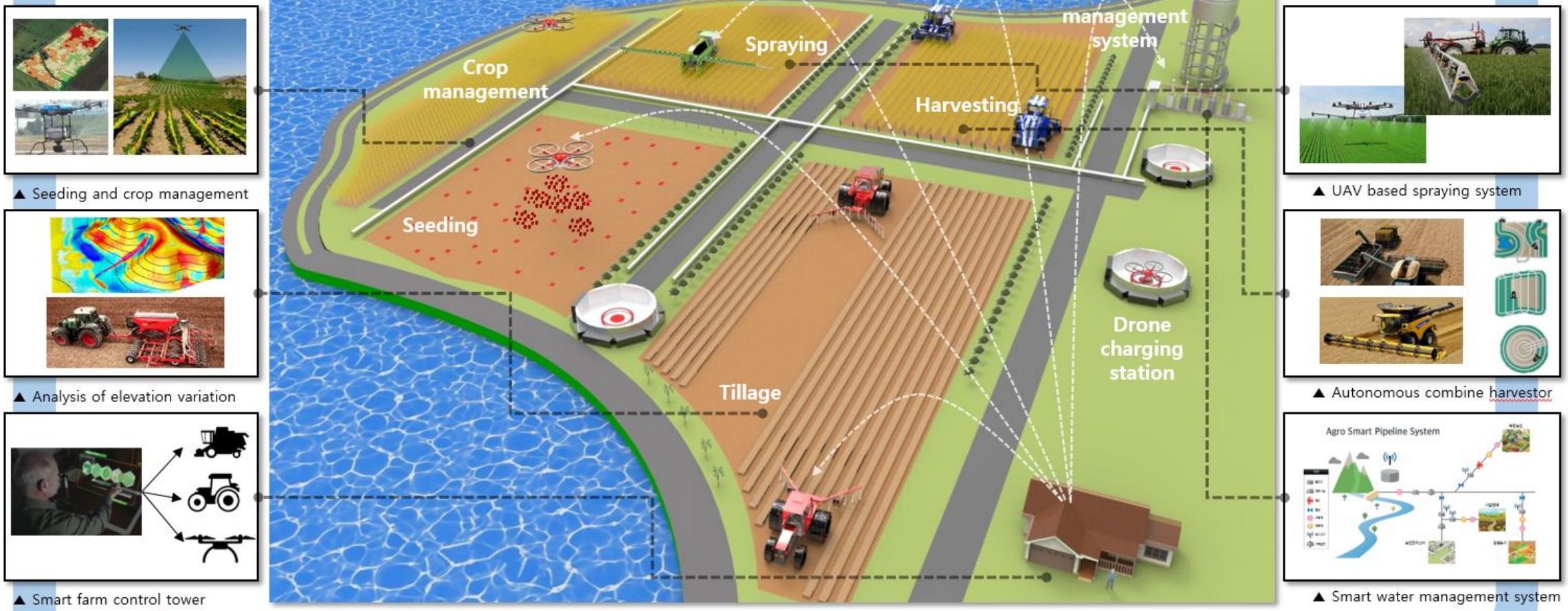
❖ Cooperation between UAV and autonomous tractor

03

Strategies and Conclusions

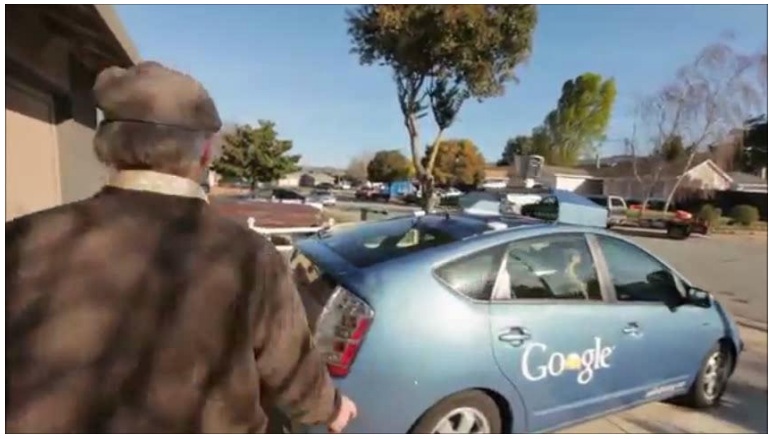
Strategies

❖ Fully automated agricultural production in the whole life cycle



Strategies

- ❖ Cooperation between automation-related industry and agriculture for the development of core technology
- ❖ Adoption of new technology from related advanced industry

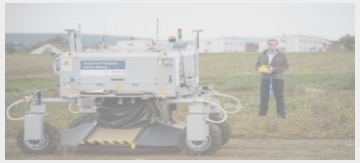


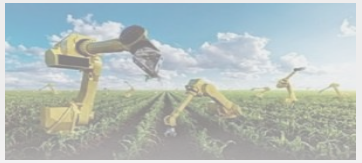
(Google's self-driving car)

(Autonomous tractor)

Strategies

❖ Innovative idea based core technology, creative engineers/researchers





Innovation of Agricultural Production System !!!

Thank You !!!

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