Development of Korean Agriculture and Digital Agriculture for Future

- The Bigdata Management and Use Case Study for Agriculture

Cho Yong-been, RDA
Contents

1. Development of Korean Agriculture
2. Digital Agriculture for Future
3. Utilization of Smart Farm Big Data Case of Productivity Improvement Model (AI)
4. AI Platform Service
Development of Korean Agriculture
About RDA and its Mission

Inauguration: 1962. 4. 1.(Suwon) → 2014. 9. 15.(New office at Jeonju)

Key Figures:
- Spokesperson
- Vice Administrator
- Auditor & Inspection Office
- Planning & Coordination Bureau
- Research Policy Bureau
- Extension Service Bureau
- Technology Cooperation Bureau
- National Institute of Agricultural Sciences (NAS)
- National Institute of Crop Science (NICS)
- National Institute of Horticultural & Herbal Science (NIHHS)
- National Institute of Animal Science (NIAS)
- Personnel: 1,847 (68.2% researchers, 96 extension workers)
- Budget: KRW 938.1 billion (2018)

Mission:
- R&D: Agricultural Technology
- Dissemination
- Extension
- International Cooperation

Objectives:
- Increase competitiveness of agri-industry
- Stable food supply to people
- Improvement of farmers' welfare
- Revitalization of rural community
- Enhance competitiveness of food industry
RDA Roles per Decade

1960s~1970s
- Tong-il Rice Development
- Green Revolution
  - Self-sufficiency of staple crop

1980s~1990s
- Green Revolution
- White Revolution
  - Year-round supply of vegetable

2000s~
- Quality Revolution
- Value Revolution
- Bio Revolution
- 4th Industrial Innovation
- 6th Industrialization
Current Situation of Korean Agriculture

Agricultural GDP Stagnation

Climate Change

Major fruit's cultivation area going north

4th Industrial Revolution

Demand on agricultural innovation

Addition-Value(% of GDP)

39.4% 30% 25.4% 20% 12.5% 10% 5.8% 5% 3.1% 0% 1965 1975 1985 1995 2005 2010

Korea's FTA Status

15 FTAs entered into force with 52 countries,
(as of Feb. 2017)

Ranked #3 in economic territory
(Korean FTA market GDP volume/Global GDP)

Ranked #109 in nation's territory
(Except North Korea)

Rep. of Korea

Acceleration of Market Opening

Climate Change

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Acceleration of Market Opening
Request for New Innovation in Agriculture

Achievement Creation that sensed by farmers and the people

President Moon Jae-In’s New Year’s Address
Select **smart farm** through leading project for innovative growth ...(2018)

Smart farm innovation valley, Project fostering young experts

RDA Administrator Kim Kyeong-Kyu
Focus on achievement creation by taking priority over two major tasks including **digital agriculture**...(2019)

Digital agricultural technology, scientific use and management of microorganism
Digital Agriculture
For Future
Data-based Digital Agriculture

Digital Agriculture

Digitalize agricultural phenomenon through big data, AI, and intellectual robot, and realize precision agriculture by returning its solution practically.

Realize customized production, distribution, and consumption through “Digital Agriculture”
Data-based Digital Agriculture

Promotion of digital agriculture through realization of agriculture big data-based AI

Utilization in Agriculture

Promising ago-food exploration → Right land selection → Smart production → Smart distribution and sales → Farm profit increase

- Increase yields
- Set appropriate price
- Reduce cost
- Increase quality

Apply AI technology in agriculture

Artificial Intelligence (AI)

- Computer program that imitates intelligent thinking and action of human

AI Technology in Agriculture

- Predict crop that consumption increases
- Development of promising crop and variety
- Right crop for right land
- Al-based smart production
- Control time and yield
- Control environment
- Satellite, robot, and drone for agricultural use
- Consumption prediction and supply and demand control
- Smart distribution and sales of agro-food products
- Customized sales strategy
- Direct mobile transaction
## Establishing the digital agriculture system

### Proceeding Digitalization by agriculture field and step

#### Breeding

- Develop new variety that meets market demand through analyzing big data on genome, climate change, population structure, and consumption pattern

  **Genome information**
  - Building system to use owning genetic resources by decoding genetics
  - Developing molecular marker based on genome information
  - Conduct research on new breeding technique such as CRISPR/Cas9

#### Environmental Data

- Provide soil information and predict weather as well as pest and disease through collection and analysis of IoT-based data

  **Soil**
  - Web-service for fertilizer prescription
  - Nutrient balance calculation program

  **Weather**
  - Early warning service for abnormal weather
  - Pest and Disease
  - Technology for identification of initial disease symptom of crop
Establishing the digital agriculture system

Proceeding Digitalization by agriculture field and step

Growth Data

Develop technologies to collect crop's growth data

Facilities
- Sensing technology for crop environment
- Robot for growth measurement
- Livestock bio-capsule

Land
- Measurement technology for crop growth, pest and disease, and soil nutrient using drone and satellite

Cultivation

Improve productivity and quality using big data and AI technologies

Information Collection
- Collect large size data with various types in each area
- Develop AI that improves productivity and profit using big data
- Support selection and cultivation of crop using AI-based solution
Establishing the digital agriculture system

Proceeding Digitalization by agriculture field and step

**Distribution & Consumption**

- Support stable supply and demand in a way such as precision prediction of main vegetable yields

  - Distribution & Consumption
  - Develop AI for yields prediction using big data on major main vegetable
  - Establish smart storage system to control supply and demand of major vegetable
  - Develop packaging technology that maintains freshness of fruit
  - Support decision making on production and distribution of agricultural products through analyzing big data on consumption trend

**Rural Livelihood**

- Develop and disseminate ICT-based alarm system and safety device for farmers

  - Accident Detection
    - Accident detection and alert system applying wireless communication technology among traffic sign, agricultural machine unit, and smart phone
  
  - Environment Detection
    - Develop safety risk factor detection equipment for farmers
  
  - Safety Equipment
    - Develop and disseminate safety vest for farmer, single-wheel cart maintaining balance automatically, individual shield for heat illness prevention
Establishing the digital agriculture system

Intelligent Agricultural Machinery Development and Utilization using Autonomous Driving Technology

Drone
Develop technologies for farm work such as sowing and pest control with using unmanned air vehicle

Pest and Disease Control  
▪ Disseminate precision spraying technology for pesticide

Crop Evaluation  
▪ Establish crop information service-based technology using unmanned air vehicle

Tractor
Develop tractor prototype available for autonomous driving and farm work

Hardware
▪ Apply 65-horsepower HST frame for autonomous driving  
▪ (transmission, steering)

Software
▪ Develop autonomous driving algorithm that drives after deciding route with using deep learning technology

Pest Control Machine
Develop autonomous driving pest control robot for unmanned pesticide spraying

Hardware
▪ Develop smart pest control machine possible to identify fruit by laser sensor

Software
▪ Develop technologies for fruit identification and opening and closing control of injection nozzle using laser sensor (LIDAR)
# Establishing the digital agriculture system

## Cloud Platform Establishment and Sharing and Utilizing the Information

<table>
<thead>
<tr>
<th>Data</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish “Agriculture Big Data Center” for big data collection and storage</td>
<td>Establish cloud platform for agriculture data sharing and utilization</td>
</tr>
</tbody>
</table>

### Collection System
- Establish bottom-up data collection system that establish big data in cooperation with rural development institutions for the data-based scientific farming

### Standardization
- Lay a ground for collection, analysis, and utilization of data per area with establishing cloud-based big data by standardizing agriculture data

### Activity
- Establish analysis, utilization and sharing platform using integrative technologies on information searching, big data and AI in connection with professional data center in agriculture

### Utilization Plan
- Set basic direction on data convergence and joint utilization among related institutions, and provide analysis and utilization service of big data through cloud platform
Development of Productivity Improvement Model (AI) using Smart Farm Big Data
Concept of Smart Agriculture

Smart farm: ICT + Agricultural production (protected)

→ For convenience and productivity
Development Stage of Korean Smart Farm Technology

First Generation (2016)
- Remote monitoring + Remote control
  - Improved convenience for farm work

Second Generation (2018)
- Complex environment control + Cloud service
  - Big data analysis ⇒ Better productivity and product quality

Third Generation (2020)
- Complex energy management + smart farm work
- Export-oriented Smart greenhouse system

Farm households adopting the first generation smart farm experienced better productivity and quality

- **Tomato (Production amount)**
  - Non-smart farm: 65
  - Smart farm: 84 kg/3.3 m²
  - Increase: 44.6%

- **Strawberry (income)**
  - Non-smart farm: 1,183 만원/10a
  - Smart farm: 1,438 만원/10a
  - Increase: 21.5%
Development of Productivity Improvement Model Using Big Data (AI)

What is Smart Farm?
Smart Farm Cultivation Status and Plan

Protected horticulture: 7,000 ha of land (2022)

Livestock: 5,750 farms
Problems Awareness in Smart Farm

Farmer’s thinking and problem

- Satisfaction(10): convenience of farming(7.3) > reducing labor(6.9) > increasing productivity(6.0)
- Problem of establishing smartfarm (MAFRA, `16): Initial investment & management expense(53.8%)

Requirement of increasing crop productivity

- Utilization of environment & growth information(92.0%), overall consulting using big data(84.0), education of control system(84.0)

Problem of smartfarm system (Netherlands) & research in Korea

- (PRIVA, Netherlands) Optimization of environment growth, yield for NL, Not Korea
  - Different to environment condition (radiation)
  - (IT research Institute, Korea) predicting the tomato yield model using environment data
* Predicting the tomato yield (multiple regression) (※ difficult to use result for farmer)
Data Collection of Smart Farm

Training researcher in smart farm: 75 people

- Gyeonggi(9), Gangwon(8), Chungbuk(3), Chungnam(10), Jeonbuk(9), Jeonnam(13), Gyeongbuk(12), Gyeongnam(9), Jeju(2)
Data Collection of Smart Farm

Status on Farm Collected Big Data for Smart Farm Life Cycle

- Number of farm (environment, growth, yield): 280 farms (2019)
  - Crop: Tomato (including cherry tomato), paprika, strawberry, oriental melon, cucumber, mushroom, flower, etc.

<table>
<thead>
<tr>
<th>Crop</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020 Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Revised</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ripened Tomato</td>
<td>8</td>
<td>14</td>
<td>49</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>Cherry Tomato</td>
<td>2</td>
<td>8</td>
<td>23</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>Strawberry</td>
<td>3</td>
<td>21</td>
<td>45</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>Paprika</td>
<td>2</td>
<td>11</td>
<td>32</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Oriental melon</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Cucumber</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Flower</td>
<td>-</td>
<td>-</td>
<td>14</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>Mushroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King Oyster Mushroom</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Oyster Mushroom</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Pig</td>
<td>3</td>
<td>20</td>
<td>23</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>80</td>
<td>180</td>
<td>315</td>
<td>280</td>
</tr>
</tbody>
</table>
The Agriculture BigData Management System

The agriculture construction map of data collecting and management

1. Data Analysis
   - Productivity Improvement Model
     - Productivity Increase (Greenhouse environment/yield)
     - Appropriate Growth Status (Greenhouse environment/Growth)

2. Data Convergence
3. Drawing appropriate greenhouse environment per farm
4. Prepare consulting message
5. Introduction Service on Internal Environment
6. Appropriate Temperature 23℃
7. Appropriate Temperature 20℃
8. Appropriate Humidity 75%

Farmer A
- Smart Farm A
- Appropriate Temperature 23℃
- Appropriate Humidity 75%

Farmer B
- Smart Farm B
- Appropriate Temperature 20℃

Farmer C
- Smart Farm C

Farm (Data Input)

Farm (Service Provision)
Development of Productivity Improvement Model using Big Data (AI)

Environment condition
(temperature) 22℃
(RH) 79%
(CO₂) 357ppm
(giftEC) 2.7dS/m

Optimal Growth
Growth length: 19.2 cm
Stem diameter: 11.3 mm

6 flower cluster
Fertilization

5 flower cluster
Fruit setting
Size: 29.58mm
Color: Green

3 flower cluster
Fruit enlargement
Size: 44.30mm
Color: Green

2 flower cluster
Fruit enlargement
Size: 40.66mm
Color: Green

1 flower cluster
Harvesting
Size: 58.01mm
Color: Orange
Process of Productivity Improvement Model using Big Data

Case of Development on Optimal Environment Setup Model for Tomato

Data Collection

- Farm environment (ground, root zone), growth, yield
- Physiological characteristics of tomato

Development Process of Basic Model: Environment → Yield (7~13 weeks), Growth → Yield (2~10 weeks), Environment → Growth (2 weeks)

Algorithm Development

- Short-term environment setup development for appropriate growth (middle stage, Jan~Feb)
- Drawing growth items and appropriate growth level affecting yield

Utilization

- Basic Model Algorithm (Environment setup for cultivation period)
  - Big data team, RDA research institute, provincial agricultural research & extension services

- Specialized Model Development (Physiological stress, pest and disease, etc.)
  - Company, university, RDA research institutes

Utilization by Farmers

- Case of Development on Optimal Environment Setup Model for Tomato
- Process of Productivity Improvement Model using Big Data
## Result for Development of Productivity Improvement Model

### The Short-term Environment Condition Setup for Maintaining Optimal Growth

Controlling the growth level using environment condition,

- Result: Can harvest 150~160 kg/3.3m² (the smartfarm average productivity: 84kg /3.3m²) → productivity 85%↑

<table>
<thead>
<tr>
<th>Period</th>
<th>Average</th>
<th>Beginning</th>
<th>Middle(month)</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>9~10</td>
<td>11~12</td>
</tr>
<tr>
<td>High productivity(kg/3.3㎡)</td>
<td>3.9</td>
<td>3.9</td>
<td>2.7</td>
<td>3.9</td>
</tr>
<tr>
<td>Average productivity(kg/3.3㎡)</td>
<td>2.2</td>
<td>1.6</td>
<td>2.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Average harvest weeks</td>
<td>40</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

### Growth

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>19.5</th>
<th>27.0</th>
<th>16.9</th>
<th>20.3</th>
<th>13.8</th>
<th>18.9</th>
<th>18.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth length (cm)</td>
<td>20.0</td>
<td>23.8</td>
<td>13.5</td>
<td>13.7</td>
<td>25.8</td>
<td>16.2</td>
<td>16.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stem diameter(mm)</td>
<td>10.0</td>
<td>12.3</td>
<td>9.3</td>
<td>10.0</td>
<td>9.4</td>
<td>8.0</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of flower(cm)</td>
<td>20.0</td>
<td>23.8</td>
<td>13.5</td>
<td>13.7</td>
<td>25.8</td>
<td>16.2</td>
<td>16.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Environment Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>1772~2441</th>
<th>1078~1330</th>
<th>993~1146</th>
<th>817~999</th>
<th>1393~1628</th>
<th>1751~1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation (J/㎠)</td>
<td>20.2</td>
<td>22.0</td>
<td>17.8</td>
<td>16.4</td>
<td>19.2</td>
<td>21.4</td>
</tr>
<tr>
<td>24h Temperature (℃)</td>
<td>27.2</td>
<td>24.3</td>
<td>20.0</td>
<td>19.0</td>
<td>21.9</td>
<td>24.3</td>
</tr>
<tr>
<td>Daytime temperature (℃)</td>
<td>14.9</td>
<td>19.5</td>
<td>16.2</td>
<td>14.5</td>
<td>16.4</td>
<td>18.1</td>
</tr>
<tr>
<td>Nighttime temperature (℃)</td>
<td>79.8</td>
<td>80.3</td>
<td>80.1</td>
<td>85.0</td>
<td>73.9</td>
<td>71.5</td>
</tr>
<tr>
<td>Daytime RH (%)</td>
<td>23</td>
<td>15</td>
<td>12</td>
<td>6</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Number of water/1 day</td>
<td>86</td>
<td>71</td>
<td>57</td>
<td>86</td>
<td>59</td>
<td>51</td>
</tr>
<tr>
<td>Water amount/1 time (cc/day/plant)</td>
<td>2.6</td>
<td>2.5</td>
<td>3.3</td>
<td>2.7</td>
<td>2.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Supply EC(dS/m)</td>
<td>5.5</td>
<td>5.7</td>
<td>5.7</td>
<td>5.7</td>
<td>5.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Supply pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Result for Development of Productivity Improvement Model

- The short environment condition setup for maintaining optimal growth

### Middle Stage (Nov, Dec)

- Distance from growing point (this week) to growing point (prior week)↑,
  distance of growing point and flower cluster↓ (②→①)
  : Inside temperature↑, nighttime temperature ↑, supply EC ↑
- distance of growing point and flower cluster↓ (③→①): supply water ↓, supply EC ↑

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Environment condition (radiation: 993~1146 J/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Productivity (kg/3.3m²)</strong></td>
<td><strong>Distance from growing point (this week) to growing point (prior) (cm)</strong></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3.8</td>
<td>20.3 (17.9~20.6)</td>
</tr>
<tr>
<td>2.7</td>
<td>18.8 (17.9~20.6)</td>
</tr>
<tr>
<td>2.1</td>
<td>21.5 (20.6~23.8)</td>
</tr>
<tr>
<td>1.8</td>
<td>22.4 (20.6~23.8)</td>
</tr>
<tr>
<td>0.7</td>
<td>20.5 (17.9~20.6)</td>
</tr>
</tbody>
</table>

☞ Possible to support short-term decision-making by comparing growth stage and crop status by season in own farm
Artificial Intelligence (AI) Platform Service
Cloud Platform Service for Digital Agriculture

**Big Data Collection**
- Smartfarm: 280 farms
- Main vegetable: 120 farms
- Experimental field: 119

**RDA**
Basic Model Development
Comparative Analysis on Suitable Growth Environment Setup of Smartfarm

**Cloud Service Platform**

**Data Collection & Management**
- 메시지 관리
- 트랜잭션 관리
- 프로토콜 변환
- 수집연계
- 데이터 관리
- CEP(실시간 정보처리 모델)
- 수집연계
- 신품 브라우징

**Data Analysis & Model Development**
- 실시간 분석
- 사용자 주도 분석
- SDK
- R, Mahout, 콘텍스, Text, GIS, 그래픽, Ad hoc, 수치 통계

**Service Provision**
- 농산물 생산성 향상 모델
- 소비예측 및 수급조절 모델
- 인공지능 기반 스마트팜
- 포털 시스템
- 데이터DB 관리
- 클러스터 관리
- 화면관리 등

**Private Sector (Company)**
Secure data set
Support on connecting with third party
Specialized model development
Use of external expert

**Farmer & Consumer**
Production, distribution, consumption, service utilization

**Environment: Growth/Management Automation**
- Manual

**Farmer & Consumer Specialized model development**
Use of external expert
Establishment of Innovative Growth Ecosystem for Digital Agriculture

- Company Sales Increase
- Job Creation
- Productivity Improvement
- Farm Income Increase
The 4th industrial revolution, We will develop it through advanced digital agriculture.

Thank you.