



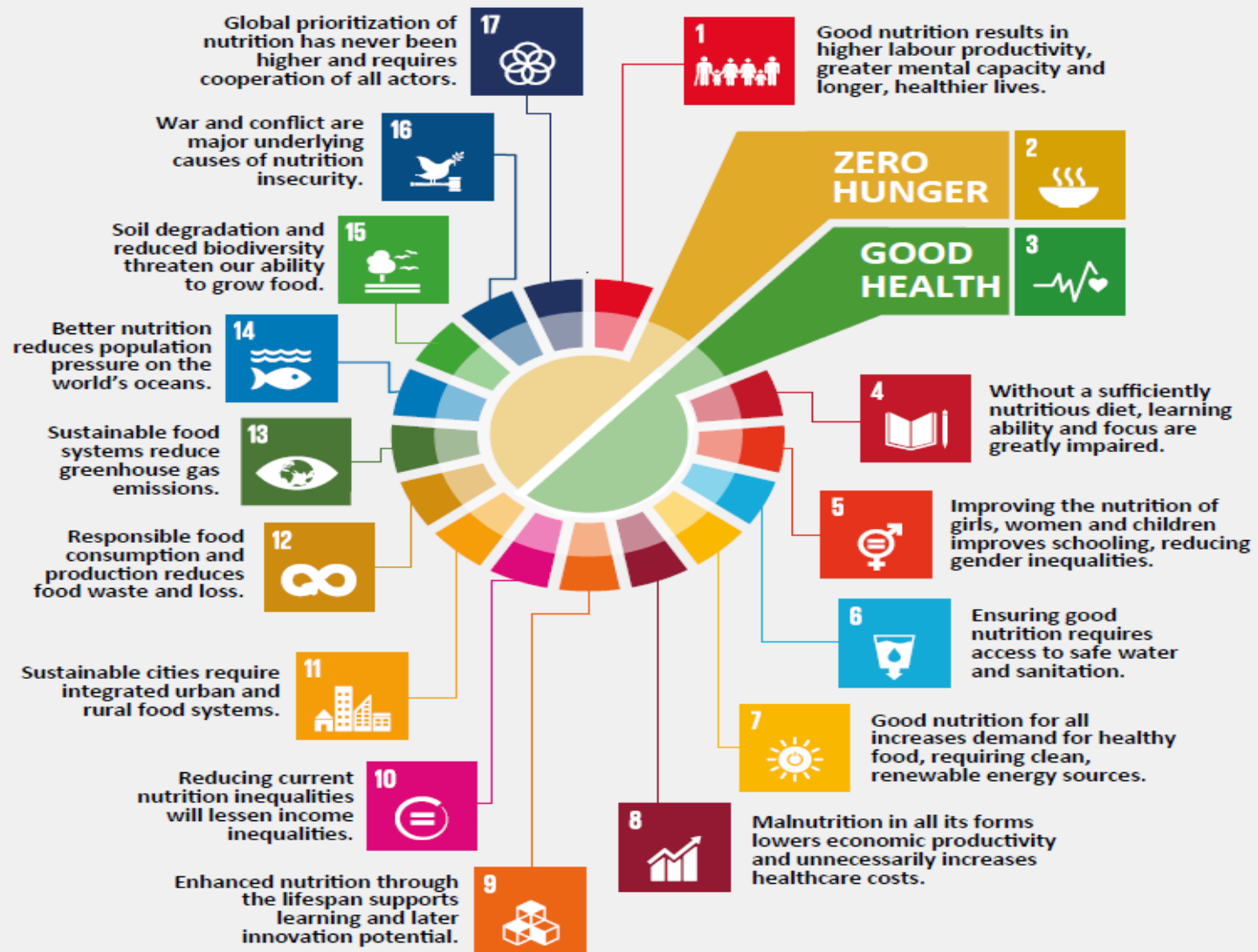
# Sustainable Agricultural Production in the 21st Century ----Smarter Agriculture with ICT

Seishi Ninomiya

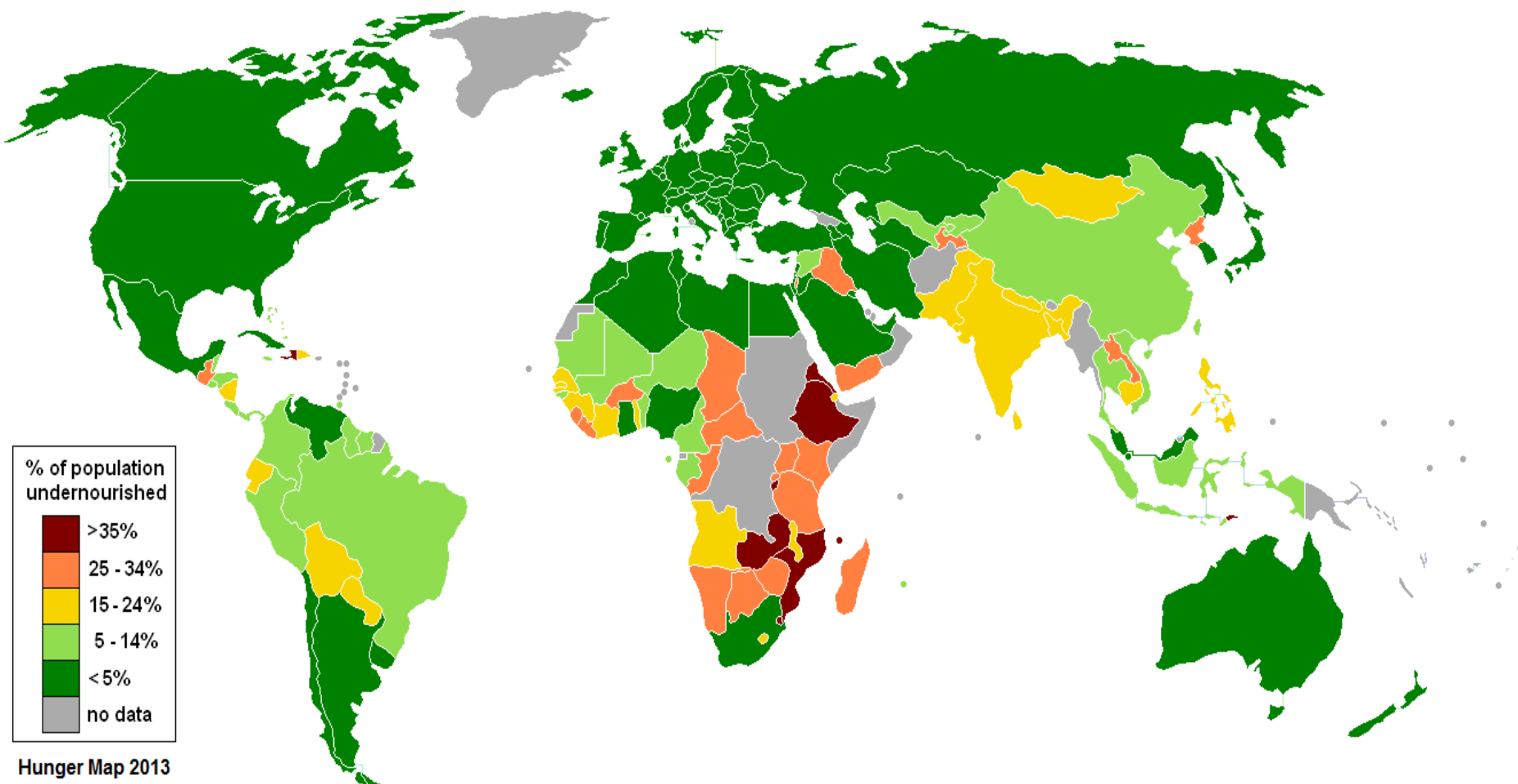
International Field Phenomics Research Laboratory,  
Graduate School of Agriculture and Life Sciences,  
University of Tokyo

# NUTRITION AND THE SDGs

## CENTRAL TO THE 2030 AGENDA

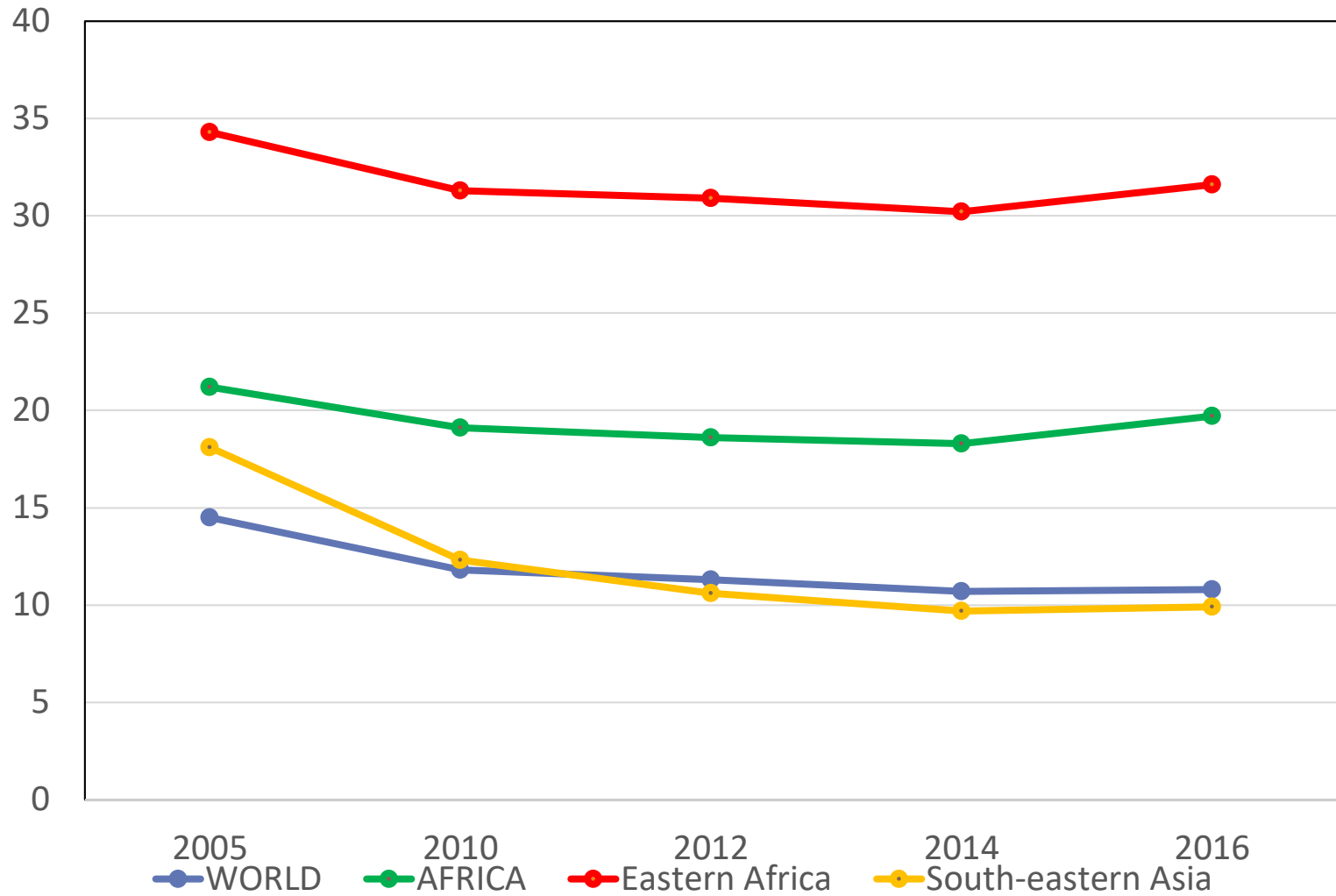


# Hunger Map in 2006

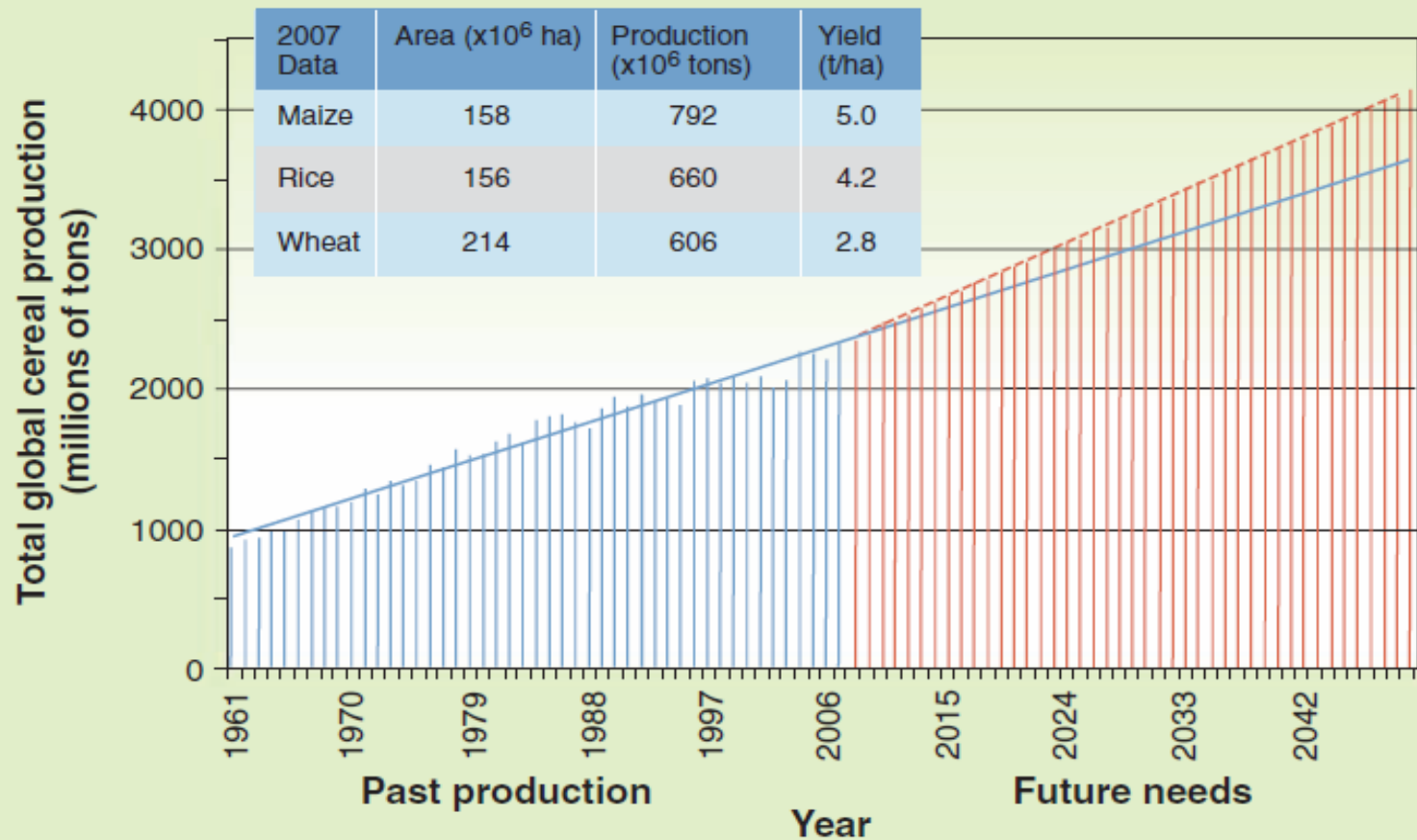


[https://en.wikipedia.org/wiki/Global\\_Acute\\_Malnutrition#/media/File:Percentage\\_population\\_undernourished\\_world\\_map.PNG](https://en.wikipedia.org/wiki/Global_Acute_Malnutrition#/media/File:Percentage_population_undernourished_world_map.PNG)

# Malnutrition Rate (%)



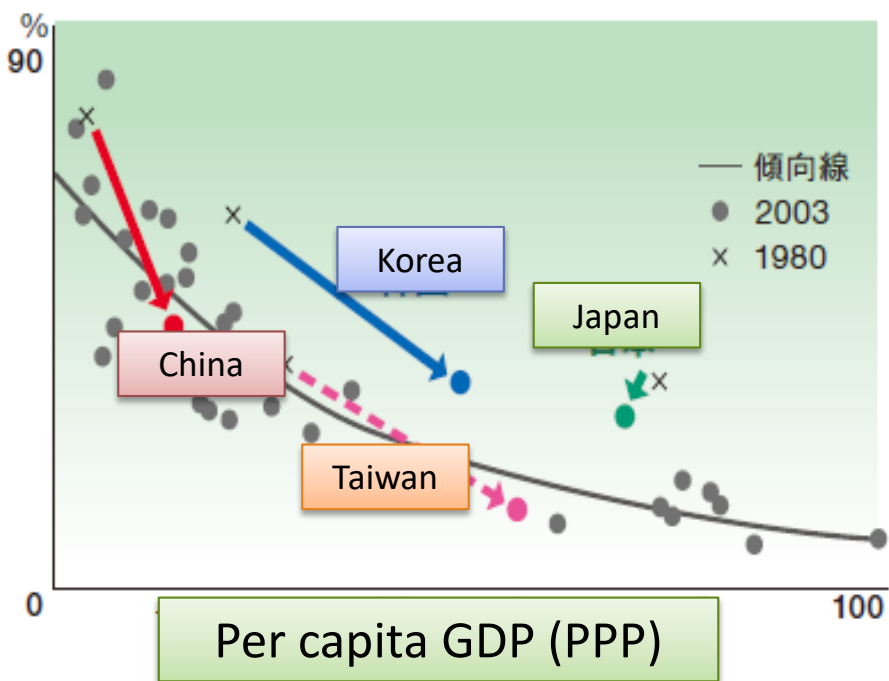
# Food demand increases



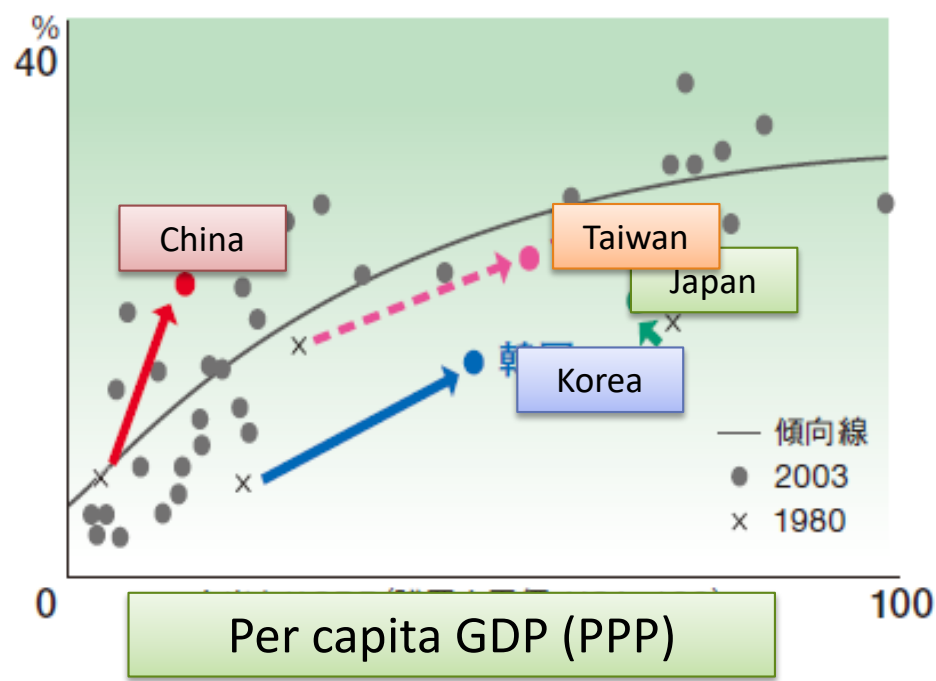
- Population growth: 7.5 billion (2017) to 9.7 billion (2050)
- Diet transition from stable food to animal products

# Diet transition is taking place with economic growth

Calorie dependency on staple food



Calorie dependency on animal products



Pennsylvaniaより.

「循環型社会に向けた食遷移への挑戦」

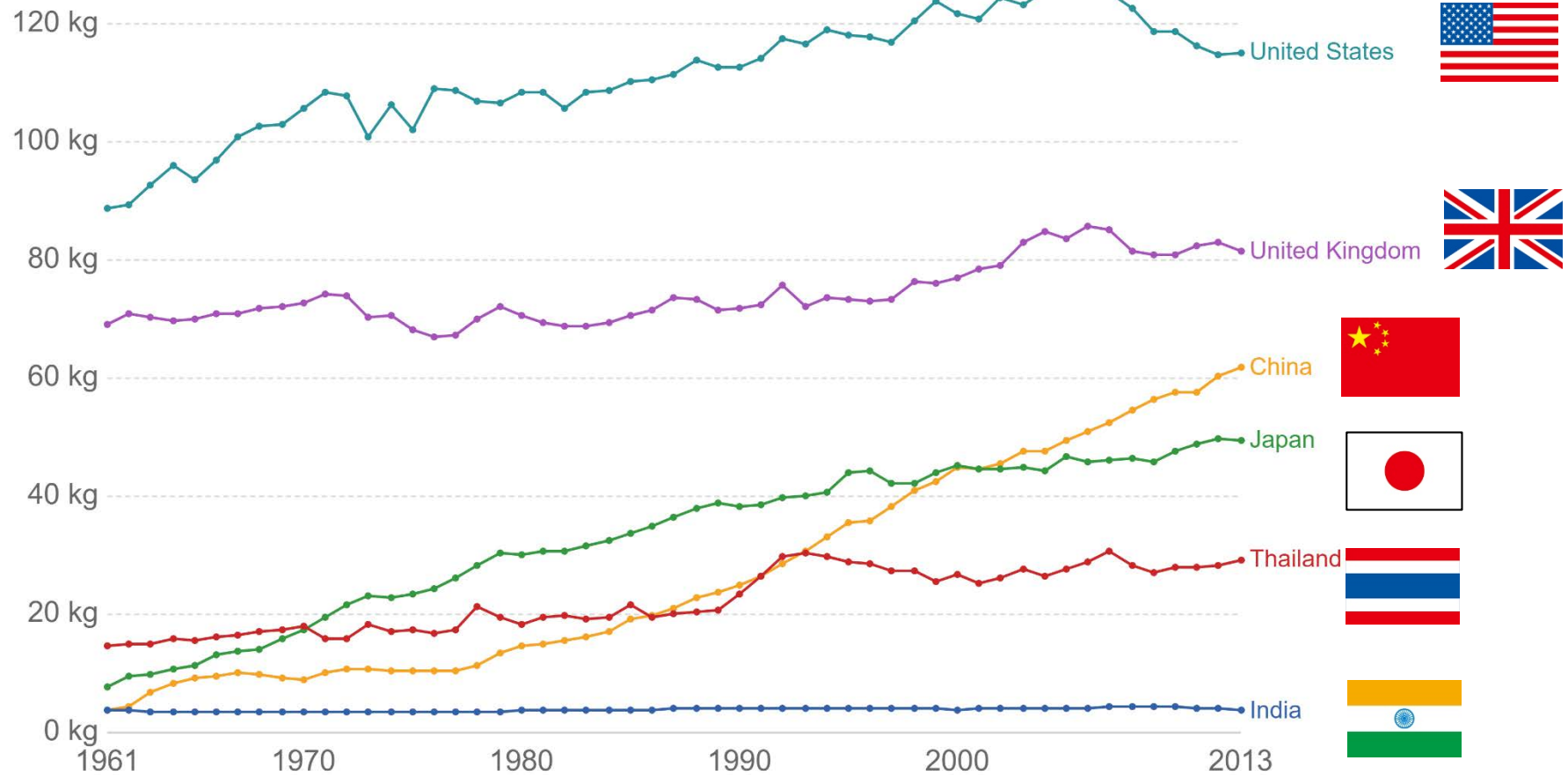
小林和彦, 東京大学農学生命科学研究科「弥生」春号(2009)より改変

<http://www.a.u-tokyo.ac.jp/pr-yayoi/48.pdf>

# Meat supply per person

Average total meat supply per person measured in kilograms per year. Note that these figures do not correct for waste at the household/consumption level so may not directly reflect the quantity of food finally consumed by a given individual.

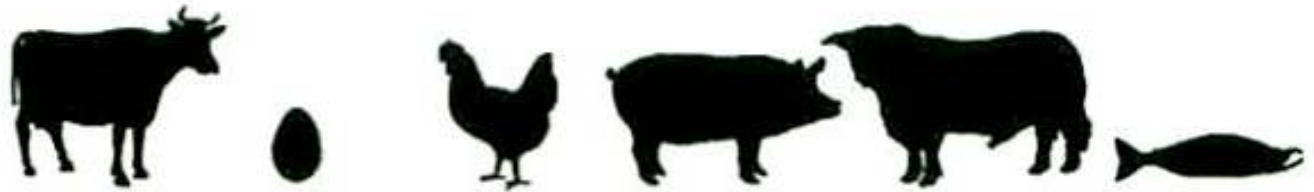
Our World  
in Data



Source: UN Food and Agriculture Organization (FAO)  
Note: Data excludes fish and other seafood sources

OurWorldInData.org/meat-and-seafood-production-consumption/ • CC BY

# Very inefficient meat production



Milk

Egg

Chicken

Pork

Beef

Fish

Grain needed to  
produce 1kg of  
product (kg)

1.1

2.8

4.5

7.3

20.0

1.4

Nitrogen uptake (%)

30

30

20

10

5

40



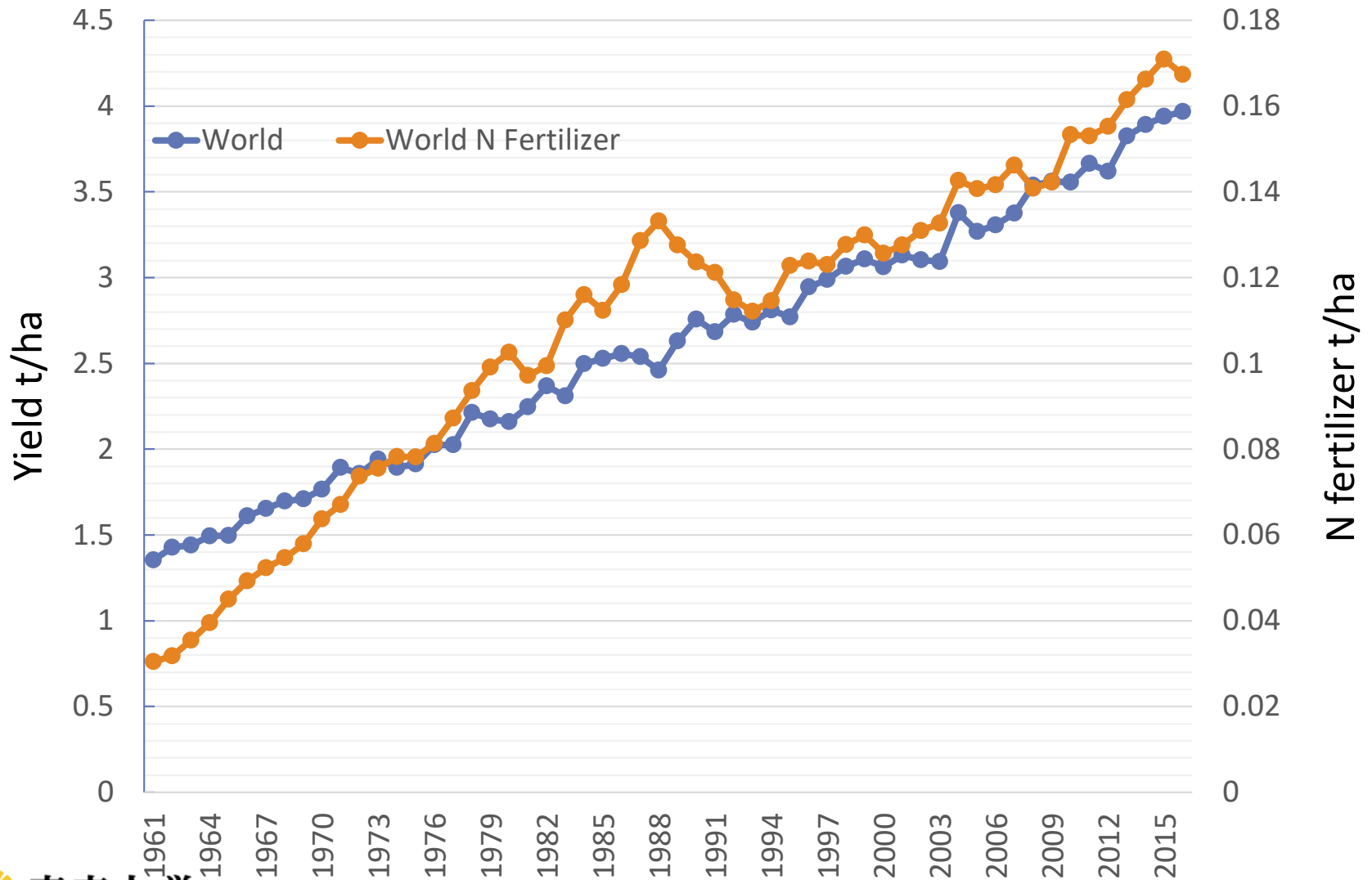
# Water consumption for food production

- Water needed to produce 1 kg of agricultural product

| Products | Water (t) | Products | Water (t) |
|----------|-----------|----------|-----------|
| Rice     | 3.6       | Beef     | 20.6      |
| Barley   | 2.6       | Pork     | 5.9       |
| Wheat    | 2.0       | Chicken  | 4.5       |
| Corn     | 1.9       | Egg      | 3.2       |
| Soybean  | 2.5       |          |           |

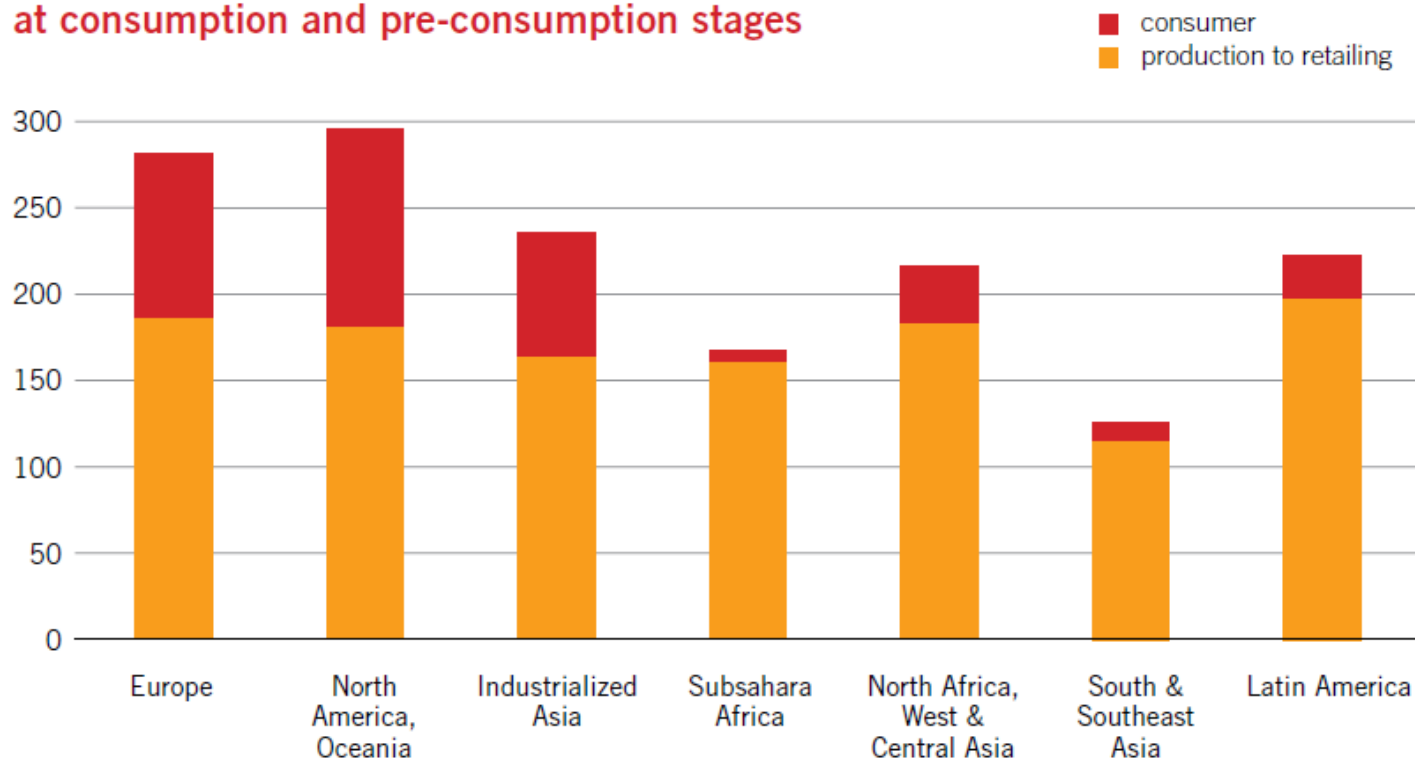
T. Oki, M. Sato, A. Kawamura, M. Miyake, S. Kanae, and K. Musiake, Virtual water trade to Japan and in the world, *Virtual Water Trade*, Edited by A.Y. Hoekstra, Proceedings of the International Expert Meeting on Virtual Water Trade, Delft, The Netherlands, 12–13 December 2002, Value of Water Research Report Series No.12, 221–235, February 2003

# Productivity and N Fertilizer



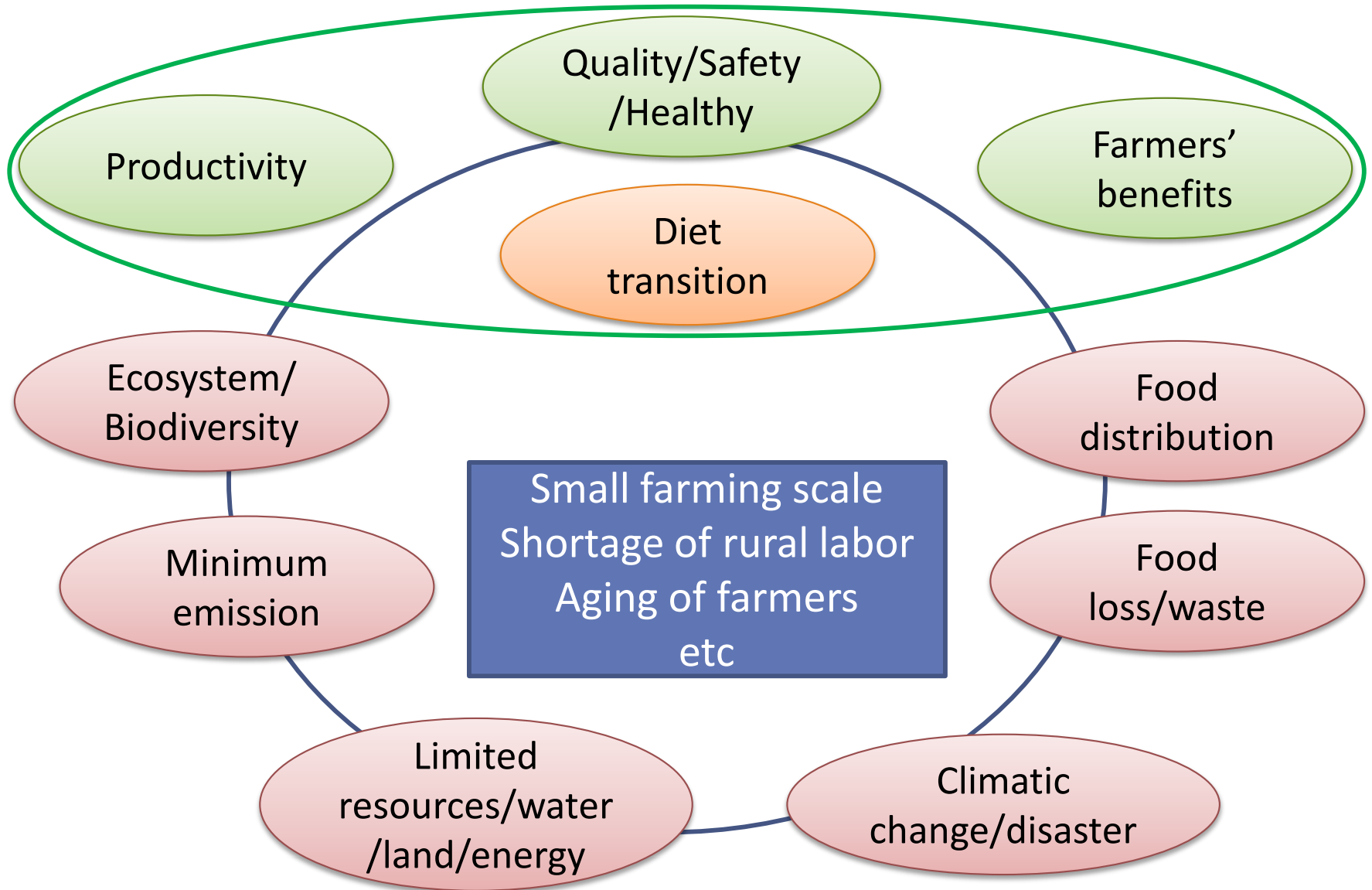
Every year, an estimated 1.3 billion tons of food = 1/3 of food production for human is lost or wasted

Per capita food losses and waste (kg/year),  
at consumption and pre-consumption stages



FAO, <http://www.fao.org/docrep/016/ap409e/ap409e.pdf>

# Food security in 21<sup>st</sup> Century



Very complex optimization problem-> Real Smart Agriculture

# How agricultural production is different from other industries?

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- Uncertainty
    - Dependence on uncertain uncontrollable weather condition
  - Site-specificity
    - Soil, water, climate, crops/cultivars, cultivation methods
    - A single generic approach is not possible
  - Limitation to large-scale farming
    - In most of the Asian and African countries
  - Labor intensive and shortage of labor
- Dynamic & real time adjustment is required
  - Customization is always required

# Keywords for solutions

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- **Cyber-Physical System** (CPS) for dynamic customization
  - Real time monitoring of current status and optimal feedback
  - Dynamic and optimized combination of sub-systems
- **Data centric approach** for complex problem where we can not find common theories to drive it
  - Agricultural production in sustainable ways is facing such a complex problem

Industry 4.0 (not yet Soc. 5.0)

# Efficient productivity in large scale farming is simple





# Large scale farming?

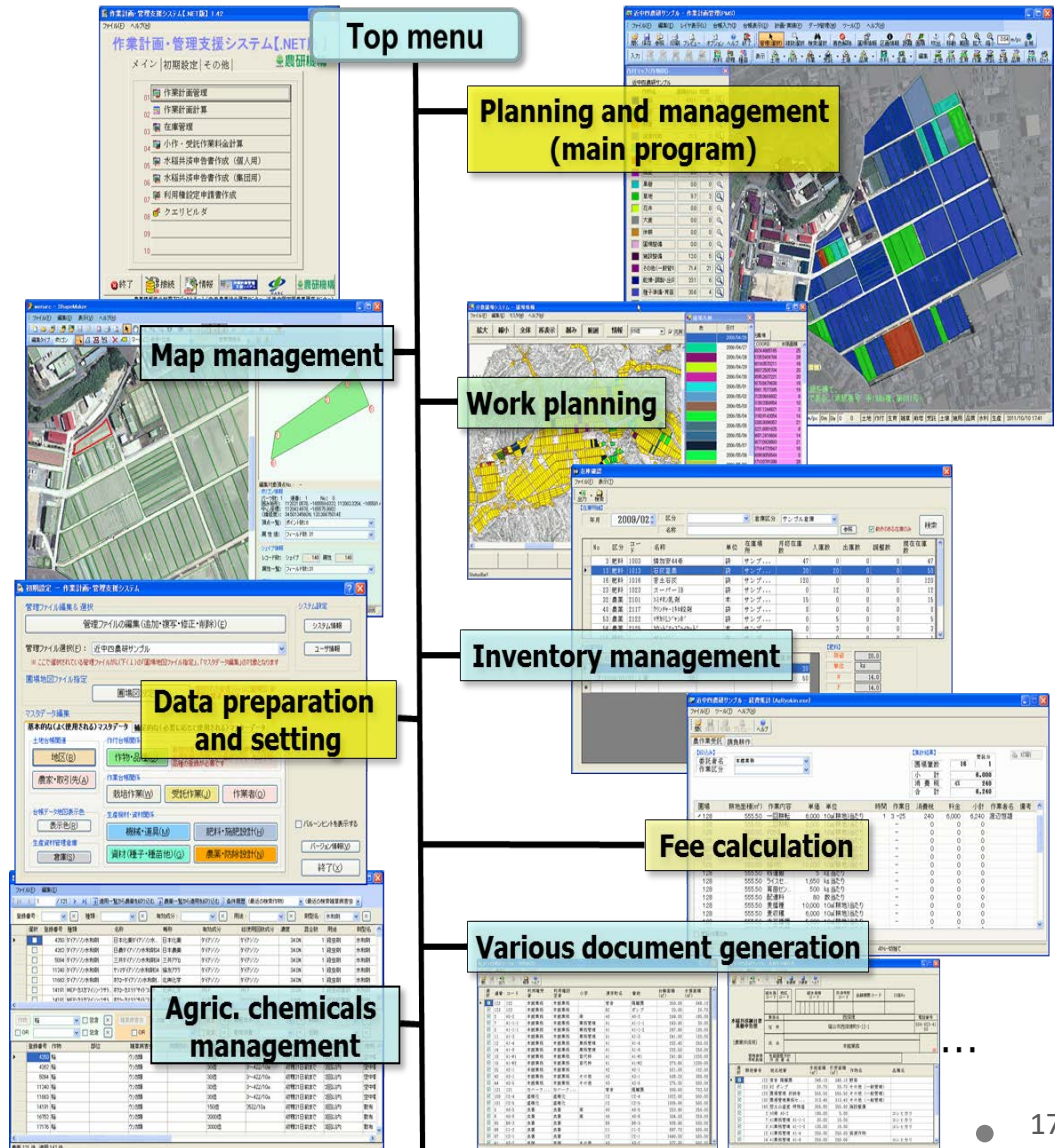




# GIS Based Farm Management System for large number of distributed plots

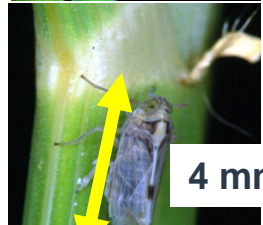


By Dr. T. Yoshida (NARO).



# Airborne pest immigration prediction

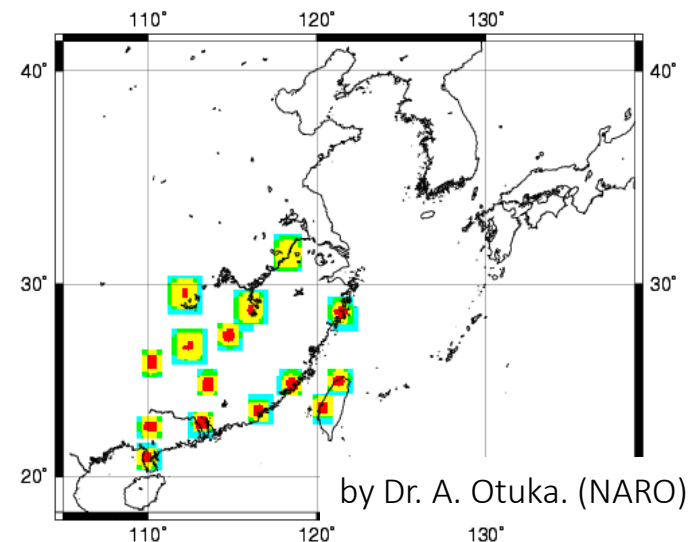
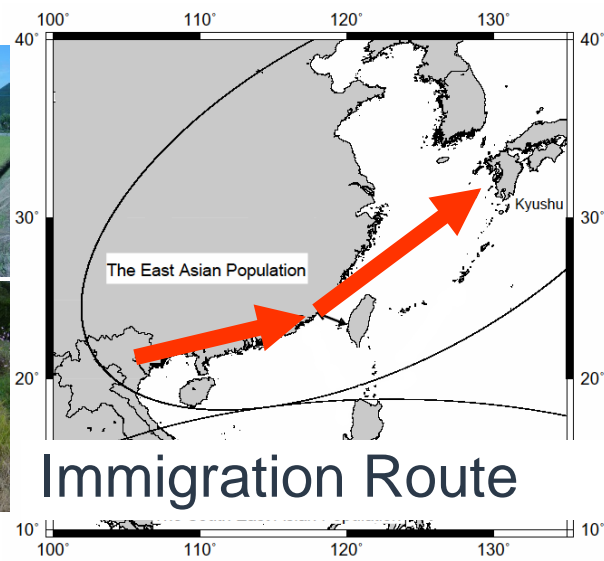
- Weather forecast to predict stream speed and direction
- Particle diffusion model to predict insect dispersion
- Identification taking-off origin
- Insect behavior model to estimate taking-off time



4 mm

3 mg

Rice Hopper





# Low cost fully automatic driving



ebay Shop by category Search... All C

Back to previous page | Listed in category: Consumer Electronics > Vehicle Electronics & GPS > GPS Units

**CASE IH TRIMBLE EZ STEER GUIDANCE KIT BU  
EZ-GUIDE 250**  
62000-50

1 viewed per hour

Item condition: **New**  
Time left: 1 day 15 hours Friday, 11:42PM

Price: **US \$2,185.00**  
Approximately JPY 248,183


**Buy It Now**

**Add to cart**

1 watching

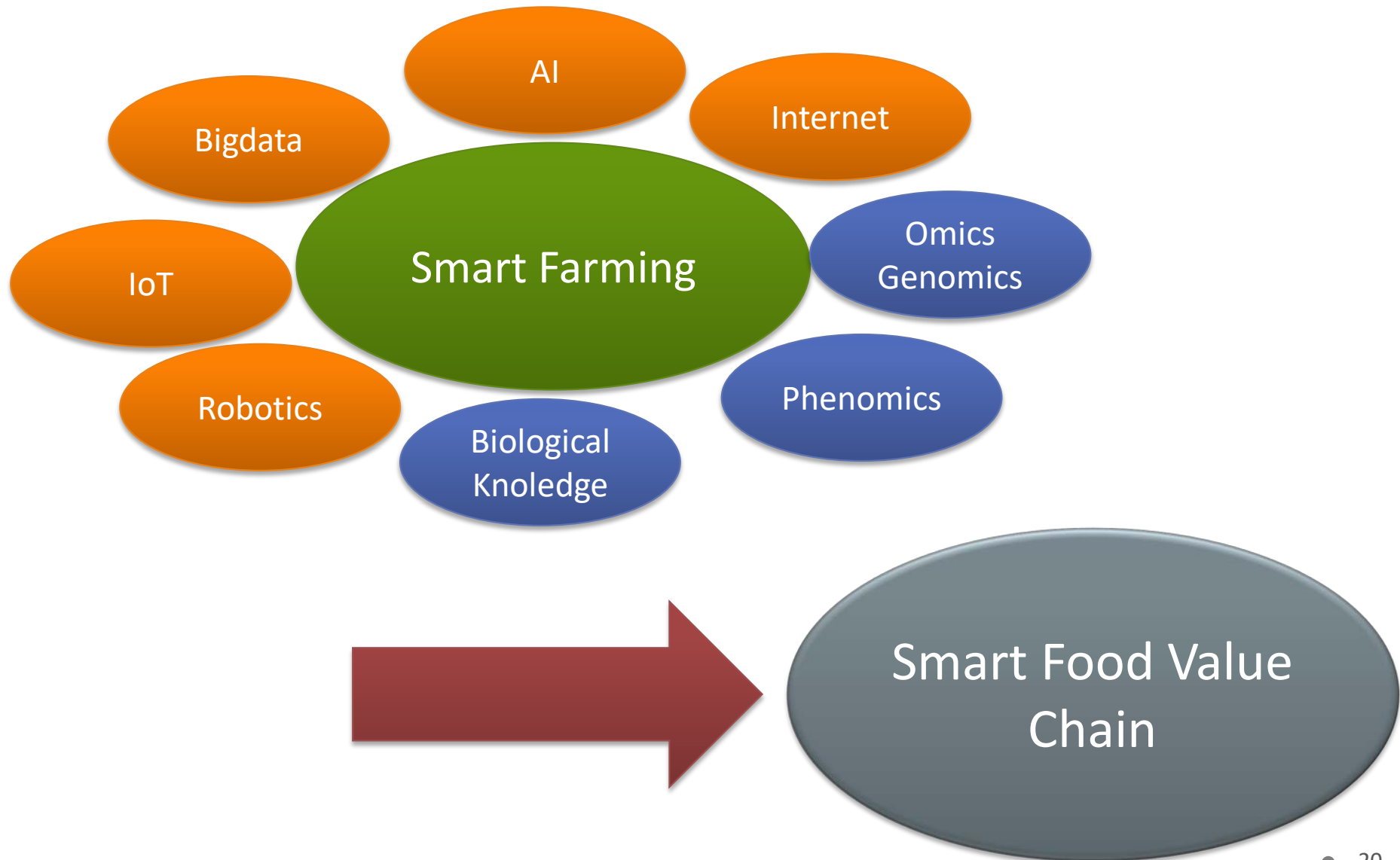
- Add to watch list
- Add to collection

**New** Condition   **Longtime** Member   **Fast and safe** Shipping



# CPS for the optimized solutions

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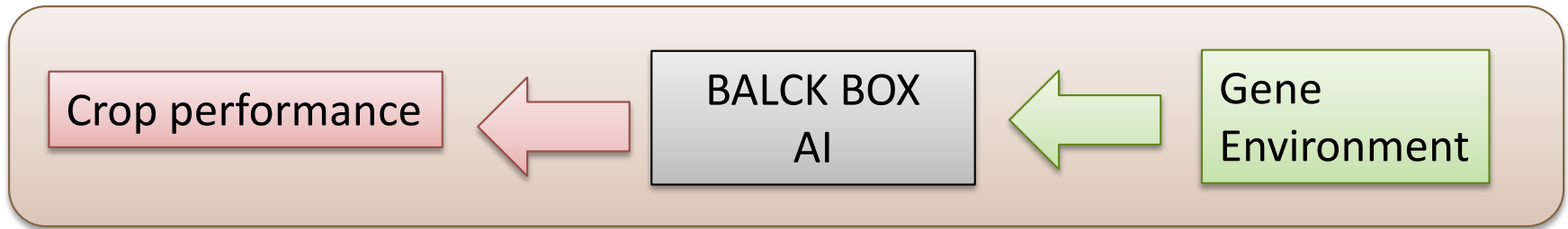
# We expect that CPS can contribute to solve very complex problems in food production and supply

- Improvement of production in sustainable ways
  - Productivity, quality, safety,....
- Improvement of information and knowledge transfer
  - Education, market information, technology information, weather data, pest information....
- Improvement of food supply chain
  - Efficient, loss-less logistics and processing,....
  - Food traceability for food safety
- Improvement of rural life
  - Online health care, education,....

# Possible solutions for sustainable and sufficient agricultural production with CPS

- Optimal crop management
  - Precision farming by small scale farmers
    - Optimal agricultural chemical management
    - Optimal resource (energy, water, land) management
  - Sharing of machinery, labor, logistics,....
  - Reduction of loss by optimal management
    - Diseases, pests, heat, drought, climatic change,.....
  - Food safety & quality
- Farm management
  - Accounting, purchase, sales, marketing
- Improvement of crop performance = breeding
  - Higher productivity
  - Resistance against biotic and abiotic stresses
    - Disease, pest, heat, drought, salinity
  - Resource saving genotypes
    - Less fertilizer and water requirement

# Field data collection is the core of CPS



- Environmental data
  - quite easy with IoT
- Genetic information
  - easy and fast by NGS
- Crop status monitoring
  - laborious and costly







- Drones are easy to fly and comparatively cheap
- Many different sensors are available
- Among several tools, drone crop monitoring seems to be promising



Hyperspectral image



Thermal image



Multispectral image





# Detection of heading of sorghum by drone images





# 3D reconstruction of peach orchard to estimate crown volume of each tree

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2016.09



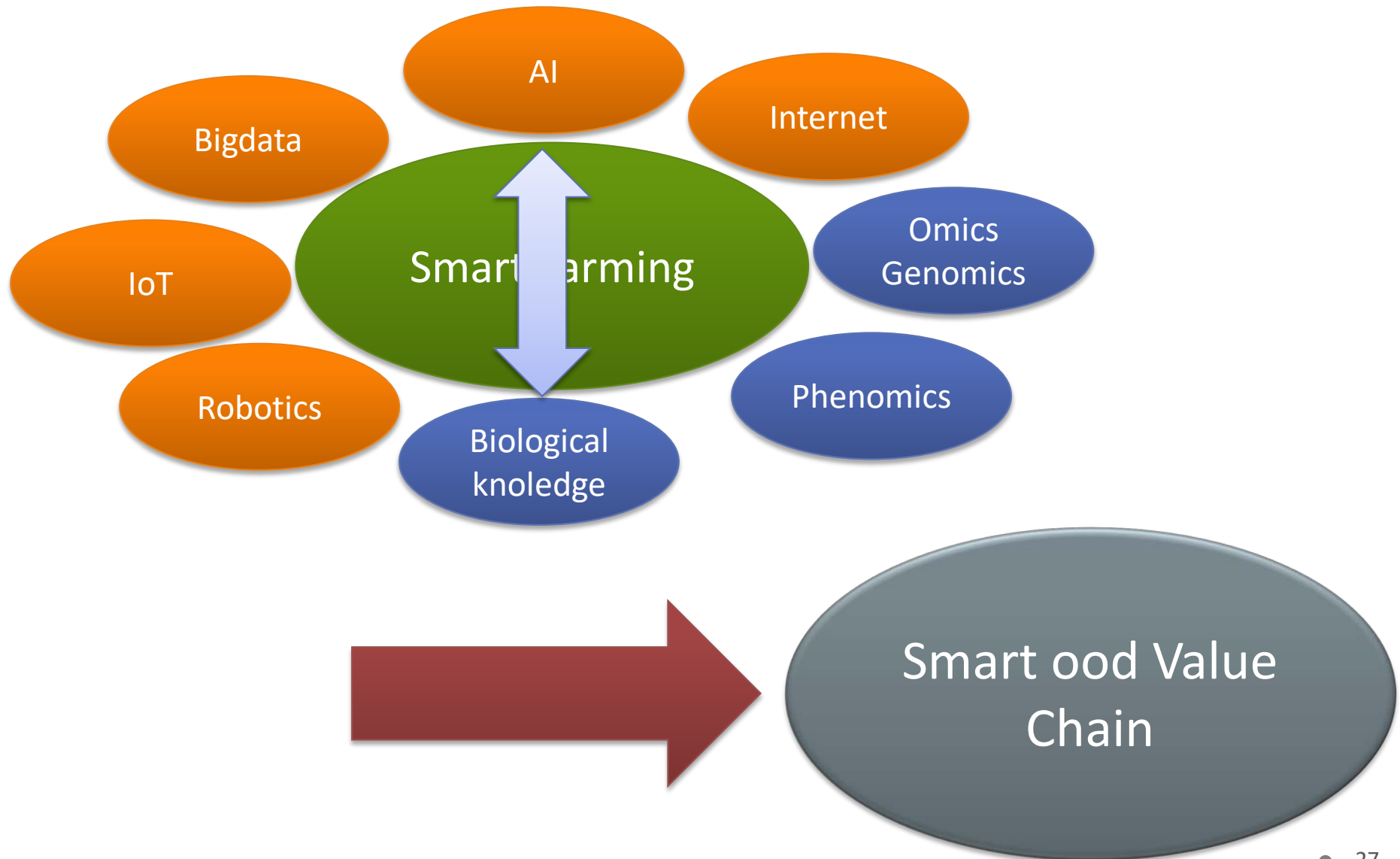
2016.12

SFM/MSV based software: Pix4d, Agisoft

UTokyo International Field Phenomics Research Laboratory

# For the optimized solutions

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# Impossible Burger




**IMPOSSIBLE**

[Our Burger](#) [Locations](#) [About Us](#) [FAQs](#)

## THE BURGER FORMERLY KNOWN AS PLANTS

Remember the best burger you've ever eaten? Our dedicated team of top scientists, farmers and chefs spent the last five years studying it from cow to bun. Then we identified methods and ingredients to naturally recreate everything – the sights, sounds, aromas, textures and flavors. The result? This impossibly delicious game changer of a burger.

Because we use 0% cows, the Impossible Burger uses a fraction of the Earth's natural resources. Compared to cows, the Impossible Burger uses 95% less land, 74% less water, and creates 87% less greenhouse gas emissions. And it's 100% free of hormones, antibiotics, and artificial ingredients.

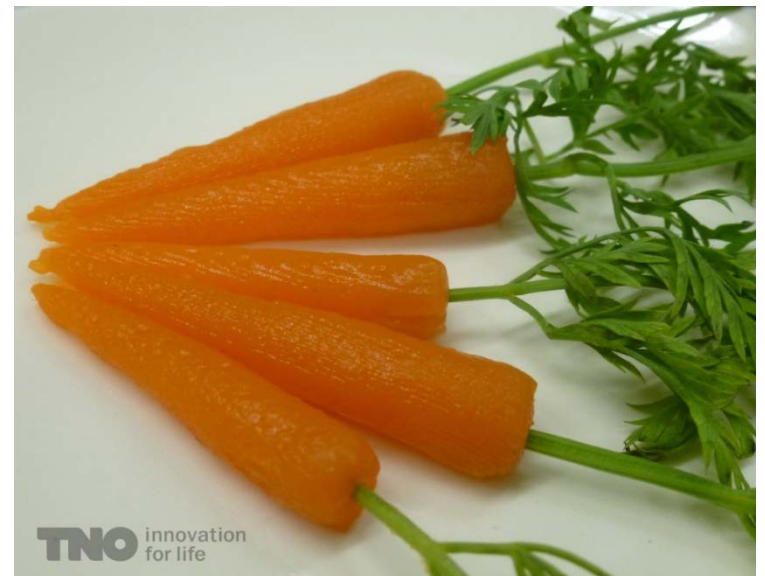




# Food 3D Printing

完璧にカスタマイズされた食

- 自由な形状
- 栄養バランス, 摂取エネルギー
- 固さ, テクスチャー
- 味
- 自分のコックさん







Thank you very much

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