Agricultural Transformation: The Evolution of Knowledge-Intensive Agriculture*

KEYNOTE PAPER

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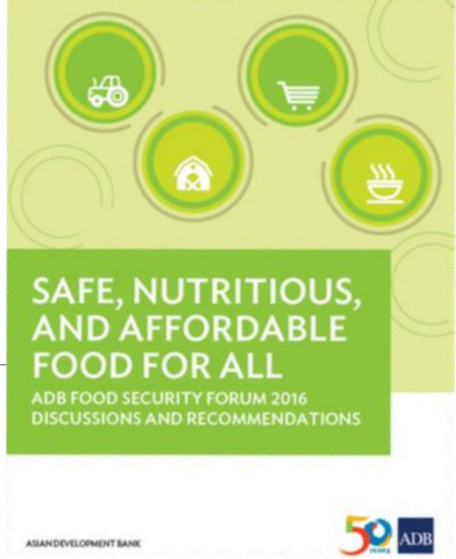
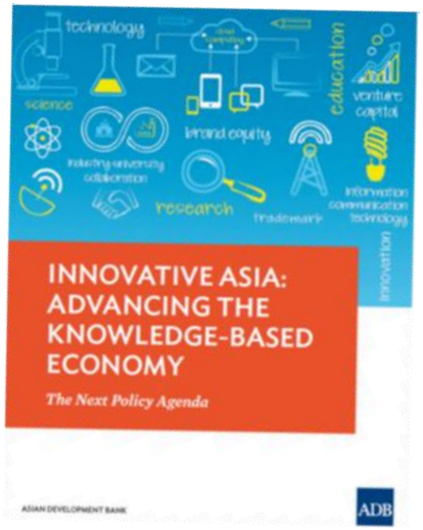
Outline

Video

- Stock-taking
- Emergence of knowledge-intensive agriculture
- Implications and way forward





Stock-taking

Transformation of human society

- Agricultural revolution – new knowledge about how to use inexpensive and abundant land
- Industrial revolution - new knowledge about how to use fossil fuels
- Knowledge revolution – new knowledge about how to use information technology

Agriculture in transition

As *Way of Life*

- Dependent on nature
- Supply-driven; depends on availability of land, inputs, favorable climate
- Subject to uncertainty of nature
- Risks to food security from harvest failure

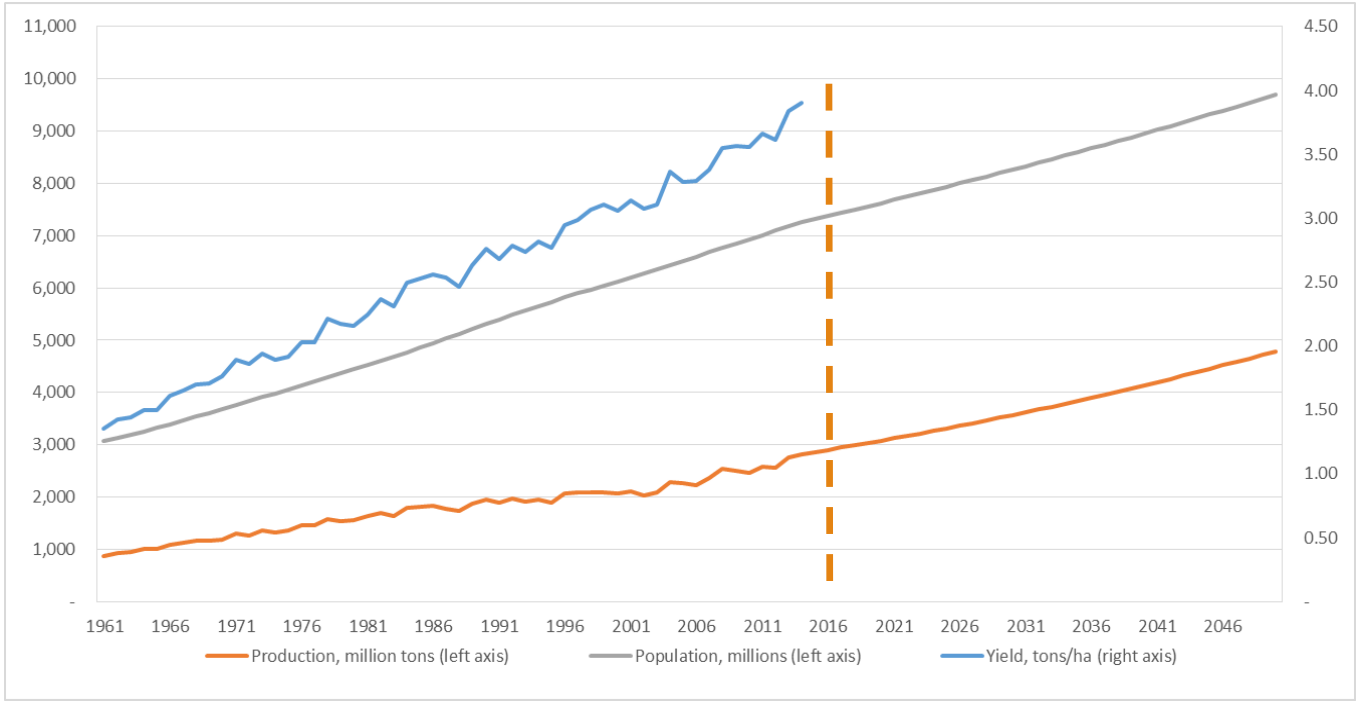
As *Way of Business*

- Dependent on technology
- Market-driven; utilizes knowledge and information
- Manage and mitagte risk
- Potential to bypass/leapfrog development phases

Technology and transformation of agriculture

- Result of industrial, scientific revolution
- Biology and chemistry - chemical inputs, modern varieties
- Mechanized cultivation, storage, transport, processing
- Resource intensive – higher cropping intensity

Enabled modern period of economic growth



Global trends in population and cereal production, 1961 – 2014; and projection to 2050

- Production outpaced population growth
- Annual growth rates
  - population: 1.6%
  - production: 2.2%
  - yield: 2.0%
  - per capita supply: increased 40%
- Can this be sustained?

Source: FAOStat; Projections from FAO (2012)

Structural Shift and Economic Growth

	In employment		In GDP	
	1970 (nearest year)	2015 (nearest year)	1970 (nearest year)	2015 (nearest year)
East Asia				
China	80.8	28.3	34.8	8.8
Japan	17.4	3.6	5.1	1.1
Korea, Rep.	50.5	5.2	27.5	2.3
South Asia				
Bangladesh	58.8	62.2	54.6	15.5
India	NA	49.7	42.0	17.5
Pakistan	57.3	48.4	36.8	25.1
Southeast Asia				
Indonesia	61.5	32.9	23.3	13.5
Philippines	50.4	29.1	29.5	10.3
Thailand	76.7	32.3	25.9	9.1

- Science and technology transformed all sectors – per capita output increased
- Agri growth outpaced by industry, services growth
- Employment and GDP share of agri has fallen

Sources: World Development Indicators; FAOStat

Other structural changes

- Demographic shifts: urbanization, aging rural population, higher female labor force participation
- Changing food habits and preferences
  - More animal proteins, fruits and vegetables
  - More packed/processed foods
  - Higher quality standards

https://commons.wikimedia.org/wiki/File:Supermarket_in_Sigatoka,_Fiji_5.jpg

Resource limits

- Land expansion no longer possible
- Pasture land overgrazed
- Water resources depleting
- Fish stocks vanishing
- Habitats being lost
- Worsening impact pollutions from industry and agri-chemicals on land, water, ecosystems, and human health

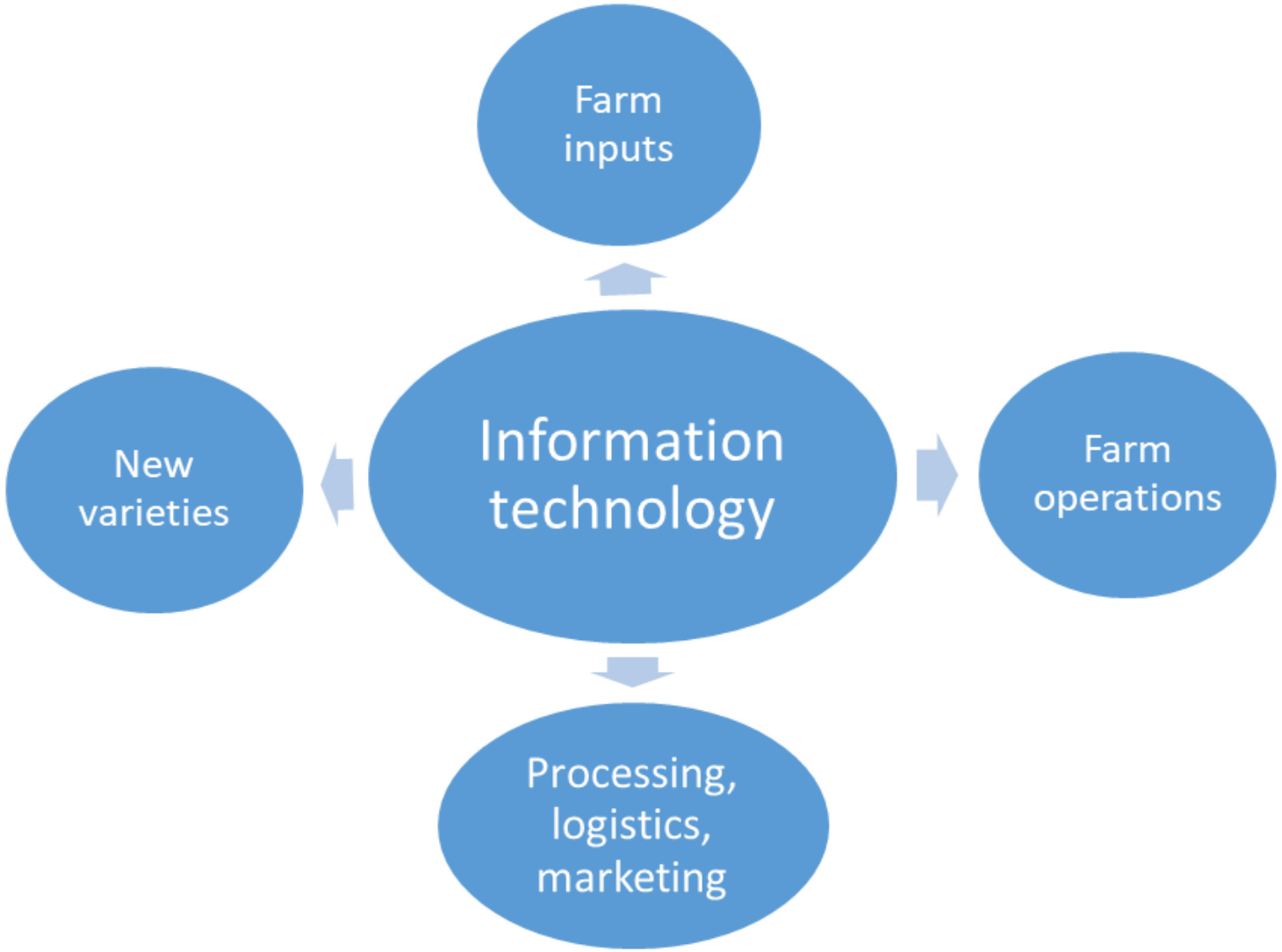
The era of climate change

- Worsening extremes: frequent droughts, coastal flooding, cyclones
- Overall: harsher environment for agriculture (especially in tropics)
- Significant carbon footprint from agricultural activity
- Conventional agriculture at risk

Emergence of knowledge-intensive agriculture

- Radical advances in information technology
- Knowledge becomes main inputs

Emerging technology: sophisticated application of IT



Variety development using bioinformatics

Genetic engineering using recombinant DNA technology

- Requires bio-informatics (IT for biology)
- Bt crops: reduced pesticide use, losses from pests – corn, cotton; other GM crops – soybean, potato

Photo: http://parrottlab.uga.edu/SIVB/HTML/102660-bt%20corn%20ears.html

Precision inputs - Nanotechnology

Manipulation of materials at nanoscale

- Agri-chemicals
- Food processing - enhance food quality and reduce food losses

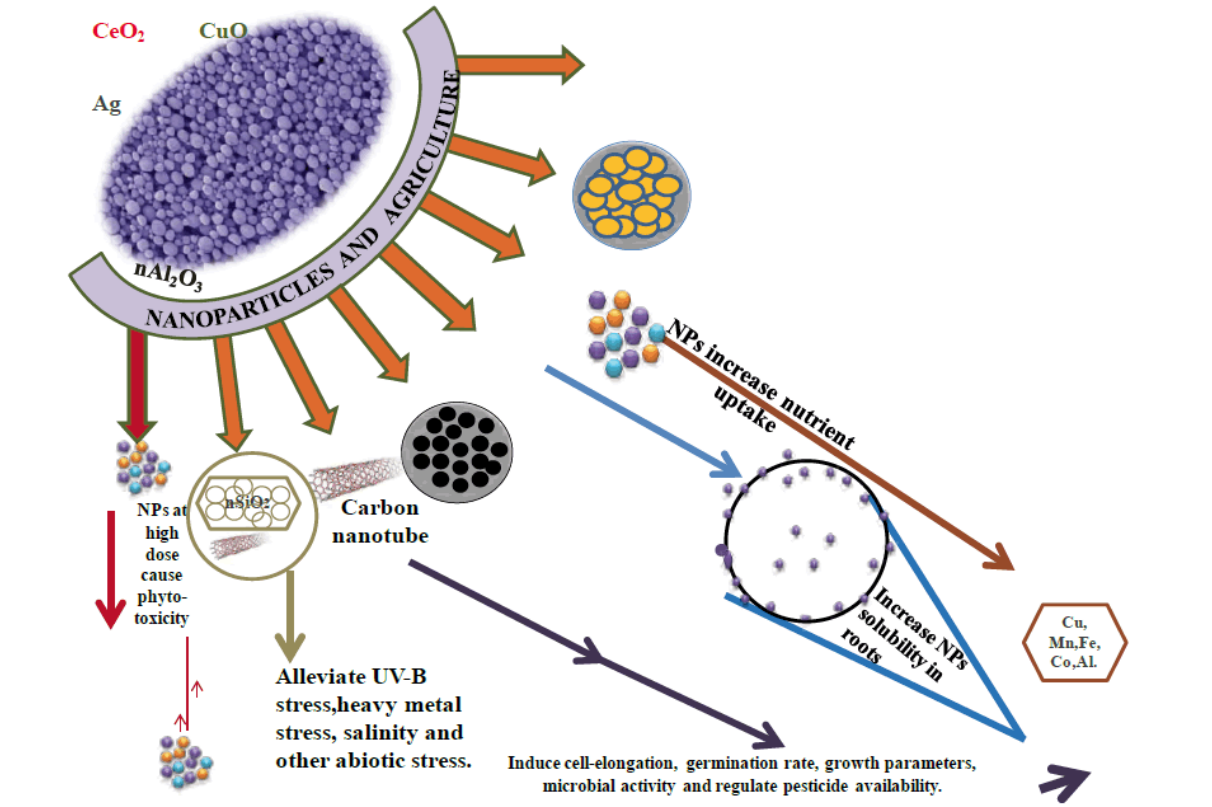
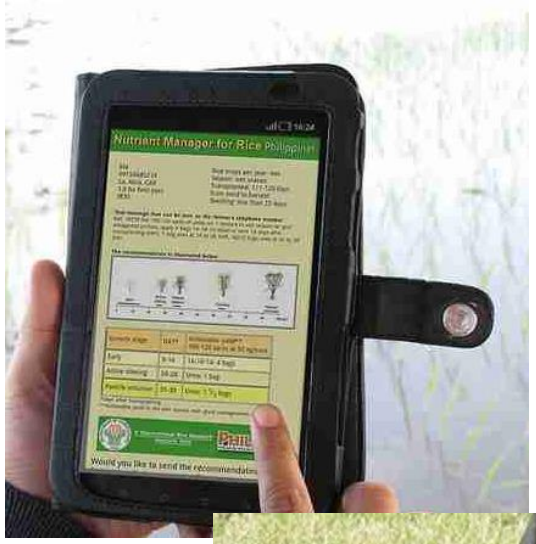


Figure 1: Nanoparticles (NPs) (metal NPs, Metal oxide NPs and carbon nanotubes) at optimum dose increases chlorophyll content, release of required chemicals, nutrient uptake, NPs solubility, cell elongation, germination rate, growth parameters, microbial activities and crop productivity [3,4,12,15-17,20-41], while at high dose cause phytotoxicity by reducing crop yield and productivity [26-33,38].

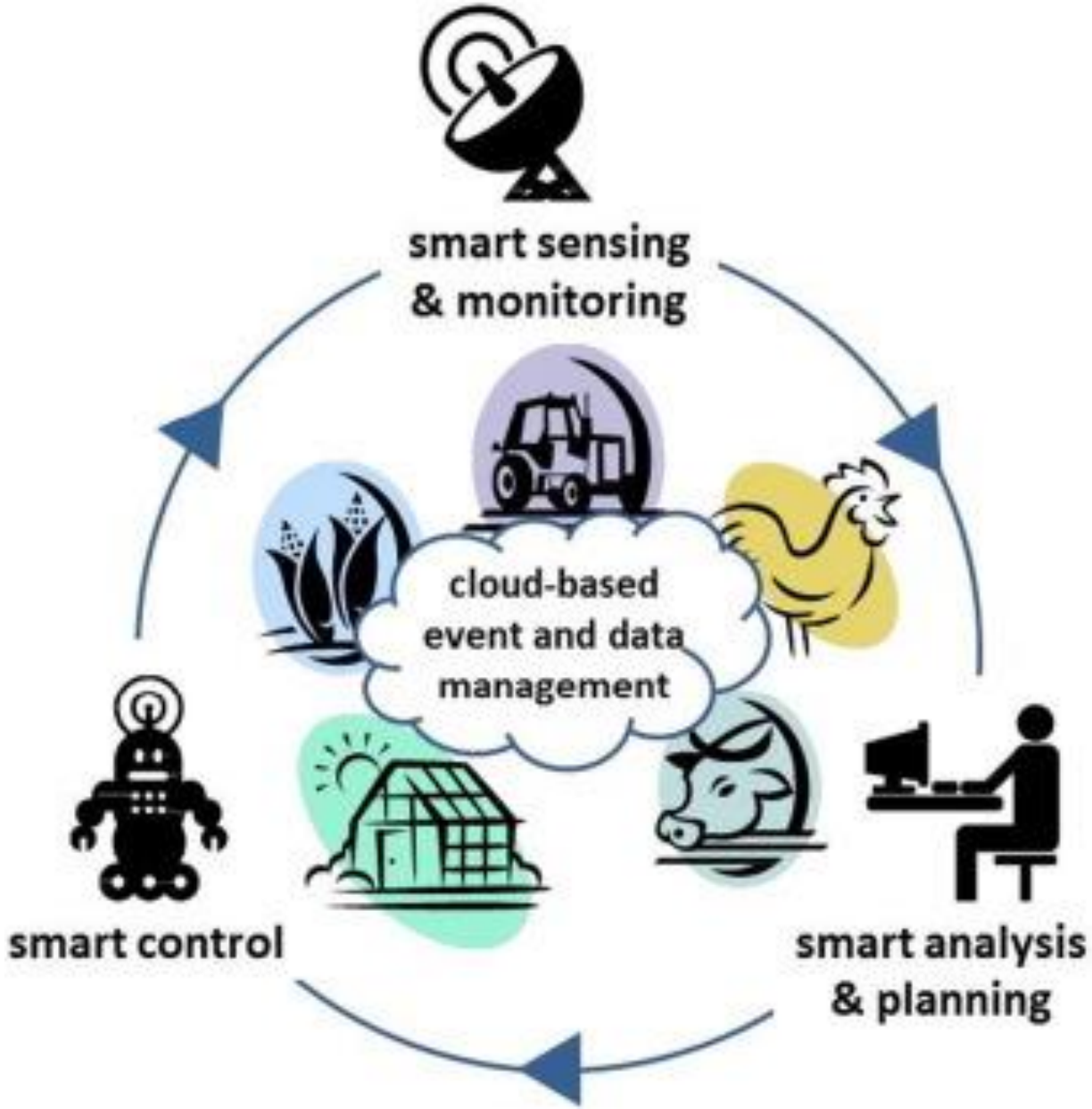
Figure: https://www.omicsonline.org/articles-images/environmental-analytical-toxicology-optimum-dose-increases-6-397-g001.png

Precision in farm operations

- Precision agriculture – based on automation, sophisticated use of data
- Collect, organize Big Data - from handheld devices, trackers, drones, remote sensing



Photos: http://irri.org/news/media-releases/feeding-rice-just-got-easier-with-smartphones; https://nova.adalidda.com/posts/JixAuYXBSSFhs3YbA/role-of-unmanned-aerial-vehicles-in-precision-farming; Creative Commons/Dohduhdah



Smart farming based on autonomous systems

e.g. delivers precise quantities of water, fertilizer to plots/plants

Photo: http://www.pigza.de/bewaesserungsschlauch-2/; infograph – Wolfert et al (2017), p. 70

Smart greenhouses

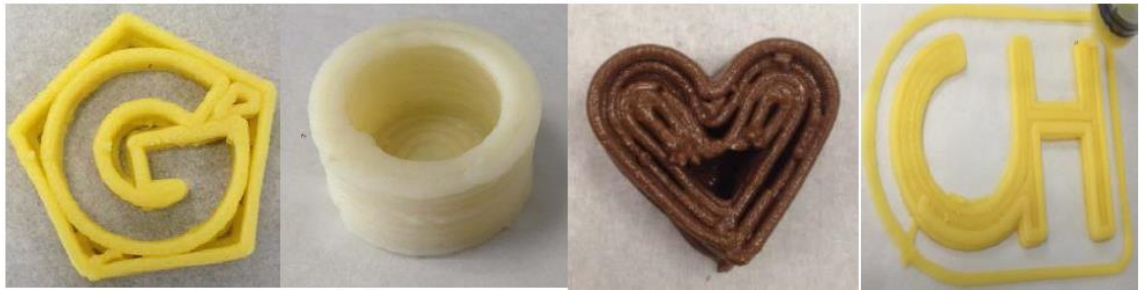
- IT enables increased control over microclimate of greenhouses – temperature, humidity etc.

- Installation of environment and remote sensors; automated system of heat and moisture control, watering, fertilization, maintenance

Source: Yang and Cheng (2015)

IT in whole food value chain

- New packaging/processing techniques – reduce food wastes
- Smart manufacturing
- Logistics information systems
- E-commerce/online marketing



Photos: ADB; Sun et al (2015), pp 311, 317

Coconut Water-Coconut Wa

https://www.alibaba.com/products/F0/coconut_water/--PH----------1222-988----- 110% Search

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Gross Weight(kg) | kg | Gross Volume(m³) | m³

Trade Terms | CIF

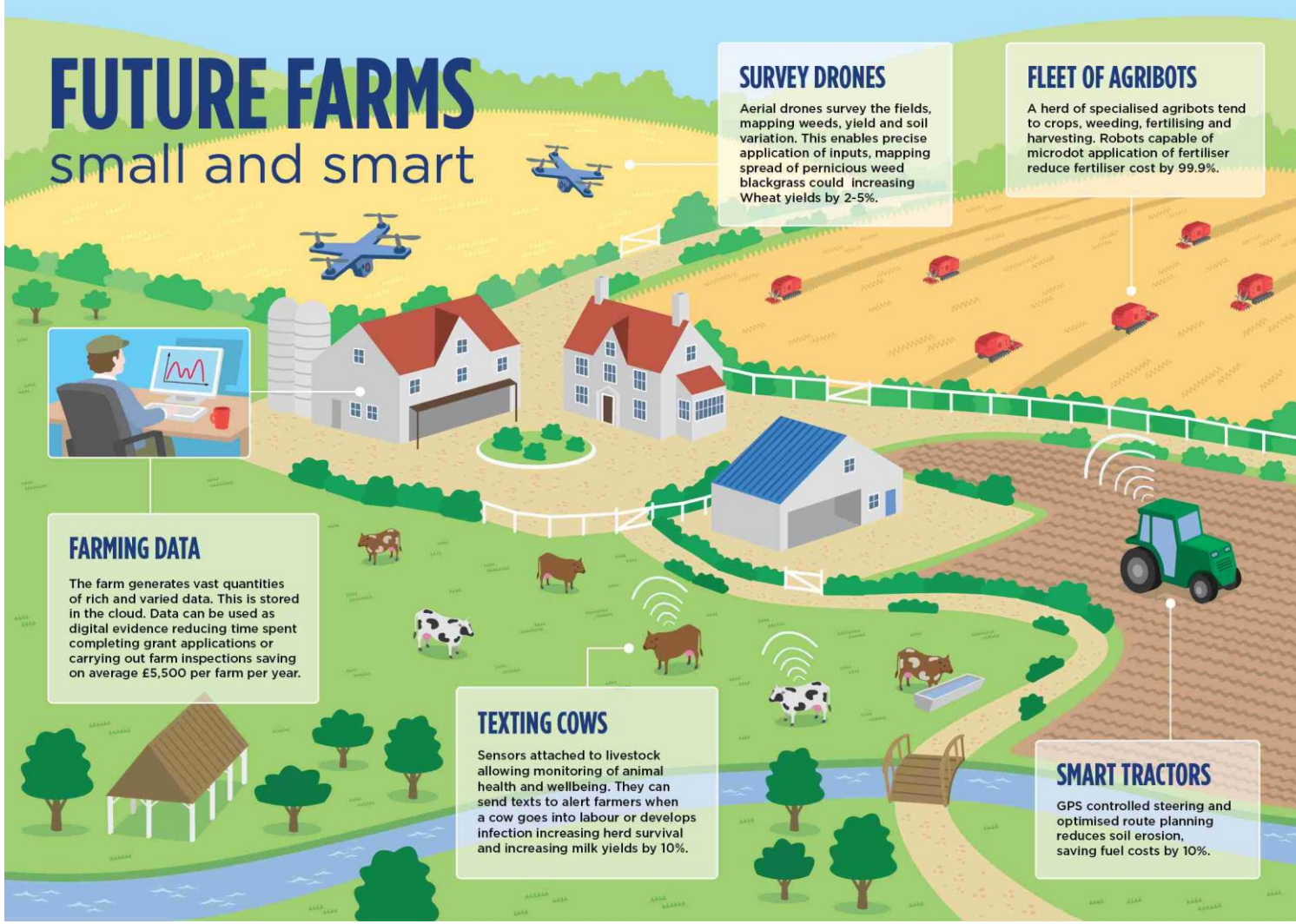
Future applications

- Promotion of food safety – traceability, hygienic processing and handling
- Plant and animal health: Development of plant and animal varieties resistant to disease – Tilapia lake virus (TiLv), avian flu, Panama disease
- Continued yield improvement: Rice genetically engineered for c4-photosynthesis

Photo: https://commons.wikimedia.org/wiki/File:Fresh_tilapia.jpg; https://commons.wikimedia.org/wiki/File:Chicken_Farm_034.jpg

The future of farming

Smart farming as the norm



Infograph: http://www.nesta.org.uk/news/precision-agriculture

Implication and way forward

Inclusion and Access

- Competition and efficiency
  - Can small-scale operations access knowledge-intensive technology and reap benefit?
  - Gender inclusion
- Will finance be a constraint?
- Can the scale and operations management issues be overcome?

Future challenges: Environment

- **Biotechnology**:
  - Possible adverse impacts on environment: on non-target species, gene flow, soil ecology
  - Perpetuate cycle of pesticide resistance
- **Nanotechnology**: effect of ingestion/dispersal of nanoparticles – few risk assessments available

Future challenges: Socioeconomic impact

- Continued structural transformation
- Farmers, MSMEs may be left behind
- Land fragmentation in Asia may reverse – automated systems → consolidation?

Shares of agriculture (%) by 2040:

	in GDP	in employment
PRC	<5	22.8
Bangladesh	<5	34.9
India	<5	33.5
Pakistan	<5	33.6
Cambodia	17.1	61.1
Indonesia	<5	24.2
Philippines	<5	5.7
Thailand	<5	<5
Vietnam	<5	36.3

Source: Briones and Felipe (2013).

Way forward

- Harness knowledge innovations to promote sustainability and inclusiveness
- Manage Sustainability: apply Big Data analytics to resource and environmental issues
- Create Inclusiveness: support for services, institutions, financial access, responsible private sector, technologies that expand access of smallholders

Way forward: Inclusiveness

- Farmer education , e-extension
- Organization of farmers – consolidation of operations
- Outsourcing to specialized service providers
- Finance - mobile payments and savings; credit scoring
- Efficiencies in trade and logistics – better price discovery, stability of markets
- Big data for better-designed risk instruments, e.g. weather-based insurance

Thank you!