New Agricultural Technologies for Sustainable AgriFood Systems in ASEAN: Challenges and Opportunities

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ASEAN – the current agrifood landscape

- Segmented use between arable land (food security) and permanent crops (export income)
- Land loss to non-agriculture uses and competition for water and labour from other sectors
- Food security robustness in most ASEAN countries less than optimal
- Still high prevalence of hunger and under-nutrition and emerging urban “over-nutrition” with NCDs
- ASEAN produces much but still depends on imports from outside region to meet needs for animal feed and wheat
Agricultural land use in Southeast Asia:

**Arable land per capita in Southeast Asia is about 0.12 ha.**

<table>
<thead>
<tr>
<th>Land-use Classification in Southeast Asia</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land area</td>
<td>434,070</td>
<td>434,070</td>
</tr>
<tr>
<td>Agricultural area</td>
<td>129,257</td>
<td>130,562</td>
</tr>
<tr>
<td>a. Arable land</td>
<td>68,412</td>
<td>69,504</td>
</tr>
<tr>
<td>b. Permanent crops</td>
<td>43,807</td>
<td>44,019</td>
</tr>
<tr>
<td>c. Permanent meadows and pastures</td>
<td>17,038</td>
<td>17,038</td>
</tr>
<tr>
<td>Forest area</td>
<td>212,978</td>
<td>211,892</td>
</tr>
<tr>
<td>Other land</td>
<td>91,835</td>
<td>91,617</td>
</tr>
</tbody>
</table>

*Arable land is about 16% of total land area in SE Asia*

*10% in plantation crops*

*About 3% loss in productive cropland per year .... C.B. D’Amour et al (2017)*

*Source: Faostat*
### ASEAN Agriculture

*Agriculture’s contribution to GDP is declining; it is still an important source of livelihood to many people in lower-income economies; Agribusiness is a major value multiplier*

<table>
<thead>
<tr>
<th>Country</th>
<th>Employment in Agriculture, % of total employment, 2015</th>
<th>Agriculture, % of GDP 1990</th>
<th>Agriculture, % of GDP 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>-</td>
<td>0.98</td>
<td>1.1</td>
</tr>
<tr>
<td>Cambodia</td>
<td>64.3 (2014)</td>
<td>50.12</td>
<td>28.2</td>
</tr>
<tr>
<td>Indonesia</td>
<td>32.9</td>
<td>17.55</td>
<td>14.0</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>72.2 (2010)</td>
<td>45.06</td>
<td>24.8 (2014)</td>
</tr>
<tr>
<td>Malaysia</td>
<td>12.5</td>
<td>14.89</td>
<td>8.6</td>
</tr>
<tr>
<td>Myanmar</td>
<td>-</td>
<td>57.26</td>
<td>26.7</td>
</tr>
<tr>
<td>Philippines</td>
<td>29.2</td>
<td>19.14</td>
<td>10.3</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.1</td>
<td>0.34</td>
<td>0.0</td>
</tr>
<tr>
<td>Thailand</td>
<td>32.3</td>
<td>10.01</td>
<td>9.1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>44.0</td>
<td>38.74</td>
<td>18.9</td>
</tr>
</tbody>
</table>

Source: ADB Key Indicators 2016

➢ 100 Million Smallholder Farmers
<table>
<thead>
<tr>
<th>Country</th>
<th>ASEAN: Top 3 World Ranking in Many Agri-Food Commodities Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>Rice, vegetables, fruits; chickens, eggs</td>
</tr>
<tr>
<td>Burma</td>
<td>#2 pigeon peas, beans; #3 mustard seed</td>
</tr>
<tr>
<td></td>
<td>Rice, vegetables, fruits, groundnuts, sugarcane</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Rice, cassava, maize, vegetables, sugar cane</td>
</tr>
<tr>
<td>Indonesia</td>
<td>#1- palm oil, cloves, cinnamon, coconuts; #2 – rubber, nutmeg; #3 – rice, coffee, cassava</td>
</tr>
<tr>
<td></td>
<td>Sugar cane, maize, bananas, fruits,</td>
</tr>
<tr>
<td>Laos</td>
<td>Rice, vegetables, sugar cane, maize, cassava, sweet potatoes</td>
</tr>
<tr>
<td>Malaysia</td>
<td>#2 – palm oil; #3 - rubber</td>
</tr>
<tr>
<td></td>
<td>Rice, chicken meat, sugar cane, coconuts</td>
</tr>
<tr>
<td>Philippines</td>
<td>#2 – coconuts, pineapple; #3 - bananas</td>
</tr>
<tr>
<td></td>
<td>Sugarcane, rice, maize, vegetables, fruits</td>
</tr>
<tr>
<td>Singapore</td>
<td>Eggs, vegetables, fish</td>
</tr>
<tr>
<td>Thailand</td>
<td># 1 –rubber, rice, pineapple; #2- eggs; #3 – palm oil sugar cane, cassava, maize, fruits</td>
</tr>
<tr>
<td>Vietnam</td>
<td># 1- cashew pepper; #2 - coffee, rice; # 3 – cinnamon</td>
</tr>
<tr>
<td></td>
<td>Sugar cane, cinamon cassava, vegetables, maize, pig meat, fruits</td>
</tr>
</tbody>
</table>

*Source: FAOSTAT*
ASEAN demographics is changing fast and driving changes in food demand and diet

**ASEAN in 2012 was already 51% urban!**

<table>
<thead>
<tr>
<th>Country</th>
<th>2012</th>
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<tbody>
<tr>
<td>Brunei</td>
<td>76.0 (2011)</td>
</tr>
<tr>
<td>Cambodia</td>
<td>22.0</td>
</tr>
<tr>
<td>Indonesia</td>
<td>49.8 (2010)</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>34.2 (2011)</td>
</tr>
<tr>
<td>Malaysia</td>
<td>72.4</td>
</tr>
<tr>
<td>Myanmar</td>
<td>30.8</td>
</tr>
<tr>
<td>Philippines</td>
<td>48.9 (2011)</td>
</tr>
<tr>
<td>Singapore</td>
<td>100.0</td>
</tr>
<tr>
<td>Thailand</td>
<td>45.1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>31.9</td>
</tr>
</tbody>
</table>

Source: ADB Key Indicators for Asia and the Pacific. 2013

The Growing ASEAN Middle Class!

Have disposable income of US$ 16 - 100 per day in 2012

• *Estimated to grow to 400 Million by 2020!*

Food Demand Changes in South East Asia

• Most food is purchased
• Reduced per capita consumption of rice, e.g. Singapore, 47 kg
• Increased diversity in the food groups consumed
• Rise in high proteins and energy dense diets
• Rising popularity of convenience food and beverages; Westernization of diets
• More vulnerable to food price shocks
• Increased consumption per capita of wheat and wheat-based products

In 2017/18, Indonesia expected to become world’s largest wheat importer, at 12.5 M tons!

.....USDA
ASEAN Relies Heavily on (Imports) Trade to Meet its Food Needs

Overall ASEAN Trade, first Half of 2010s

Source of Basic Data: UN Comtrade

- ASEAN imports more from outside ASEAN than from within the region
  - Soybean, Corn, Wheat are major imports
- ASEAN exports more to outside ASEAN than to the region

One reason for continuing debate about food self-sufficiency versus self reliance (based on ability to import)

Courtesy of Dr. Ramon Clarete, UPLB, 2015.
Nutrition Security: Annual income spent on food and malnutrition rate, 2008

- Higher % household income spent on food, More malnutrition
- Micronutrient deficiencies higher in poor households

Courtesy: GAIN. 2015.
“Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active life.”


Four Dimensions of Food Security

- **Food Availability**
  Production, Imports, Stockpiles

- **Food Access (Physical)**
  Access to markets, Logistics & Infrastructure,
  Trade (Supply chains), Storage & processing facilities

- **Food Access (Economic)**
  Safety nets, Food pricing, GDP per capita

- **Food Utilization**
  Nutrition & Health, Food Safety, Sanitation & Hygiene
Agrifood systems may be described by their supply chains. Supply chains start at the input and production (agriculture) end, and commonly finish with consumers.

Sustainability of production systems and supply chains are continually challenged.

Describe the challenges as “Disruptors”

- 100 Million Smallholder farms in ASEAN
- Monocropped & Mixed enterprises
Direct negative disruptors on agrifood systems

**Food Availability**
- Production
- Imports
- Stockpiles

**Food Access (Physical)**
- Logistics & Infrastructure
- Trade (Supply chains)
- Storage & processing facilities

**Food Access (Economic)**
- Food pricing
- GDP per capita
- Safety nets

**Food Utilization**
- Nutrition & Health
- Food Safety
- Sanitation & Hygiene

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- Severe Weather
- Natural calamities
- Pest & Disease outbreaks
- Input shortages
- Pandemics

- Rising energy prices
- Sudden Policy changes e.g. trade
- Lower holdings of cereal stocks (Hoarding)
- Diversion from staple to cash crops
- Conflict or Terrorist activities
- Artificial Price hikes
- Alternative Uses of Biomass
- Trade wars

- Food safety, contamination
- Diet changes from urbanisation
- Human health crises (e.g. SARS)
- “Adventitious” presence

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Food Security Dimensions
**Mid to long term negative disruptors**

- Climate change
- Demographic changes (Urbanisation, Declining no. of farmers)
- Poverty (Increasing gap between “haves” and “have-nots”)
- Underinvestment in infrastructure/technology
- Degradation of land and water resources for agriculture
- Unfriendly policies towards farmers
- Attracting new players into agrifood systems with strong livelihood and economic incentives
- FOOD FRAUD

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**Food Availability**
Production, Imports, Stockpiles

**Food Access**
(Physical)
Logistics & Infrastructure, Trade (Supply chains), Storage & processing facilities

**Food Access**
(Economic)
Food pricing, GDP per capita, Safety nets

**Food Utilization**
Nutrition & Health, Food Safety, Sanitation & Hygiene
Meeting the challenges (disruptors): Essentials and enablers

• Essentials (Imperatives)
  – Technology (and Scientific knowledge)
  – Infrastructure
  – Human Resources

• Enablers
  – Policies and regulations (science-based)
  – Financing
  – MultiStakeholder Partnerships (MSPs)

Opportunities
Types of technologies in agrifood systems

• **Bio-products (technologies)**
  – Improved Seeds to
    • Narrow yield gaps
    • Adapt to climate change
    • Improve nutritive value
  – Biofertilizers and other soil enhancers
  – Biopesticides

• **Physical** technologies for improving productivity and efficiency
  – Fertilizers, pesticides, Nanotech-based applications etc.

• **Mechanical** technologies
  – Drones, Sensors, sprayers

• **Integrated Knowledge (Digital)** technologies
  – Integrated systems (KIA), mobile devices
Disruptive innovations (in agriculture)

• First wave: Green Revolution technologies of improved seed, fertilizer, pesticides, irrigation and mechanization (1960s…..)

• Second wave: GM Biotechnology (1996 ….)

• Third wave: Digital – Biological integrated technologies (2000….)
  – “Agtech” – KIA, digital revolution, 4th Industrial Revolution, Biotech revolution
  – “Fintech”

• Fourth wave:
  – Gene editing Biotech
  – Food without agriculture
Disruptive innovation #1 DIGITAL

Agriculture is the least digitized industry

The 4th Industrial Revolution --- Digital Technology

Knowledge Intensive Agriculture: The New Disruptor in World Food?

By Paul Teng

Source: AgFunder
Digital agriculture: “Internet of things” (IoT)

AgFunder: “$4.6B invested in AgTech (2016)”

“Data-Enabled Agriculture”

“Knowledge Intensive Agriculture”

Knowledge Intensive Agriculture: The New Disruptor in World Food?

By Paul Teng

“Technology Enabled Farming (TEF)”

“Extensive Farms”

Can technology-enabled urban farms be a winner for S’pore?

By Paul Teng and Christopher Vas

Singapore needs to deepen its interests in food production, not just consumption, with strategic partners like Australia. One approach to this is redirecting some of its tech, digital strategies and sharing of IoT to scaling up smart food zones based on technology-enabled farming (TEF).

The company founders have set up their next agtech ventures and are on the path to urban farming 2.0. So, arguably the investment, technology and operating costs show promise. What about the consumer market? Also, with Singapore’s land constraints, how would an urban farm here commercialise and scale up?
Technology Enabled farming: Archisen Indoor Farm, Paya Lebar, Singapore

> 120 “Plant Factories” now in commercial production in Japan
Disruptive Innovation # 2: Breeding Technologies

Gene-Editing biotechnologies (CRISPR, TALENs, Zinc Finger Nucleases)

- **Capability** – Ability to edit *native crop genes* coding for important traits and generating **non-transgenic plants**
- **Four Comparative Advantages over Conventional/GM**
  1. **Precision** – more precise, similar to natural mutations, no new material inserted in the genome
  2. **Regulation** – science-based, fit-for-purpose, proportionate and non-onerous regulation – several countries have classified genome-edited as non-GM
  3. **Speed** – substantially faster
  4. **Cost** – faster-speed and less onerous regulation translates to significant cost savings
- **Genome-edited crops** being improved include, soybean, maize, wheat, rice, potato, tomato, and peanuts
To meet the 50% increase in food demand by 2050 requires **biotechnology**

- **Reduce Food Preparation Losses**
  - **Non-browning technology**
  - **Insect resistance**

**Enhanced nutrition** (Biofortification)

**New Breeding Technologies: A Disruptive Innovation**

- Gene-Editing biotechnologies (CRISPR, TALENs, Zinc Finger Nucleases)
Technologies not fully utilized but with high potential impact on food production in ASEAN

Adaptation technology: New Sub1 lines after 17 days submergence in field at IRRI, Philippines

B.t. Eggplant

Submergence-tolerant rice

Ringspot Virus-resistant papaya

Two varieties of papaya resistant to papaya ringspot virus have been developed using biotechnology; SunUp, left, and Rainbow, right. They have performed well for Hawaiian growers, even under prolonged and heavy disease pressure.
Beyond conventional food: New food technologies for Future Food (without agriculture!)

Artificial vegetable protein

Meat Alternative Protein (MAP) versus Animal Sourced Food (ASF)

“Impossible Foods”, Redwood City, CA. $75M
Plant-based meat and cheese substitutes
- Hamburger patty that bleeds

Haem (animals) = Heme (plants)

Source: The Economist, March 7 2015

Animal protein without animals

- Hamburger meat from the lab
- Animal protein without killing animals
- Technology-enabled food farming

From $350 to $25 per hamburger patty
From Food & Nutrition Security (current) to Food & Nutrition Sustainability (long term)

The Big Challenge

ENSURE UNINTERRUPTED, ADEQUATE SUPPLY
Of
MORE NUTRITIOUS & SAFE FOOD
(quantity and quality)
Produced with
LESS LAND, LESS WATER, LESS LABOR
(less chemicals)
Under
LESS PREDICTABLE WEATHER

Which technology (or set of technologies) is most appropriate and acceptable in ASEAN?
Thank you - 谢谢 - Terima Kasih - ขอขอบคุณ - ขอบใจ - Maraming selamat - cảm ơn - นับพร้อมธุรกิจ-
Thank you

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