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OF INTERNATIONAL STUDIES**
A Graduate School of Nanyang Technological University

The Potential of Biotechnology to Strengthen Sustainable Agriculture

– *An Asian Perspective*

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An Institute of **NANYANG
TECHNOLOGICAL
UNIVERSITY**

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Asia: A contrasting scorecard

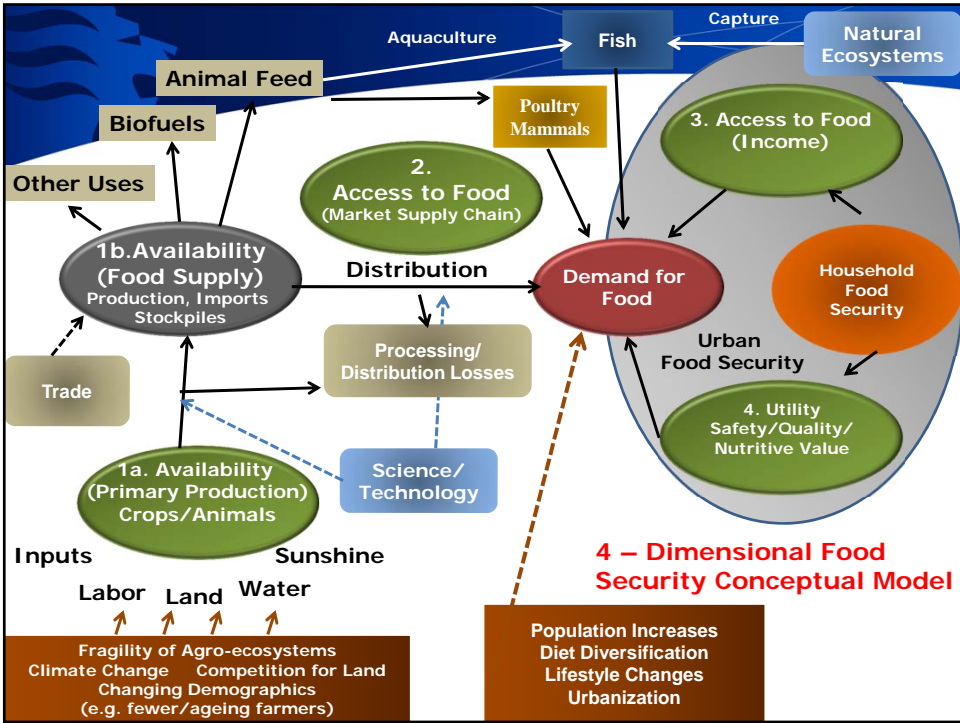
- 60% of world's population
- 34 per cent of the world's arable land
- 36 per cent of the world's water resources
- Six of the top ten most populous countries
- Fastest growing economies
- Half of world's urban population
- Eleven megacities
- Large agricultural exporter and importer
- 60% of world's under-nourished

Why should Asia be concerned?

Food Security as the *raison d'être* for sustainable agriculture

- Food Security depends on a productive natural resource base (environment) to sustain productivity
- Food Security depends on a productive workforce of farmers who can derive their livelihoods from farming
- Food Security depends on there being surplus production over consumption, i.e. exportable volumes at affordable prices

Need to Increase Production and Productivity, sustainably



Biotechnology applications in agriculture

1. Improving conventional breeding using marker aided selection,
2. Diagnostic and early detection tools for reducing losses caused by pests and diseases,
3. Increasing the knowledge of genetics and ecology for managing yield and losses (Biodiversity management), and
4. **Genetic engineering for improved yield and pest resistance traits using transgenes (Biotechnology- or "GM-" crops).**

What is sustainable Agriculture?

- There is no universally accepted definition of sustainable agriculture.
- **A sustainable agricultural system is one that can indefinitely meet the requirements for food and fibre at socially acceptable, economical and environmental costs. Crossen (1992)**



Some indicators of un-sustainability



Sustainable Agriculture Indicators

Sustainable Agriculture

Contribution of Biotech Crops

- **Environmentally-friendly**
 - *Conserves Natural resource base ✓*
 - *Minimizes external inputs (pesticides, etc) ✓*
- **Economically viable**
 - *Enables farmer livelihood ✓*
- **Socially just**
 - *Benefits small and large farms ✓*
 - *Benefits producers and consumers ✓*

Sustainable Development

GLOBAL IMPACT of BIOTECH CROPS

Sources: Brookes and Barfoot, 2011; Clive James, 2011; Carpenter, 2011



- **IMPROVED PRODUCTIVITY AND INCOME**
- **PROTECTION OF BIODIVERSITY**
- **ENVIRONMENTAL IMPACT**
- **SOCIAL BENEFITS**

The impact of biotechnology crops is in direct congruence with the goals of sustainable agriculture, and consequently, of sustainable development

Courtesy: R. Hautea, ISAAA

GLOBAL IMPACT of BIOTECH CROPS

Sources: Brookes and Barfoot, 2011; Clive James, 2011; Carpenter, 2011



- **IMPROVED PRODUCTIVITY AND INCOME**
 - Direct farm income gains \$65 B from 1996 to 2009
 - Spill-over benefits from biotech to conventional
- **PROTECTION OF BIODIVERSITY**
 - Reduced impacts of agriculture on biodiversity
 - Enhanced farm ecology
 - Alleviating pressure to convert additional land into agriculture

Courtesy: R. Hautea, ISAAA

GLOBAL IMPACT of BIOTECH CROPS

Sources: Brookes and Barfoot, 2011; Clive James, 2011; Carpenter, 2011



• ENVIRONMENTAL IMPACT

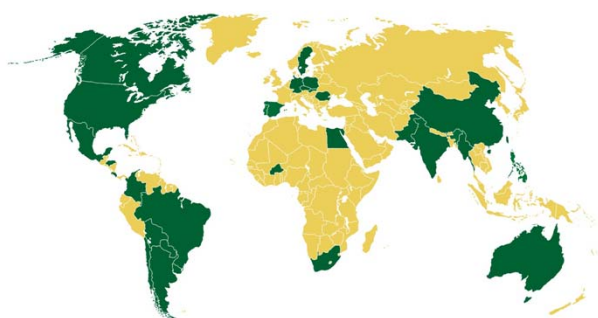
- Reduce need for external inputs
- 9% reduction in pesticide use from 1996-2009
- Reduction in CO2 emission – equivalent to removing 8 M cars off the road in 2009
- Conservation of soil & water through biotech + no/low till

• SOCIAL BENEFITS

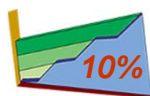
- Contribution to poverty alleviation of 14.4 M small resource-poor farmers in 2010 & welfare benefits emerging.

Courtesy: R. Hautea, ISAAA

Global Area (Million Hectares) of Biotech Crops, 2010: by Country



Increase over 2009



Source: Clive James, 2010.

29 countries which have adopted biotech crops

In 2010, global area of biotech crops was 148 million hectares, representing an increase of 10% over 2009, equivalent to 14 million hectares.

Biotech Mega Countries

50,000 hectares or more


USA	66.8
Brazil*	25.4
Argentina*	22.9
India*	9.4
Canada	8.8
China*	3.5
Paraguay*	2.6
Pakistan*	2.4
South Africa*	2.2
Uruguay*	1.1
Bolivia*	0.9
Australia	0.7
Philippines*	0.5
Myanmar*	0.3
Burkina Faso*	0.3
Spain	0.1
Mexico*	0.1

Less than 50,000 hectares


Colombia*	Czech Republic	Costa Rica*
Chile*	Poland	Romania
Honduras*	Egypt*	Sweden
Portugal	Slovakia	Germany

* Developing countries

Examples of biotech crop products nearing commercialization



Courtesy: R. Hautea, ISAAA




Insect resistant eggplant
India, Philippines, Bangladesh

Drought tolerant corn
USA

Insect resistant rice
China, Iran

Biofortified rice
Philippines, India, Bangladesh, Vietnam, and Indonesia

The Future – 2011-2015. A WAVE OF NEW & IMPROVED BIOTECH CROPS



- Many new crop/trait options will be ready before 2015
- Drought tolerance – principal trait – maize in US 2012
- Biotech rice – major crop, up to 1 billion beneficiaries
- Quality traits – Golden Rice in 2013, omega-3, others
- More biotech crops developed by countries from the South in public inst. – more South-South cooperation
- Biotech applications for “Speeding the breeding” – MAS and biotech crops, to provide a faster response to more severe and rapid changes in climate change
- Asia will grow more in 2nd decade than first decade

Source: Clive James, 2011

Courtesy: R. Hautea, ISAAA

Emerging Issues Affecting Sustainable Agriculture

...and Sustainable Development

1. Population growth, urbanisation, increased income
2. Declining performance of agriculture
3. Environmental degradation & climate change
4. Increase in oil prices/biofuel expansion

Biotechnology has great potential for addressing many emerging issues in Asia

Asia by 2050

Population

	Urban 2010	Rural 2010	Total 2010	Urban 2050	Rural 2050	Total 2050
ASIA	1.8	2.4	4.2	3.4	1.7	5.1
WORLD	3.5	3.4	6.9	6.3	3	9.3

- ~20% increase in total population
- ~89% increase in urban population
- 51% of global GDP (from 27% in 2010)

Food Balances in Asia

Crop	Item Million MT	06/07	07/08	08/09	09/10	10/11
WHEAT	Global Production	596	612	682	684	648
	Asia Imports (% of Global Exports)	35 (30)	31 (27)	34 (24)	35 (26)	33 (27)
RICE (milled)	Global Production	421	434	448	440	452
	Asia Imports (% of Global Exports)	10 (31)	8.5 (29)	6.9 (24)	8.6 (28)	8.7 (29)
CORN	Global Production	714	795	799	812	814
	Asia Imports (% of Global Exports)	34 (37)	35 (36)	34 (40)	37 (39)	36 (39)
SOYBEAN	Global Production	237	221	212	261	258
	Asia Imports (% of Global Exports)	39 (56)	48 (61)	51 (66)	61 (65)	68 (69)

Source: USDA FAS

Food Demand Changes in Asia

- Reduced per capita consumption of rice
- Increased consumption per capita of wheat and wheat-based products
- Increased diversity in the food groups consumed
- Rise in high proteins and energy dense diets
- Increased consumption of temperate zone products
- Rising popularity of convenience food and beverages
- Westernization of diets

Source: Pingali, FAO 2004

Food Demand Changes in Asia (cont'd)

- **Meat consumption**

100 years ago, average 25 kg/person/yr

Today, average 80 kg/person/yr (USA – 124 kg/person/yr)



China: 1962 – 4 kg/person/yr; 2005 – 60 kg/person/yr
- **Fish consumption**


1960s – 9.9 kg/person/yr; 2005 – 16.4 kg/person/yr

China accounted for most of world growth (26.1 kg/person/yr)
- **Vegetable consumption**

 - 1970s – 60 kg/person/yr; 2000 – >100 kg/person/yr
 - China: 1970 – 44.4 kg/person/yr; 2005 – 270.6 kg/person/yr

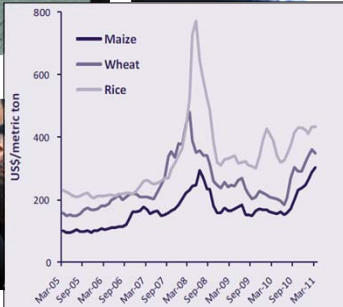
Downstream effects of food insecurity



“A hungry person with low blood sugar is a very angry person – virtually ungovernable”

Ruth Oniang'o



US\$/metric ton

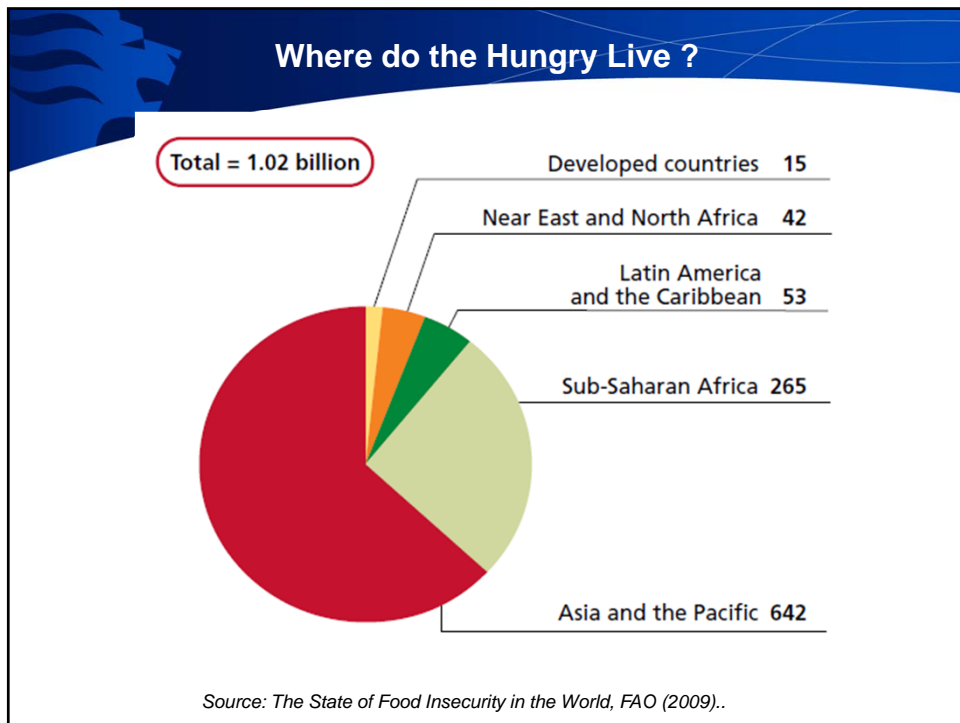
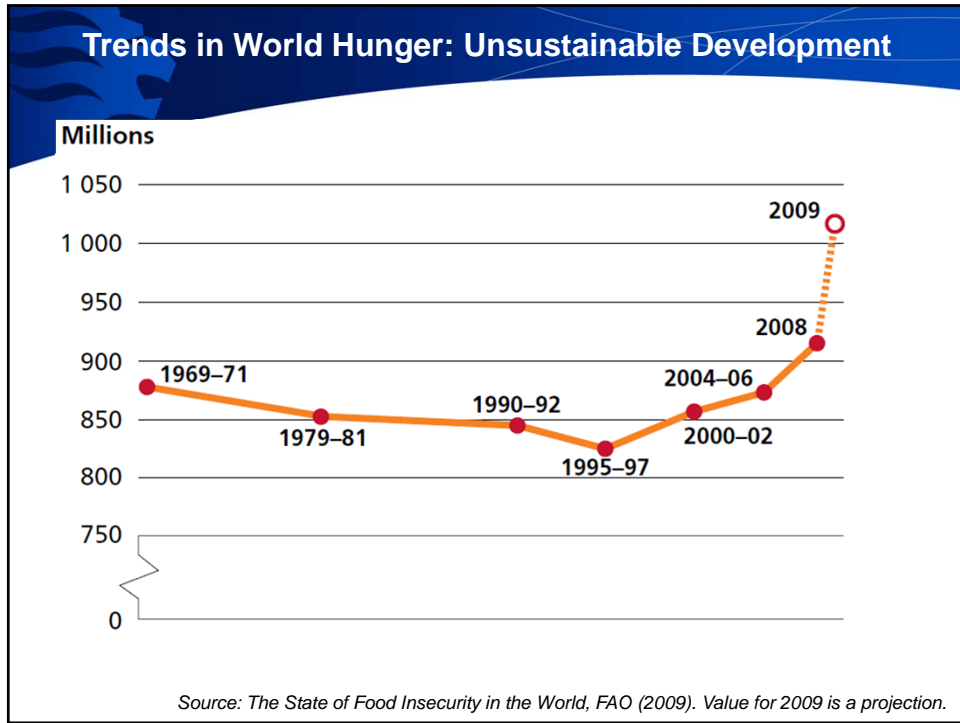
— Maize
— Wheat
— Rice

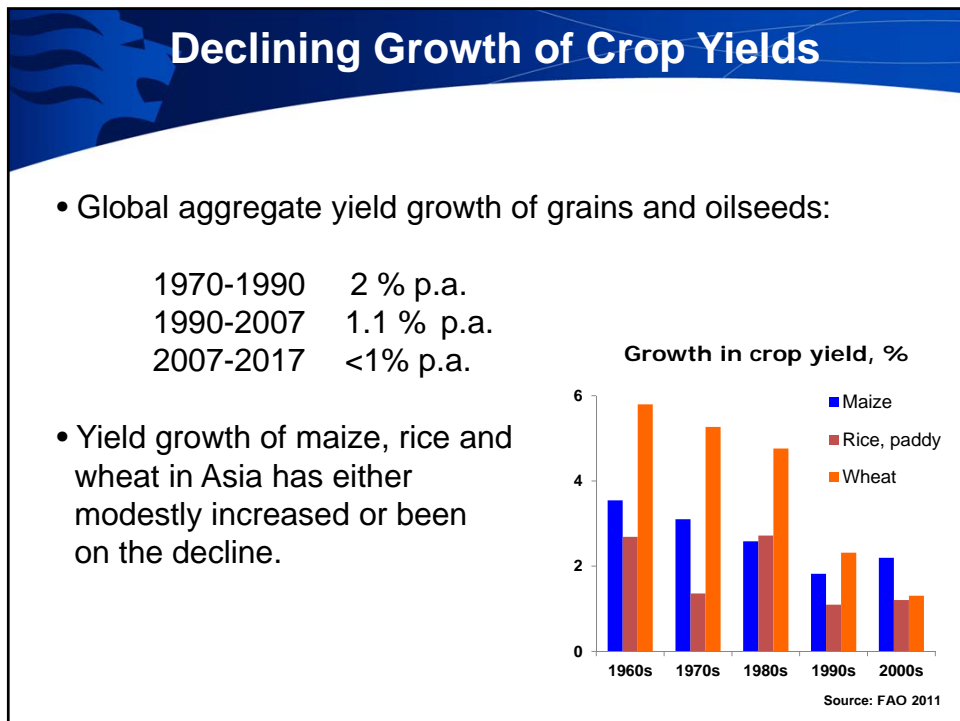
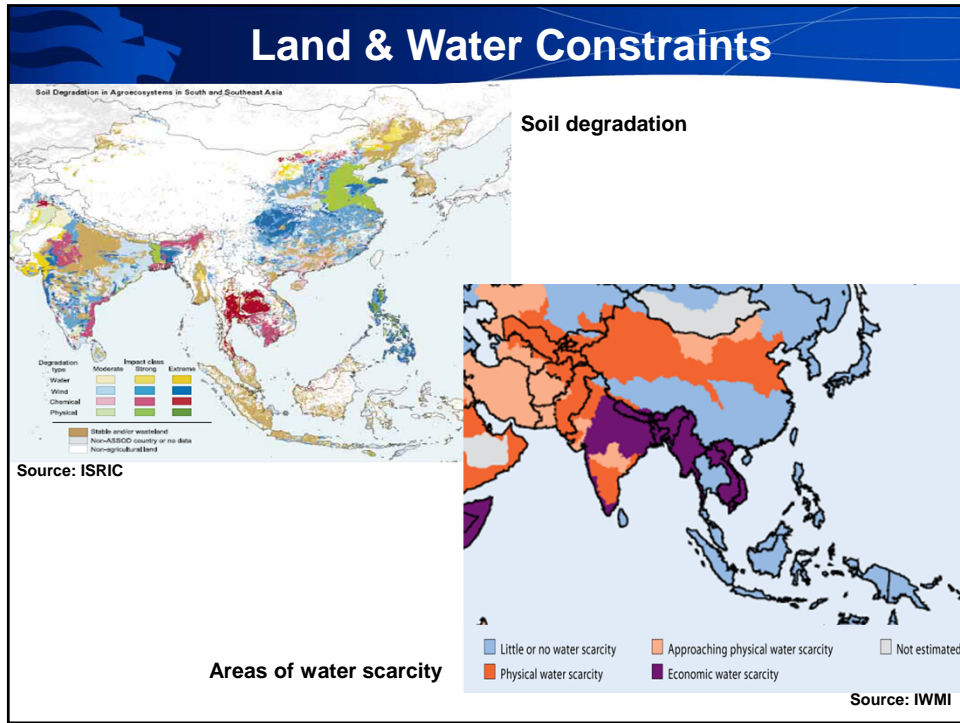


Indicative export prices, f.o.b.

— Butter
--- Milk

Source: FAO (Food and Agriculture Organization of the United Nations), International Commodity Prices Database, accessed March 24, 2011, www.fao.org/es/esc/prices/PricesServlet.jspx?lang=en





ASIA: Dominance of Smallholder Agriculture

- Smallholder agriculture dominates farming systems
- **87%** of world's 500 million small farms (<2 ha) are in Asia
- Declining farm size -

	Census year	Avg. Farm Size (Ha)	Number of Small Farms (million)
India	1971	2.3	49
	2005/2006	1.2	108
Nepal	1992	1	2.4
	2002	0.8	3.1
Pakistan	1971/73	5.3	1.1
	2000	3.1	3.8

Source: Hazell 2011; Headey, Bezemer and Hazell 2010

Source: Shenggen Fan, 2011

Climate change impact on crop yields, 2050

ASIA	
Crop	Change in Production (%)
Rice	
Irrigated	-10.47
Rainfed	0.66
Maize	
Irrigated	-5.54
Rainfed	1.71
Wheat	
Irrigated	-13.50
Rainfed	-1.91
Soybeans	
Irrigated	-6.73
Rainfed	8.58

Source: IFPRI 2011 (preliminary)

How can SA help in ameliorating Food Security concerns?

Increasing Food Availability

- Increased Production (Yield and Husbandry)
- Reduced wastage and losses
- Mitigation and adaptation to Climate Change (CC)

How can Biotechnology Help?

Adaptive technologies and farming approaches which ensure food availability through sustainable agriculture, minimize wastage/losses in the supply chain, ensure affordable prices, and improve food utilization

Food Security Dimensions with Biotechnology Applications

Food Availability

- Increase Production (Yield and Husbandry)
- Reduce Losses
- Mitigate/Adapt to Climate Change (CC)

Food Distribution

- Reduce Losses
- Efficiency of distribution (diagnostics, LLP management)

Economic Access to Food

- Maintain affordable food prices

Food Utilization

- Nutrition Quality (Biofortification)
- Reduce wastage

RSIS Commentaries
No. 86/2011 dated 1 June 2011


Asia's Food Security Conundrum

By Paul S. Teng, J. Jackson Ewing and Margarita Escaler

Synopsis

Feeding Asia's growing population requires modern agriculture based on the latest science and technology. Asian countries should embrace modern farming techniques and invest in R&D to develop sustainable food production systems.

Sustainable Agriculture



Technology Environment

Contribution of Biotech Crops to Sustainable Development

- Ensure Affordable, consistent and safe supply of food, feed and fiber
- Ensure food security and alleviation of poverty and hunger
- Mitigation of and adaptation to climate change

Source: Clive James, 2011