

HELSINGIN YLIOPISTO HELSINGFORS UNIVERSITET UNIVERSITY OF HELSINKI

Sustainable food production

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Food production technologies: past 40 years

- Productionist paradigm: technologies for yield increases
- The "Green Revolution"
- Present state of the World food production
- Challenges
 - Population
 - Economics
 - Environment
 - Culture
- Food production technologies: next 40 years
 - Life-Sciences paradigm: "Functional Foods"
 - Ecologically integrated paradigm: The "Doubly Green Revolution"

Food production technologies: past 40 years



http://www.vistech.net/users/rsturge/wheat2.jpg



Productionist paradigm: technologies for yield increases (1)

40 years ago 50% of population in the developing countries suffered from hunger

	40 years past	Now
World population	3 billion	6 billion
Hungry	1 billion	1 billion
Hungry %	33 %	16%



Productionist paradigm: technologies for yield increases (2)

- 40 years ago 50% of population in the developing countries suffered from hunger
- In developed countries, recent experiences of food shortages
- Obvious technological orientation: "grow more food!"



Productionist paradigm: technologies for yield increases (3)

- Focus in Mg/h from the "solar food panel": agricultural crops
 - Potential yield is <u>determined</u> by incoming flux of photosynthetically active solar radiation and biological efficiency of the plant for photosynthesis and growth
 - Attainable yield is <u>limited</u> by shortages of the essential water and nutrients for plant growth
 - Realised yield is <u>reduced</u> by competing weeds, plant pathogenic microbes, and herbivorous pests



Flux intensity: max. in the tropics 800 J/sm², seasonal variation from cloudiness only



Example of growth rate of a grain crop in semi-arid tropics



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Productionist paradigm: technologies for yield increases (4)

Obvious technological options:

Develop the crop's physiology for higher potential yield under the determining growth conditions

Release the crop from growth limiting factors

Protect the crop from growth reducing factors



Breeding for efficient crop canopies (leaf area, leaf position): focus in Word's main stables (= cereals)



Source: Sinclair & Gardner 1998, page 65.



Breeding for input efficiency (nutrients, water)



Source: Conway 1997, page 51



Developing chemical pesticides against weeds, pests, and pathogens



Population density of the pest in the crop

Source: Dent 1991, page 128





Cereal production in the developing countries. Source: Conway 1997, page 45.





Figure 4.3 Growth in wheat yields in Mexico





Figure 4.5 Growth in wheat yields in India and Pakistan

Source: Conway 1997, page 45.





Source: Conway 1997, page 45.





Source: Conway 1997, page 45.





Source: Conway 1997, page 45.





Figure 4.8 Proportion of cereal lands under new Green Revolution or Chinese varieties in the early 1980s [30]

Source: Conway 1997, page 45.





Source: Conway 1997, page 45.





Source: Conway 1997, page 113.



Tilman et al. SCIENCE VOL 292 13 APRIL 2001 281



Tilman et al. SCIENCE VOL 292 13 APRIL 2001 281



Tilman et al. SCIENCE VOL 292 13 APRIL 2001 281



The Green Revolution



Source: Evans 1998, page 205. Data: Fao



Present state of the World food production





Source: Von Brown, IFPRI, Dec 6, 2005, Marrakech.



Present state of the World food production



Calorie supply in the developing countries. Source: Conway 1997, page 45.



5.1 Average Annual Rate of Growth of Total Agricultural Production

	Total Agricultural Production				
World/Region	1970-	1980-	1990-	2000-	
tionancegion.	1980	1990	2000	2003	
	(%)				
WORLD	2.4	2.4	2.3	1.9	
Developed countries	2.0	1.0	0.1	-0.4	
Industrialized countries	2.2	0.7	1.4	-0.9	
Transition economies	1.5	1.7	-3.7	1.7	
Developing countries	2.8	3.6	3.8	3.1	
Latin America and the	2.4	2.3	3.1	3.5	
Caribbean	3.4				
Near East and North Africa	2.8	3.4	2.9	3.1	
Sub-Sahara Africa	1.0	3.0	3.1	1.7	
East and Southeast Asia	3.3	4.3	4.8	3.9	
South Asia	2.6	3.8	3.1	1.4	
Oceania developing	2.4	1.7	2.0	0.9	
North America developing	-2.4	1.2	-0.9	0.4	

Present state...

Food and Agriculture Statistics

Summary Food and Agriculture Statistics (as at November 2005)

Prepared by the Statistics Division http://www.fao.org/es/ess/sumfas/sumfas_en_web.pdf

5.2 Average Annual Rate of Growth of Food Production

Present

state...

World/Region	Total %				
	1970-	1980-	1990-	2000-	
	1980	1990	2000	2003	
WORLD	2.5	2.4	2.5	2.0	
Developed countries	2.0	1.0	0.2	(-0.3)	
Industrialized countries	2.3	0.7	1.4	-0.8	
Transition economies	1.5	1.8	-3.6	1.8	
Developing countries	3.0	3.6	4.0	3.2	
Latin America and the Caribbean	3.6	2.5	3.4	3.7	
Near East and North Africa	3.1	3.5	2.9	3.4	
Sub-Sahara Africa	1.1	2.9	3.1	1.9	
East and Southeast Asia	3.3	4.4	5.2	4.0	
South Asia	2.7	3.8	3.3	1.3	
Oceania developing	2.2	1.7	1.9	1.2	
North America developing	-2.3	1.2	-0.9	0.5	

Food and Agriculture Statistics

Summary Food and Agriculture Statistics (as at November 2005)

Prepared by the Statistics Division http://www.fao.org/es/ess/sumfas/sumfas_en_web.pdf



Present state...

Source:

Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.or g//en/Products.Synthe sis.aspx





Challenges



http://www.isp.msu.edu/photocontest/2003/gall eries/medium/student/Rice%20Paddy.jpg



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2005). World Population Prospects: The 2004 Revision. Highlights. New York: United Nations.

http://www.un.org/esa/population/publications/WPP2004/2004EnglishES.pdf





Source: Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/Products.Synthesis.aspx



Economics: poverty

- Enough food energy and proteins are produced in world agriculture to meet the need of the present population
- The main reason for a person to be hungry is poverty (both in the developed and in the developing countries)
 - The poor are economically invisible
 They don't generate economic demand
 Which results in their needs being not met in the food system

Subsidies to food production in developed countiries result in overproduction (local food security) being



Economics

- Subsidies to food production in developed countries result in overproduction (local food security)
 - The overproduction is dumped in world marked at price lower than the production costs
 - The farmers in the developing countries cannot compete with the artificially low prices of the world market
 - Hence, overproduction for local food security in the developed countries results in reduced production and lower local food security in the developing countries



Economics: welfare

Growth in economic welfare is associated with two important trends:

- Reduction of fertility rates at replacement level (compare: the developed welfare countries, in which population growth has stopped or is negative)
 - This tends towards relieved pressure to grow more food, but is a slow process (demographic)
- Increase in consumption of food of animal origin (especially meat)
 - This tends towards increased pressure to grow more feed: to meet the energy and protein requirement of food by meat needs ca. 7 times more plant production than in vegetarian diets



= continuous in economics! The forecast: A return to more sustainable growth

Percent growth, annual rates

Forecast





Source: Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/Products.Synthesis.aspx



Economics: welfare

Figure 8—Annual growth rate of high-value agriculture production, 2000-2004



Source: Von Brown, IFPRI, Dec 6, 2005, Marrakech.



Environment

Increasingly, environment sets limits to increasing production



Environment: land



Source: Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/Products.Synthesis.aspx





Source: Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/Products.Synthesis.aspx



Source:

land

Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/ Products.Synthesis.aspx



Environment: land

Source:

Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/ Products.Synthesis.aspx





Environment: water





Environment: nutrients

Source:

Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/ Products.Synthesis.aspx





Environment: nutrients



Source: Millenium Ecosystem assessment 2006. Ecosystems and Human Well-being: Synthesis. WRI. http://www.maweb.org//en/Products.Synthesis.aspx



Environment: biodiversity and ecosystem services

- Land conversion to agricultural use, and associated homogenisation of farmland environment
- Increased nutrient levels
- Impacts of pesticides used to protect crops from weeds, pests, and diseases
- Contribute to loss of ecosystem and species diversity
- Loss of biodiversity is associated to loss in global ecosystem services
 - Maintenance of atmosphere and climate
 - Purification of water
 - Etc.



Culture

Entitlement to food

Equitability

- Gender issue (key roles of women)
- Hunger of children: proportionally high in Asia as compared to Africa
- Food in culture
 - Food and religion
 - Adoption of new foods, changes in diets
- Globally: "Do we want a world of wheat and people only " (*Joel Cohen*)



Food production technologies: next 40 years



The "life sciences integrated paradigm"

- Functional foods
- Bio-high-tech
- Food as medicine
- Food and lifestyle: brands, values, etc.
- More processing, more specialized variety, more packing, global imports and exports
- Focus in better-off social segments in developed countries
- Mentally: continuation to the productionist paradigm



The "ecologically integrated paradigm"

...and the doubly green revolution





The "Doubly Green Revolution": setting

Unavoidable population growth: 50% more people, 50% to 100% more food needed by 2050

Increasing environmental concerns

- Climate change and associated losses and increased variability in yields
- Excessive pollution by emissions in intensive agriculture
- Land degradation in extensive agriculture
- Loss of biodiversity at increasing rate



The "Doubly Green Revolution": setting

Limiting natural resources

Energy

Increased prices of fossil energy

Competition with bioenergy production

Water

Limited availability, increased competition

Land

Best lands converted

Competition

Degradation



The "Doubly Green Revolution": setting

- Limiting natural resources
 - Biodiversity
 - Reduced genetic and species diversity of crops and farm animals
 - Reduced species diversity providing agroecosystem services



The "Doubly Green Revolution": way forward

Continue with the present productionistic paradigm?

- Increase external input intensities for higher yields in the developing countries
- Reduce food production area in the developed countries
- Globalize (externalize) food system and make use of relative benefits of each region
- Dump overproduction to world market
- Rely in your relative purchasing power to be competitive in capturing food ecosystems to your food production



The "Doubly Green Revolution": way forward

Or: switch to ecologically integrated paradigm?

- Increase local circulated input intensities for higher yields in the developing countries
 Decrease external input intensities in the developed countries, but maintain farmland
- Regionalize and localize to build a global network of locally adapted food systems
- Maintain emergency storage by per capita overproduction, but don't dump to world market (renew through bioenergy uses)