



Climate Change and Global Food Crisis - With emphasis on Taiwan

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A hungry world is a dangerous world.

Josette Sheeran, UN WFP Executive Director, 2009



Soldiers stand guard during the sale of government rice in Manila, Philippines.



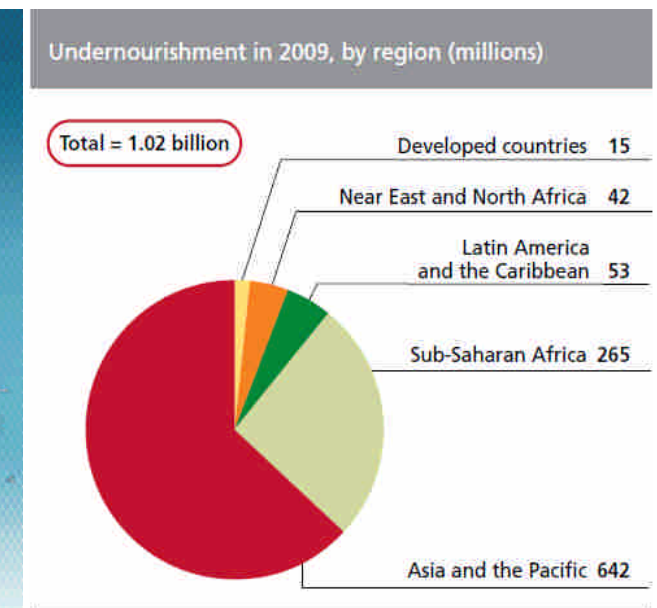
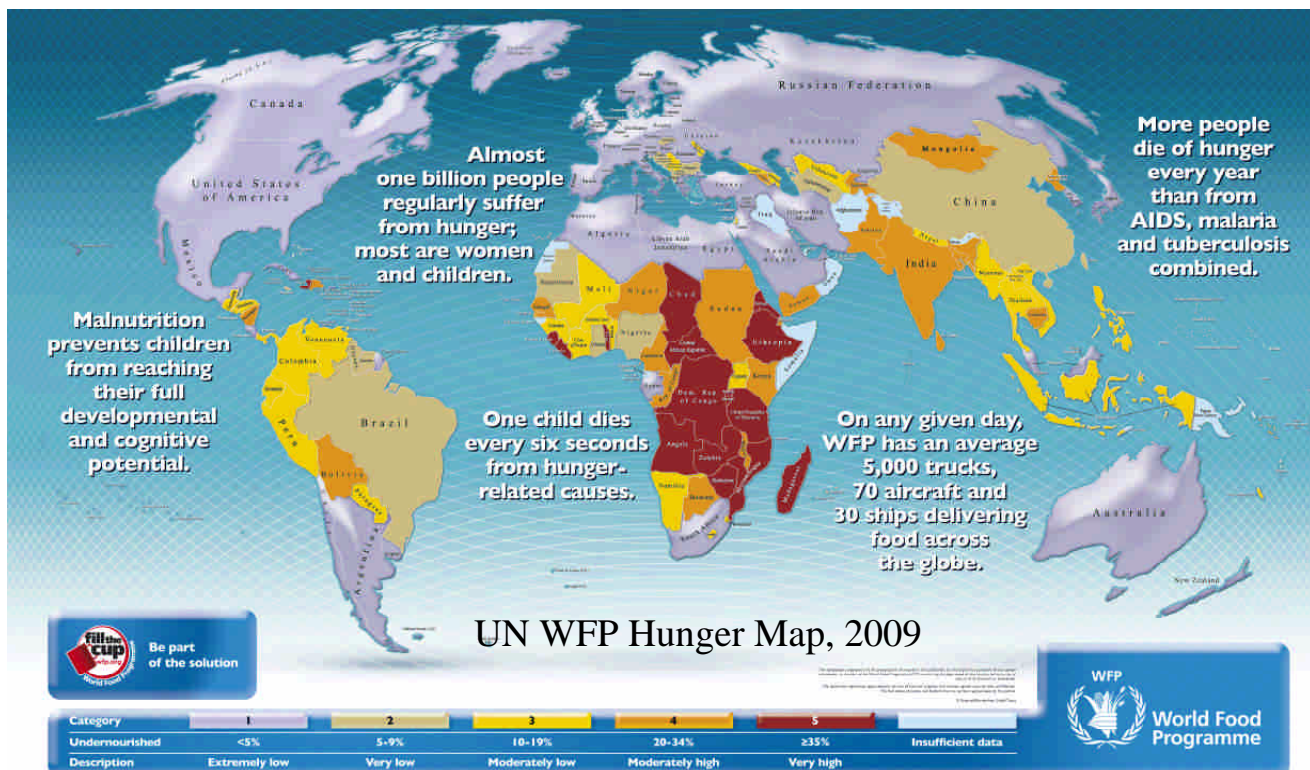
Rising food prices have sparked violent protests in Port-au-Prince, Haiti.



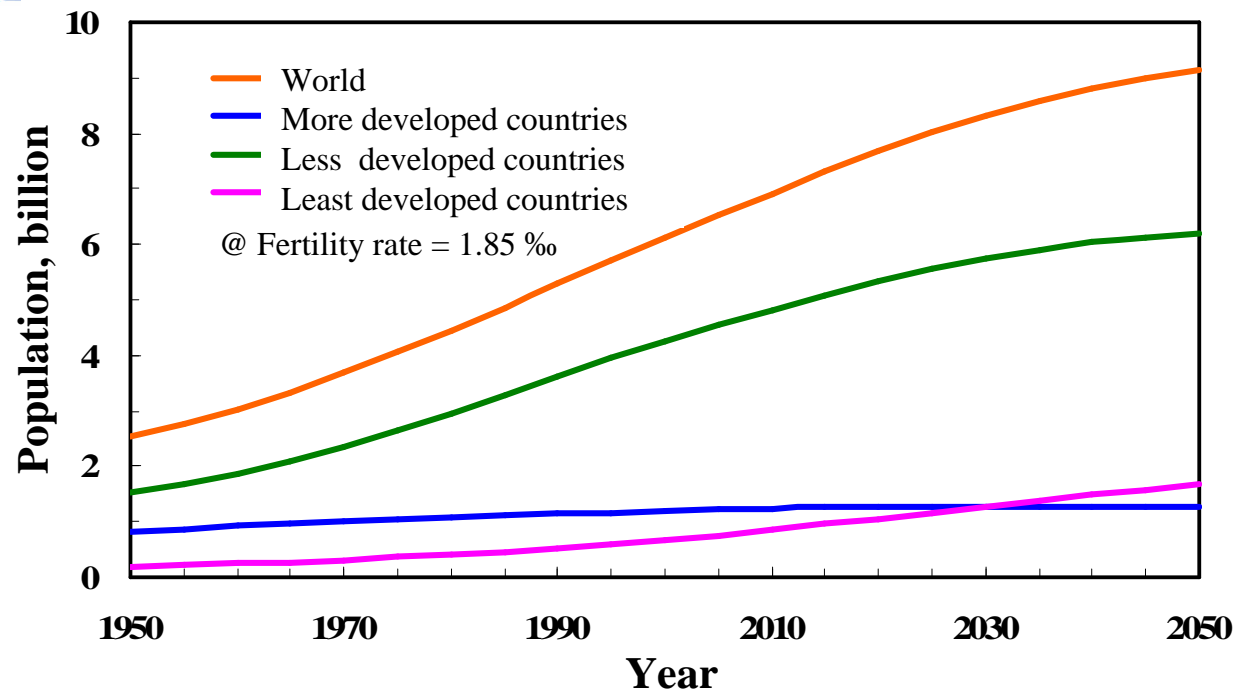
Women rushed to buy subsidized flour in Lahore, Pakistan.



Locals fight to get food in Punjab province, Pakistan.



UN FAO, 2009

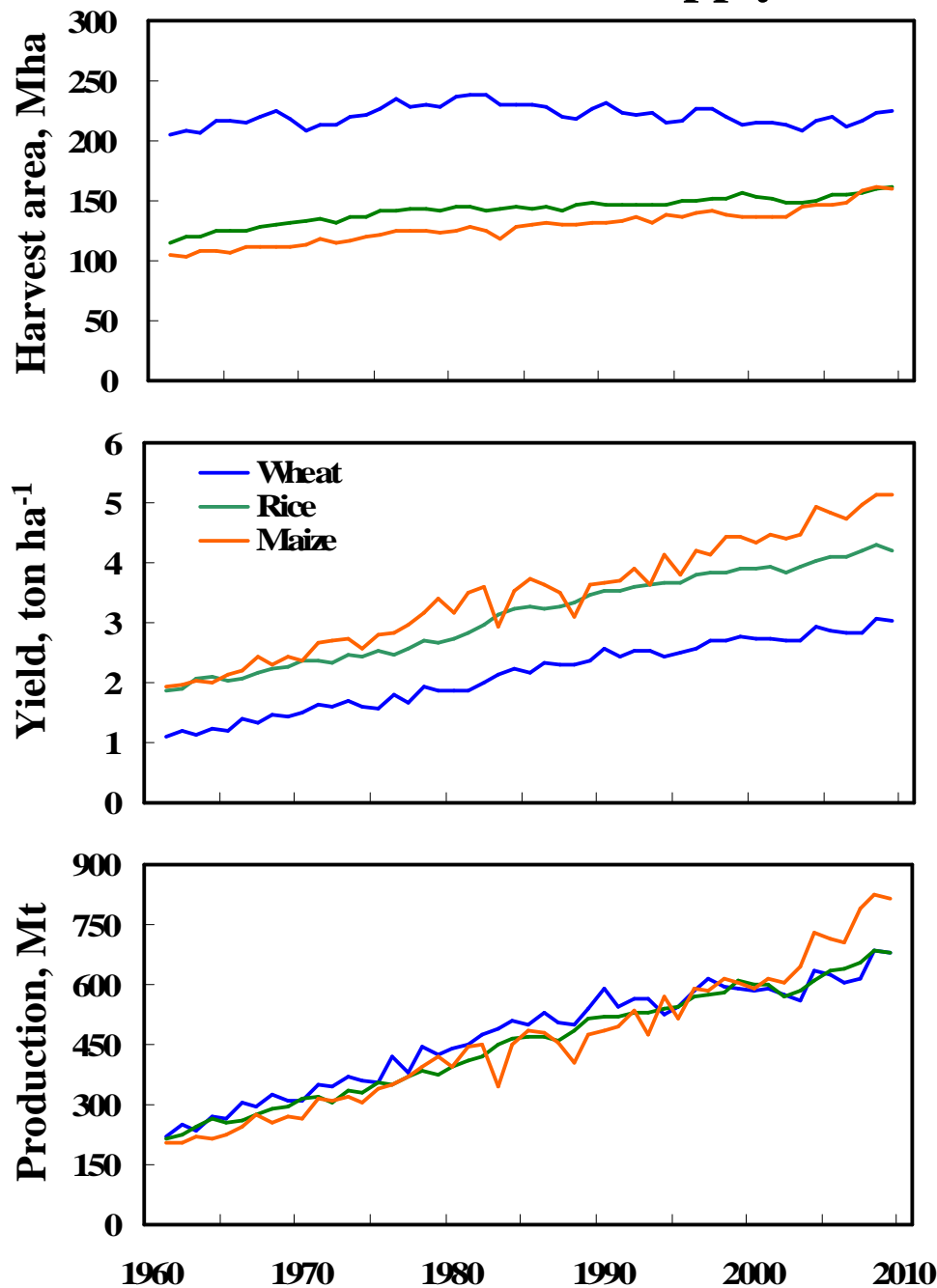


World Pop. Increase rate, % y^{-1}

Period	Fertility rate	
	1.85 %	2.35 %
1990s	1.6	
2000s	1.3	
2010s	1.1	1.4
2020s	0.8	1.2
2030s	0.6	1.0
2040s	0.4	0.9

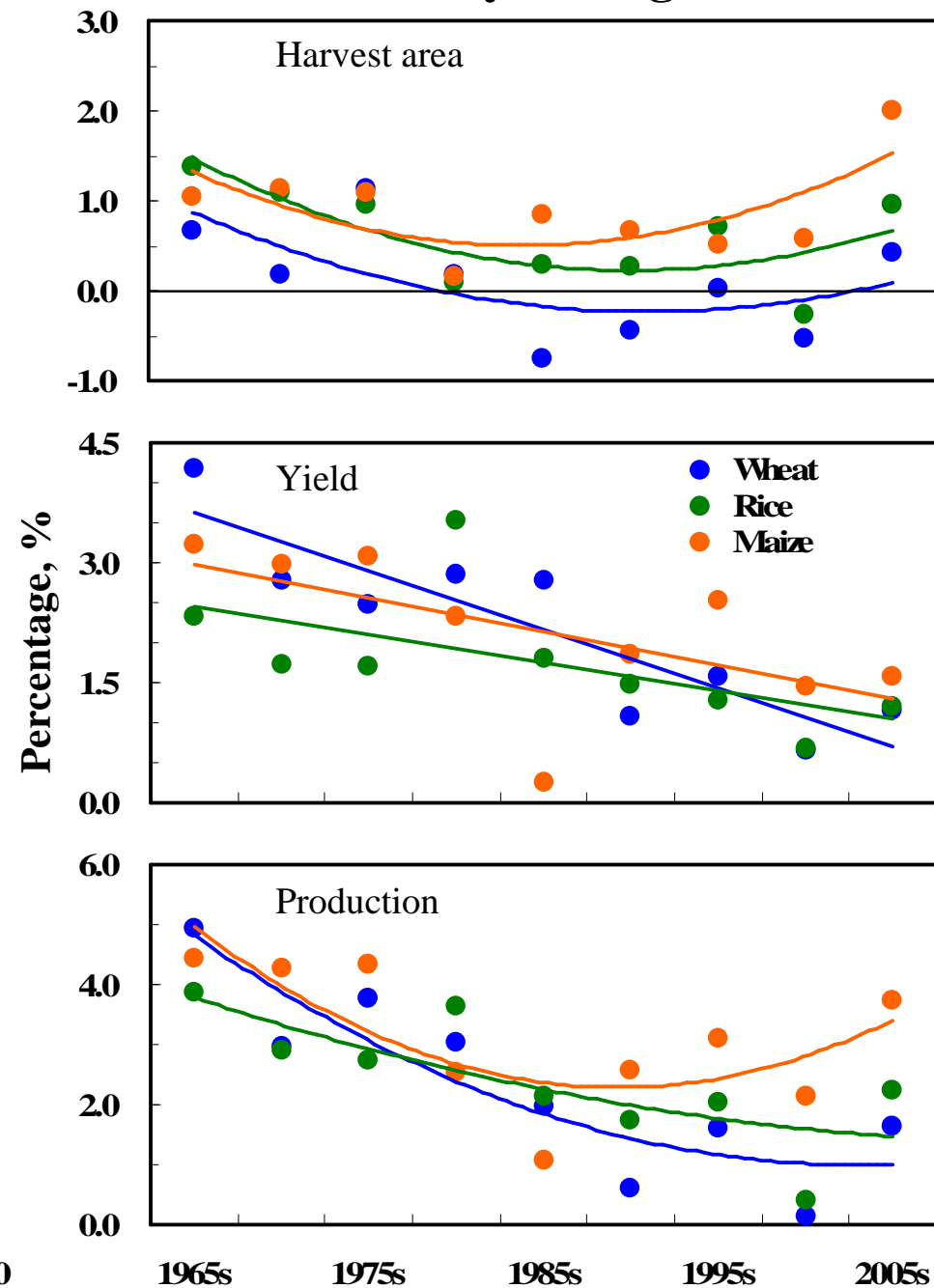
UN Population Division, 2008

World Cereals Supply

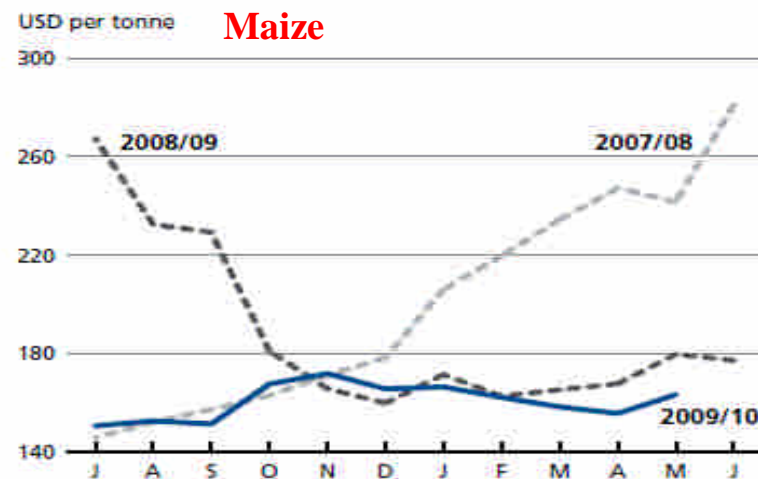
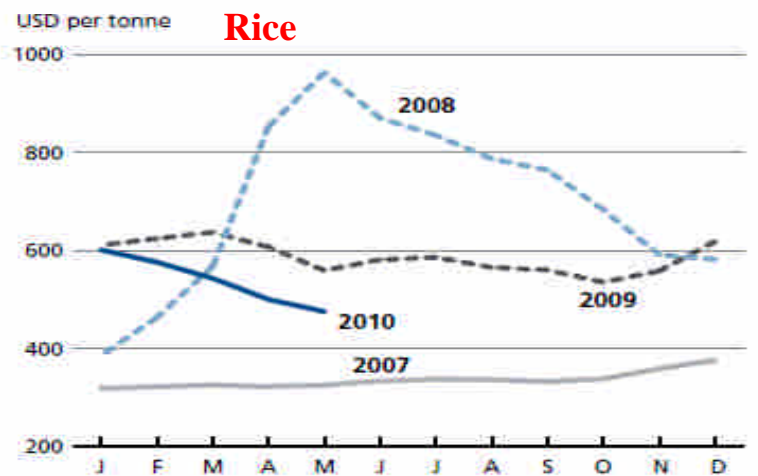
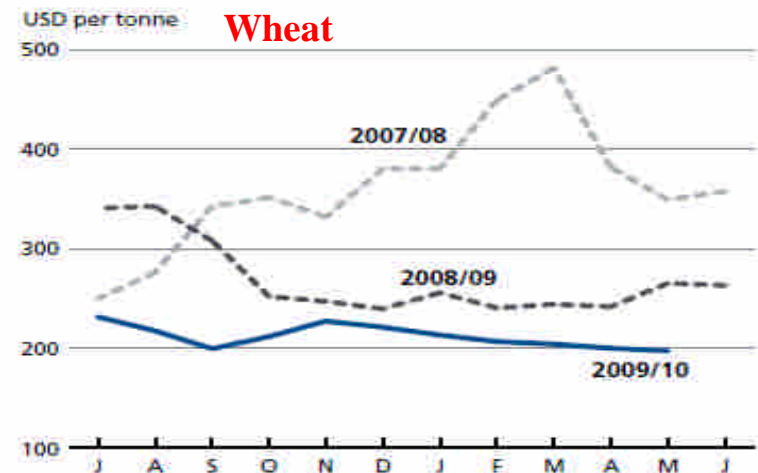
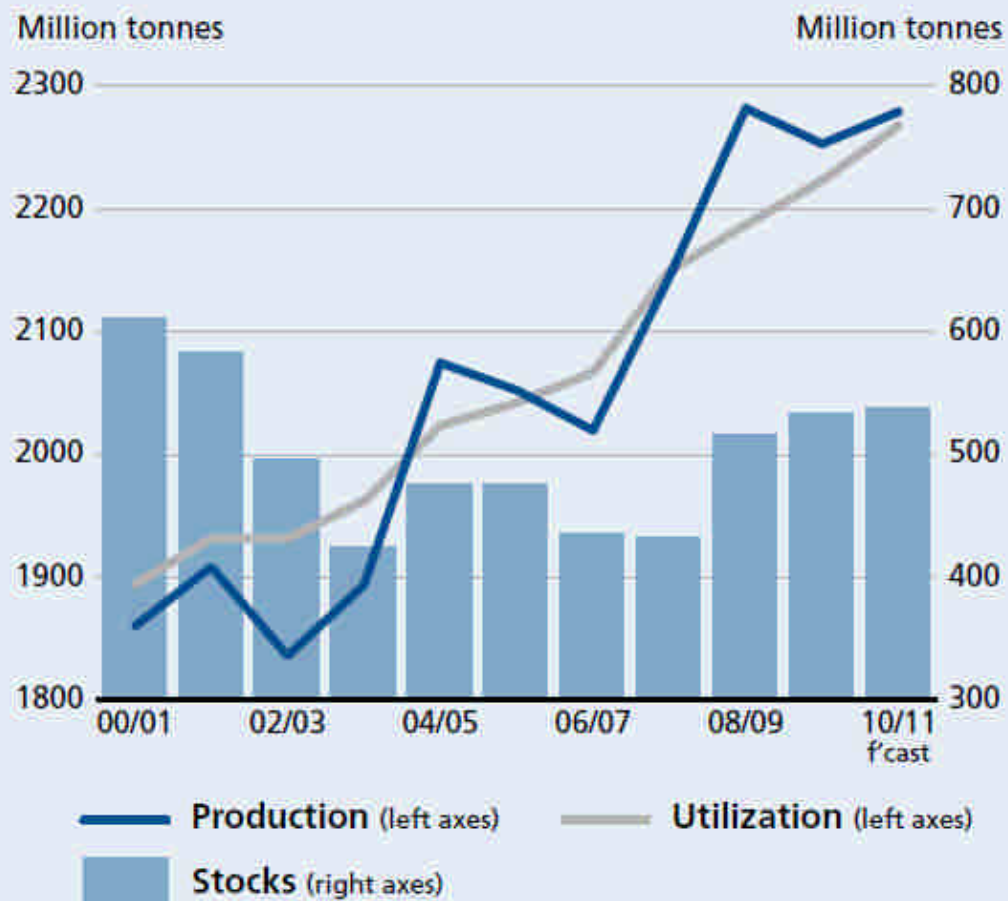


Yearly Change

FAOSTAT



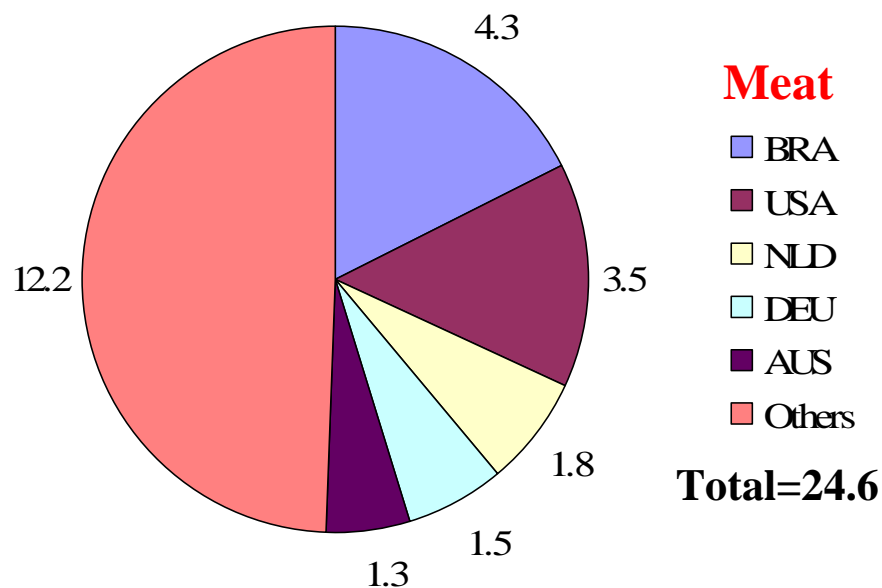
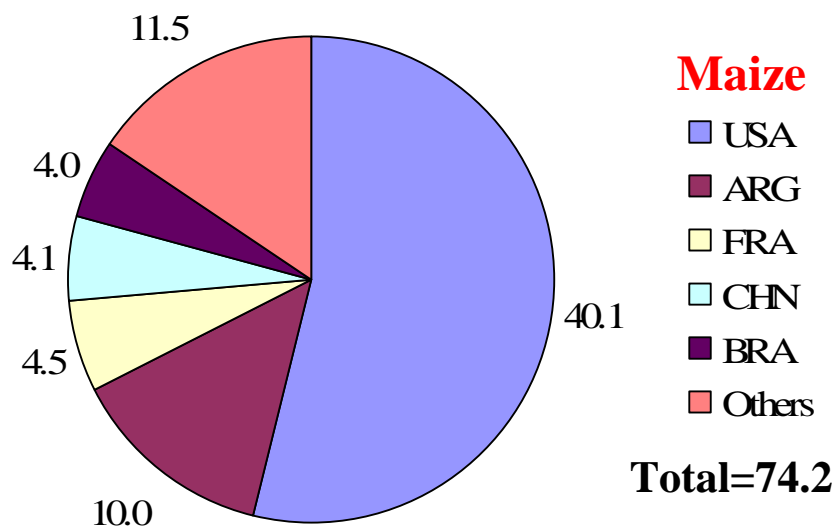
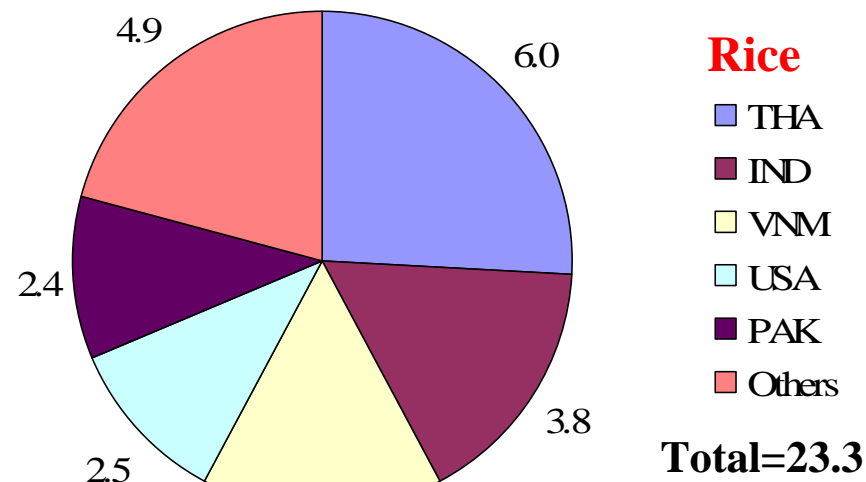
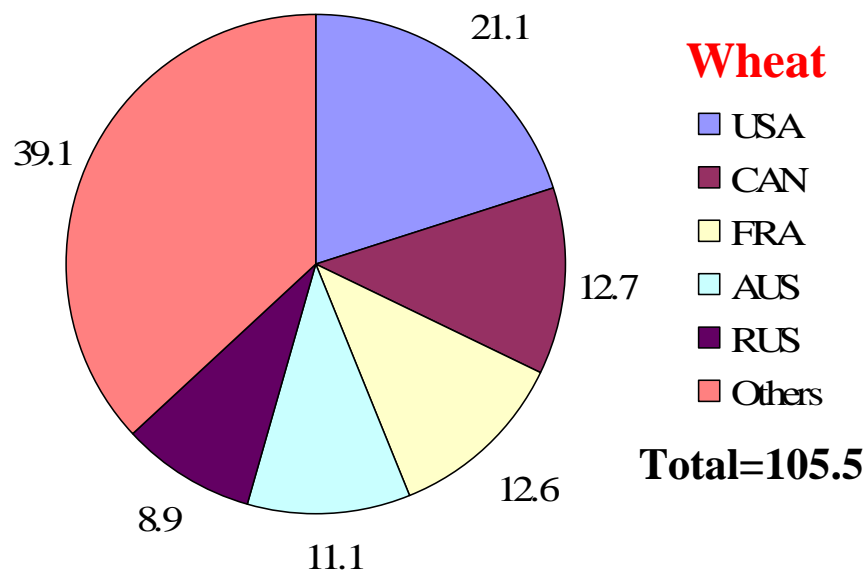
Cereal production, utilization and stocks



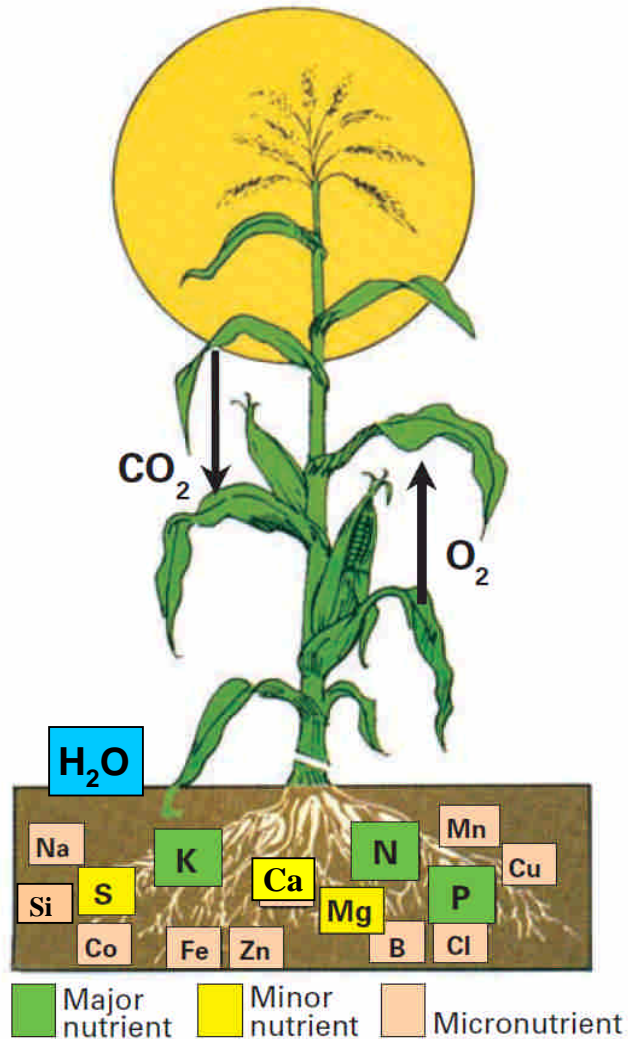
Major Food Exporting Countries

FAOSTAT, 2005-2007

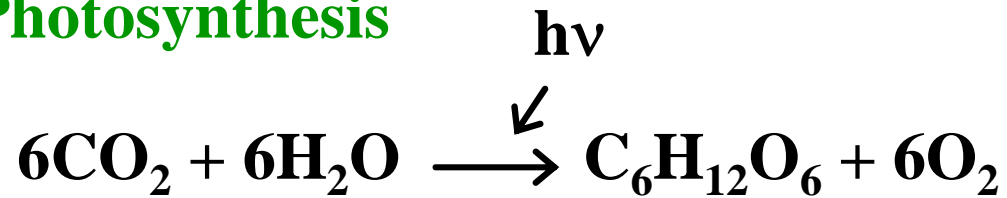
Unit: million tones



Crop Production and Environment



Photosynthesis



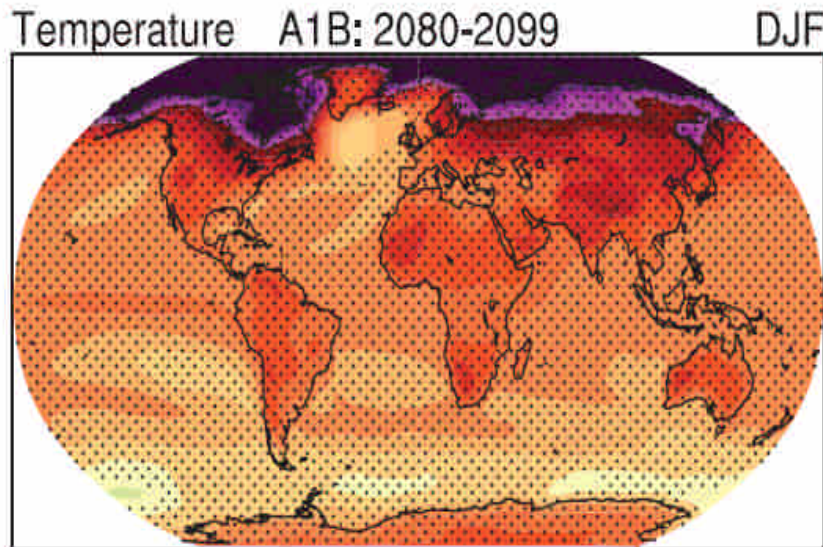
$$\text{Yield} = \begin{matrix} \text{Solar Rad} \\ \text{Temp} \\ \text{Water} \\ \text{CO}_2 \end{matrix} \times \begin{matrix} \text{Soil} \\ \text{Fertilizer} \\ \text{Weed} \\ \text{Insect} \\ \text{Disease} \end{matrix} \times \begin{matrix} \text{Disaster} \\ \text{Weather} \end{matrix}$$

$$Y = Y_{\max} \times f_1 \times f_2 \times f_3 \times \cdots \times f_n$$

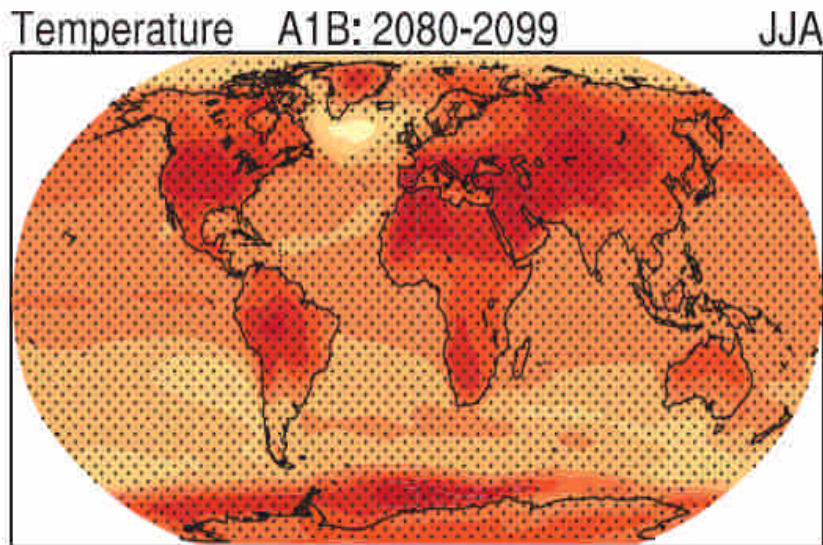
$$f_i = 0 \sim 1$$

Y_{\max} : Yield Potential

Temperature Projection (~2100)



Land areas warm more than the oceans with the greatest warming at high latitudes and in winter

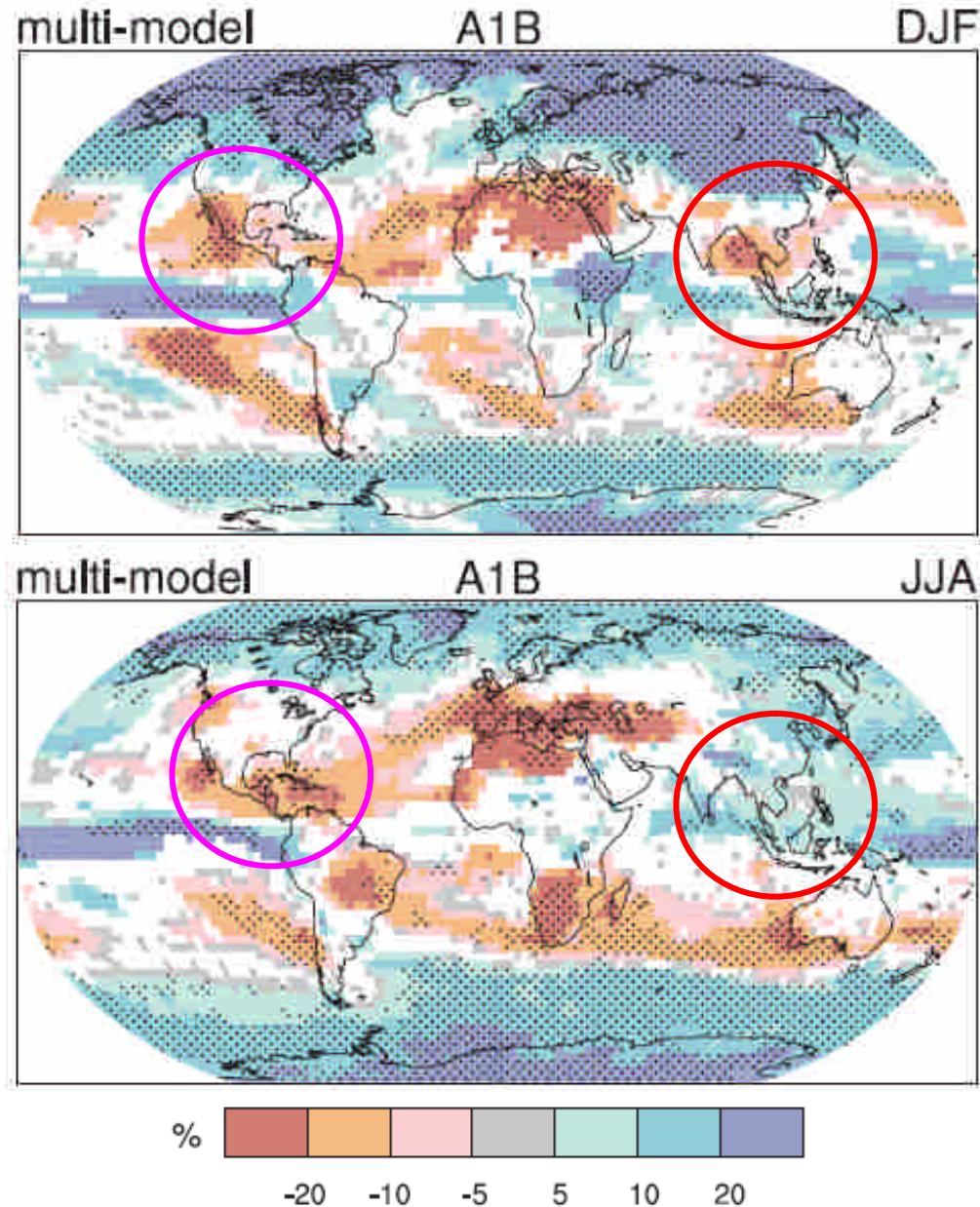


Precipitation Projection (~2100)

US

Winter
Drought

Summer
Drought



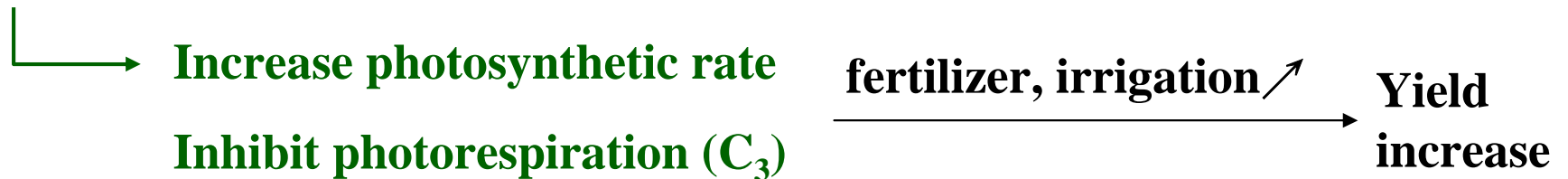
SEA

Winter
Drought

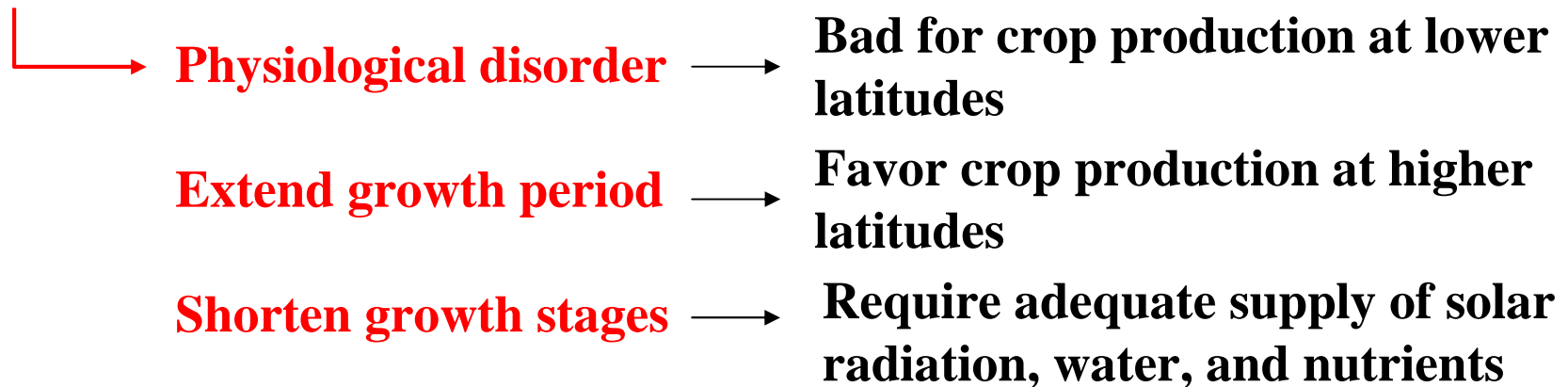
Summer
Flood

Effects of Increasing CO₂ and Temperature

**Increasing
CO₂**



**Increasing
Temperature**



Effects of Global Warming on Cereal Production

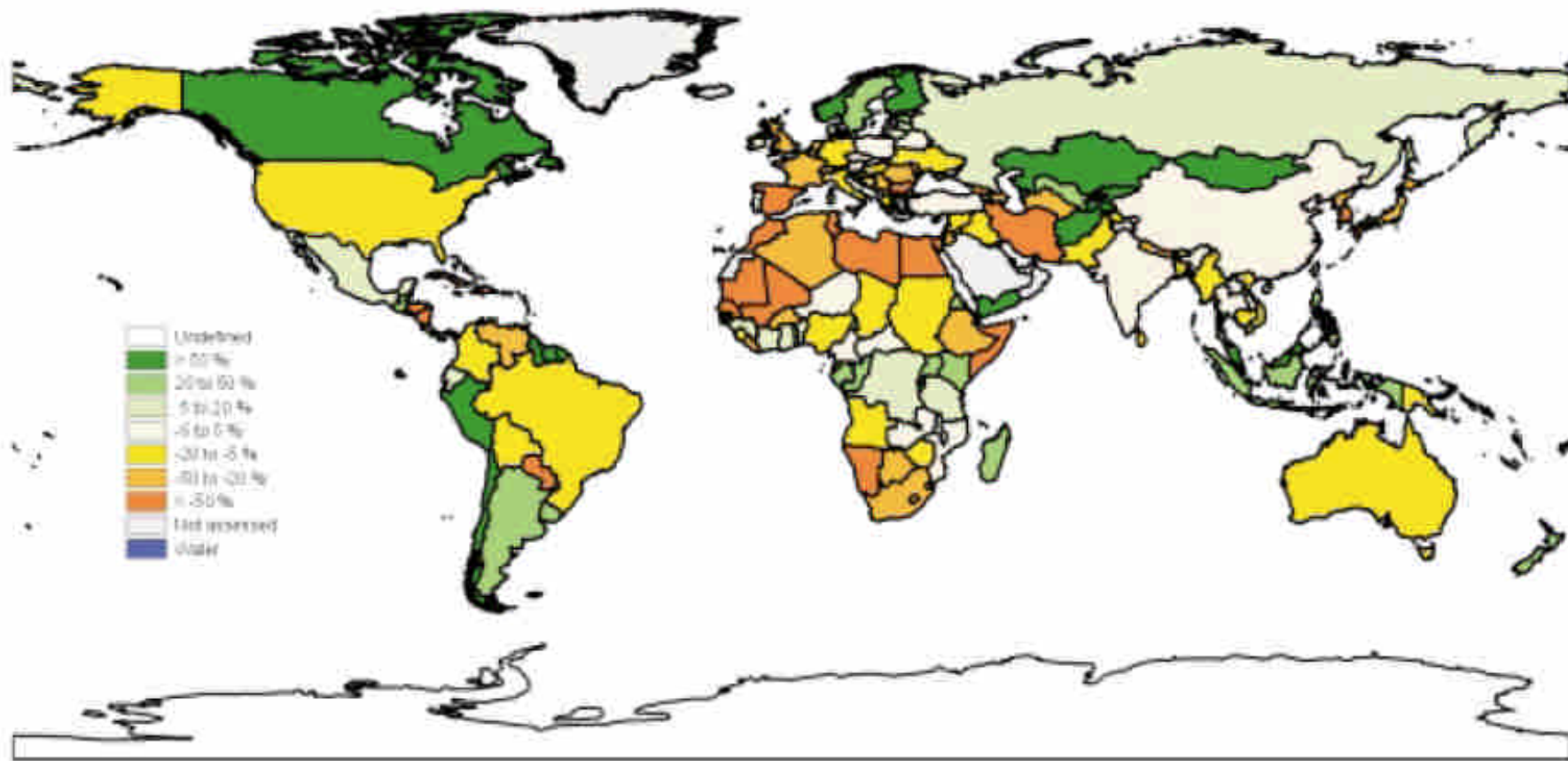
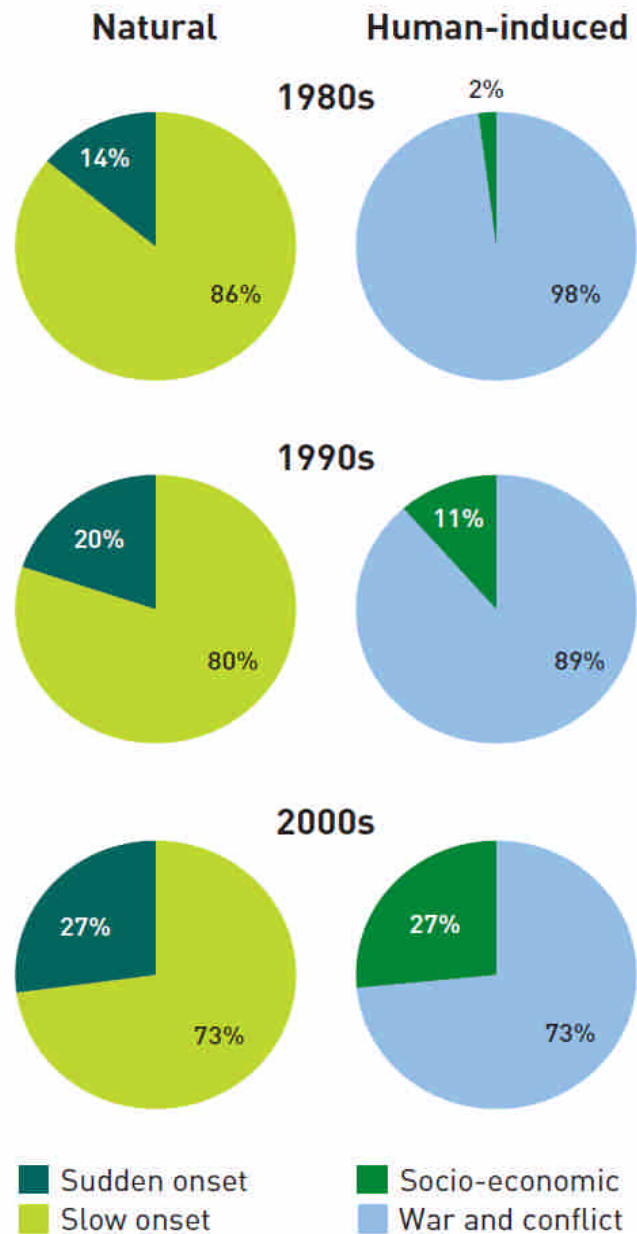
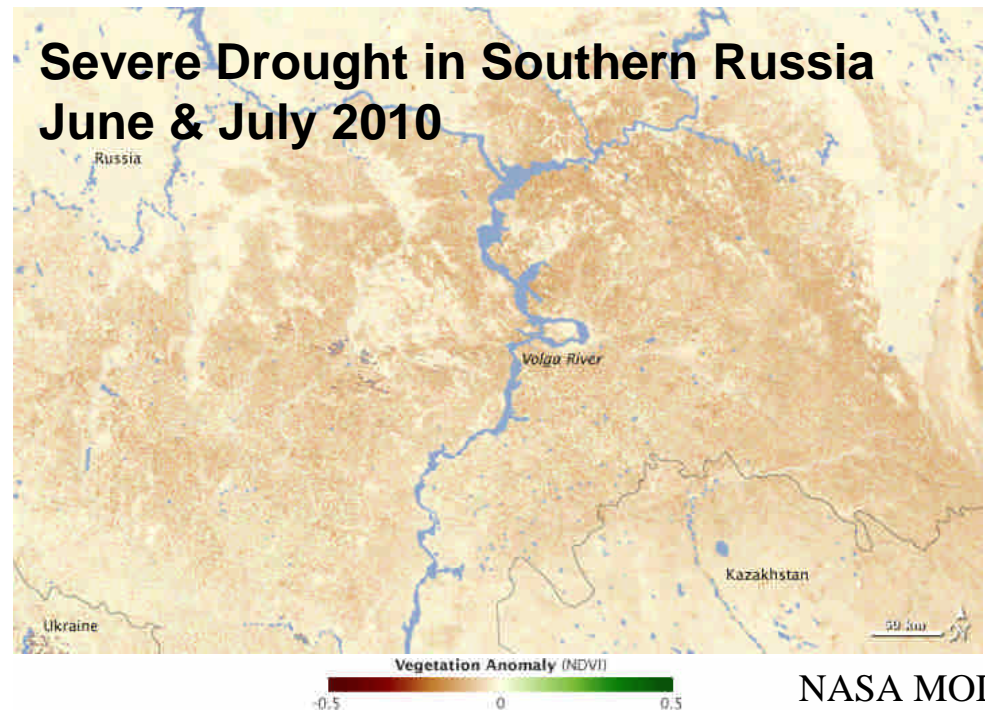
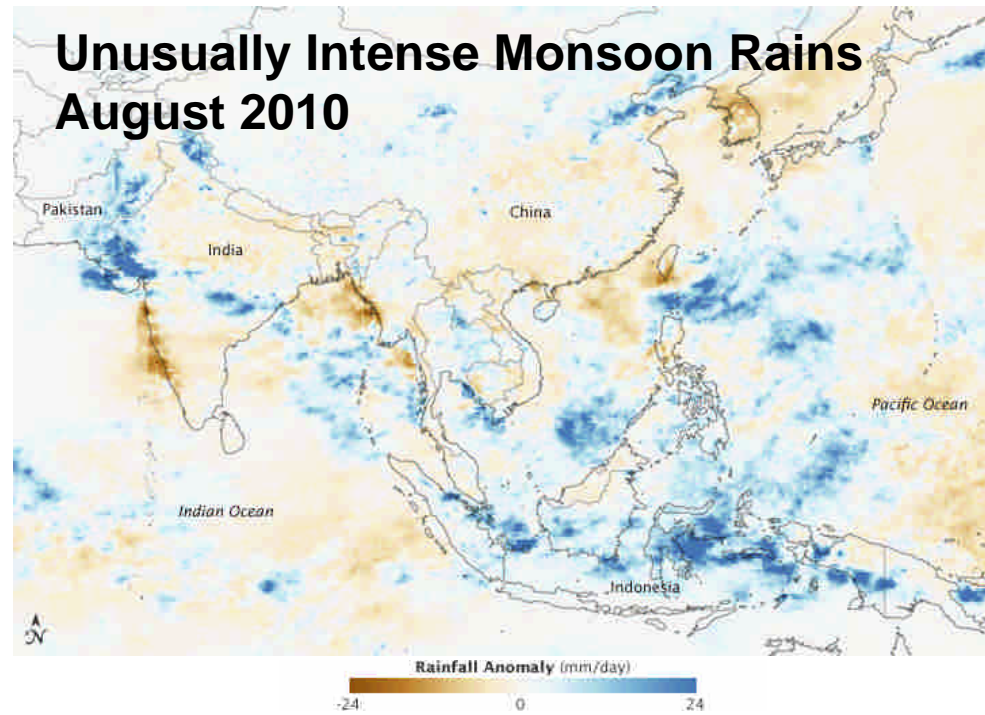


Plate 3.18. Country-level climate-change impacts on rain-fed cereal-production potential on currently cultivated land (HadCM3-A1FI, 2030s).

Changing nature of natural and human-induced disasters



FAO/GIEWS



NASA MODIS

Crop Breeding

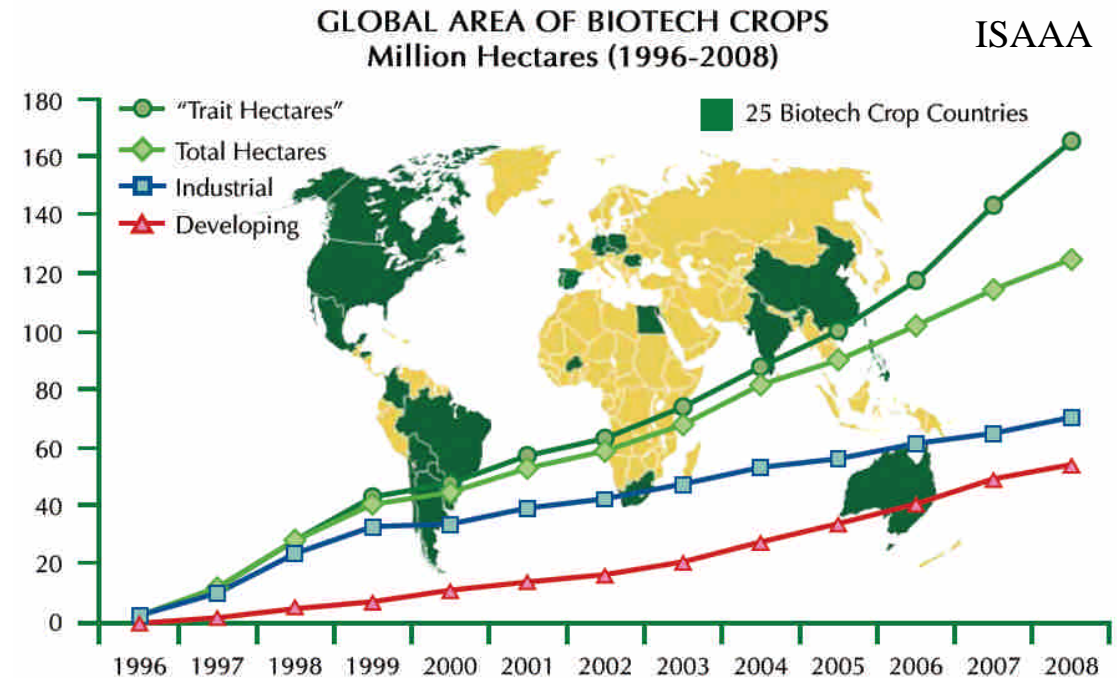
Increase yield potential
canopy structure
photosynthetic efficiency

Stress tolerant/resistant
drought
flood
heat
insect
weed

Mutation Breeding

Marker-assisted Selection

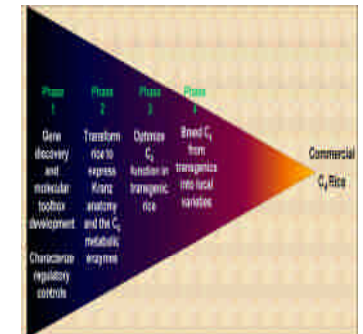
Genetic Modified/Engineered (Environment & Health Concern)



IRRI IR64+*SUB1*

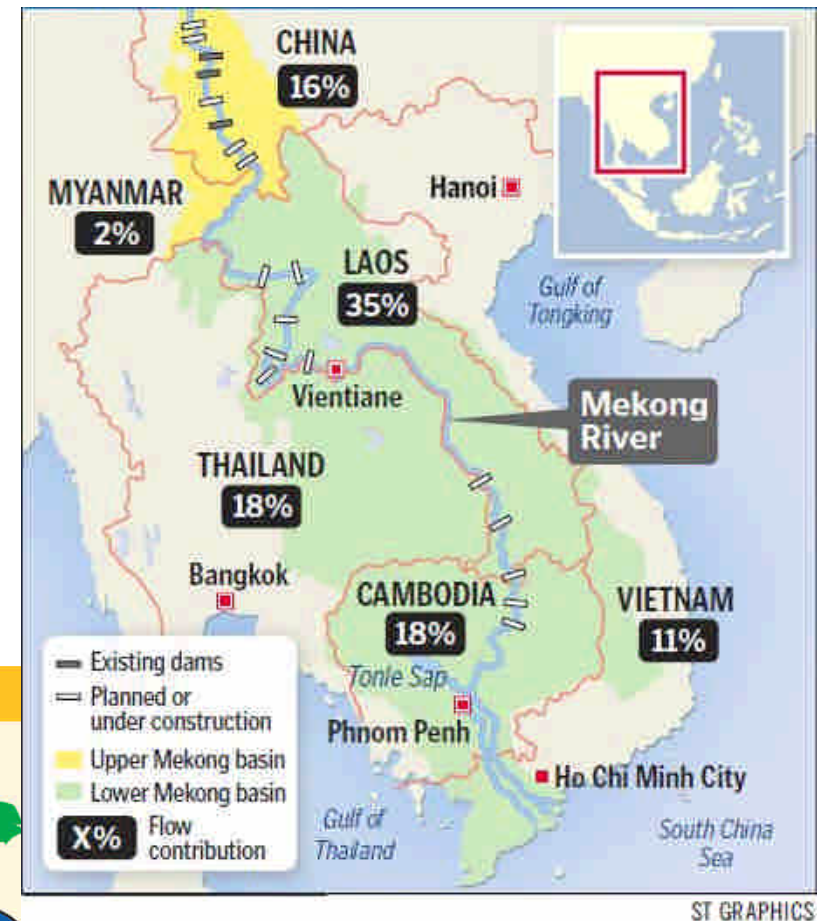
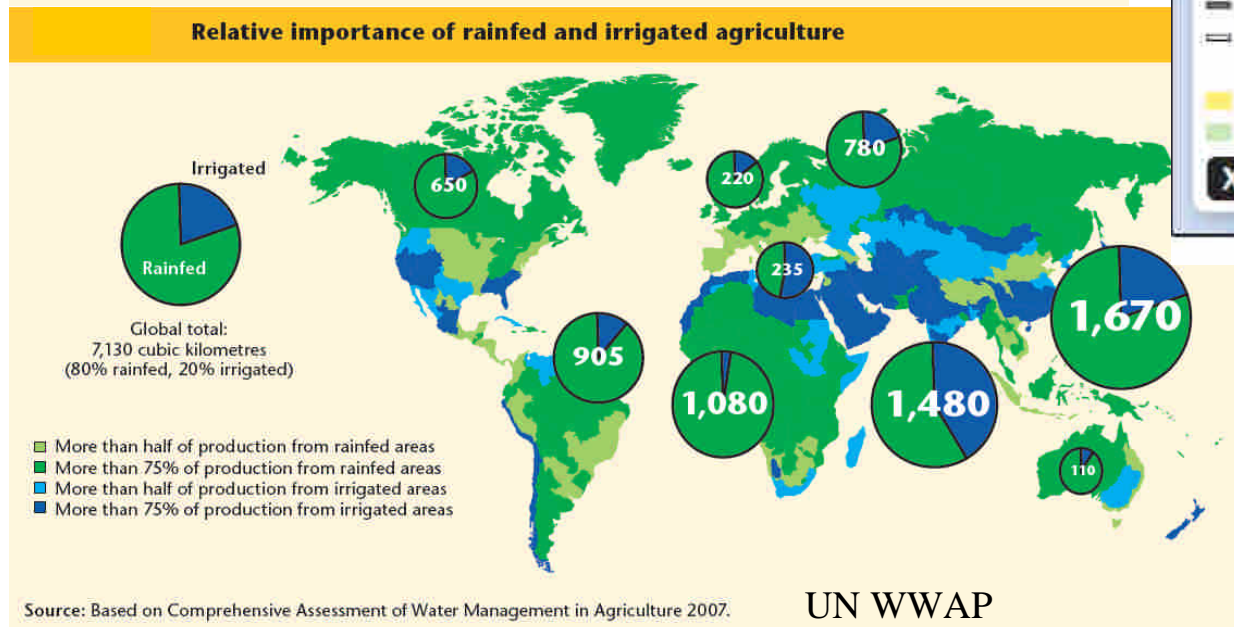
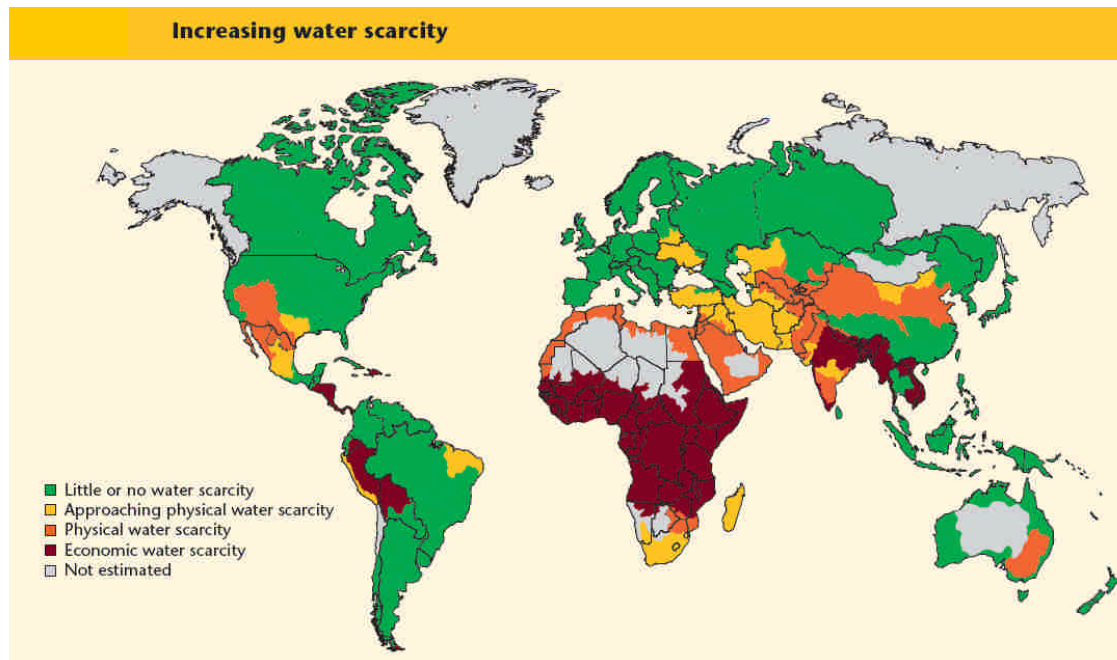


IRRI DFP



IRRI C₄ Rice

Water Scarcity

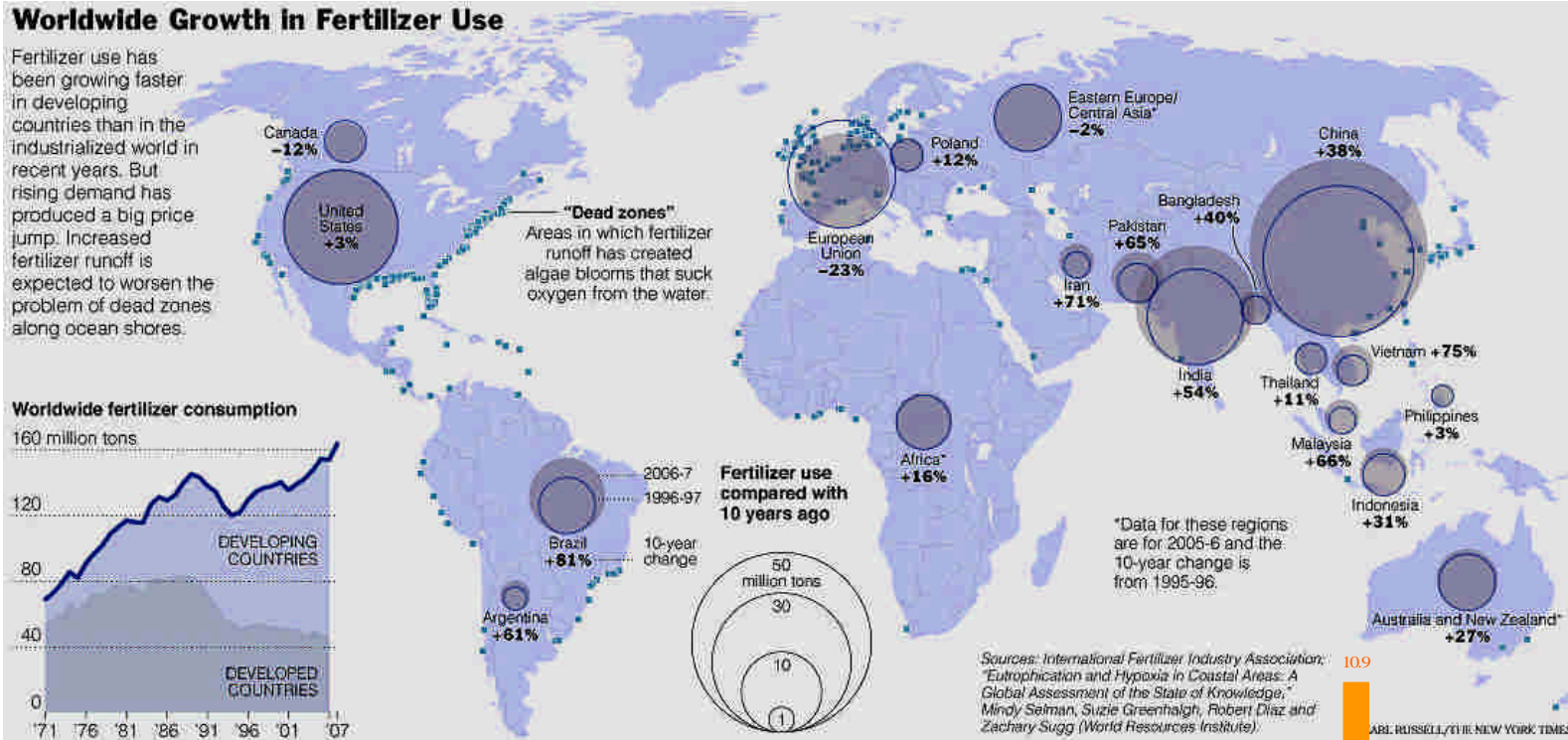
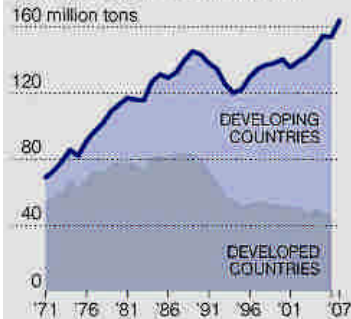


Dams :
Environmental concerns
International conflicts

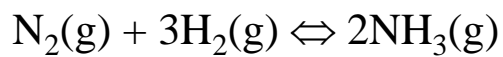
Worldwide Growth in Fertilizer Use

Fertilizer use has been growing faster in developing countries than in the industrialized world in recent years. But rising demand has produced a big price jump. Increased fertilizer runoff is expected to worsen the problem of dead zones along ocean shores.

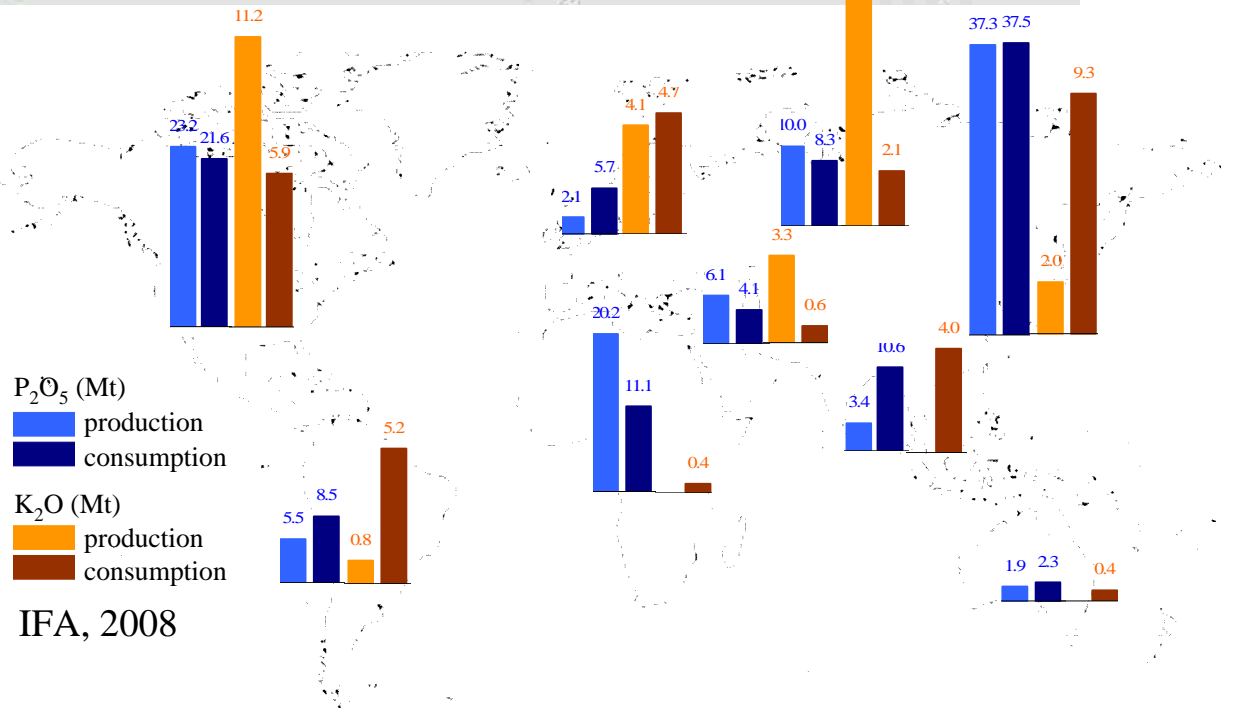
Worldwide fertilizer consumption



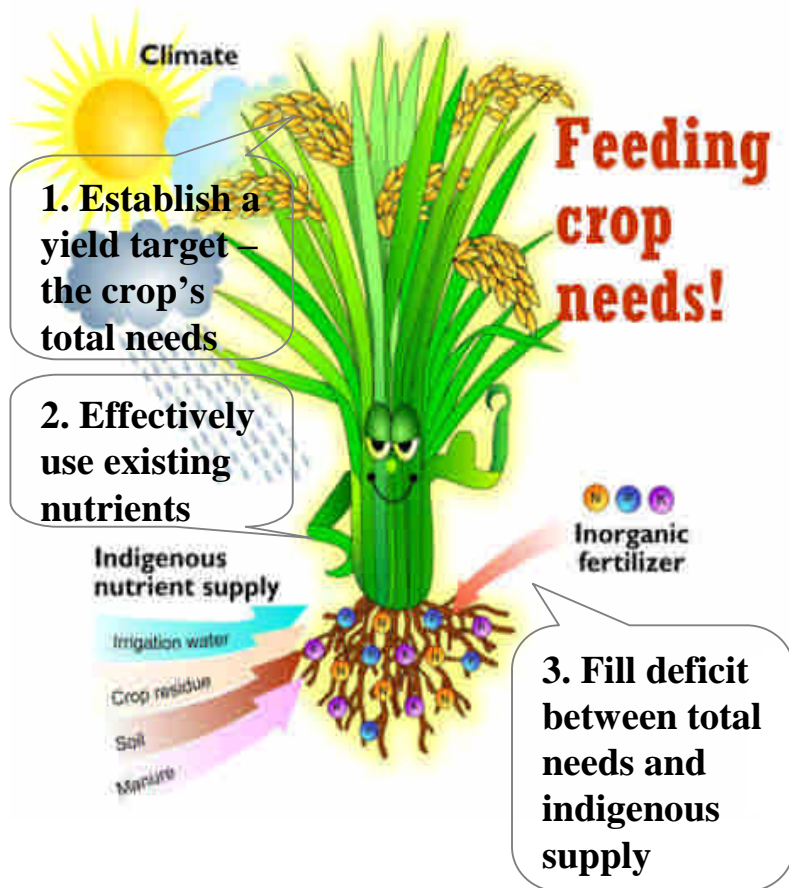
Haber-Bosch process



@ 200atm, 500°C



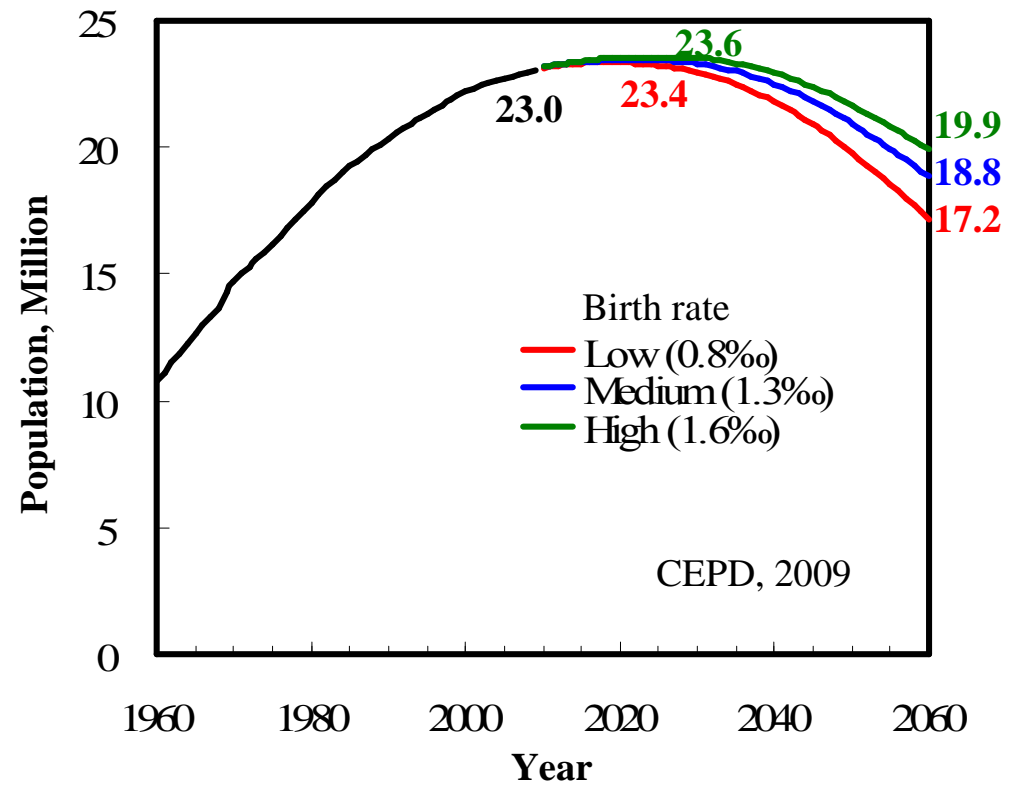
Site Specific Nutrient Management - Precision Agriculture



<http://www.irri.org/irrc/SSNM/index.asp>

<http://earthobservatory.nasa.gov/Features/PrecisionFarming/>

- **Global food crisis can significantly affect a nation's social stability and economic developments, particularly those poor nations and nations in lower latitudes.**
- **World as a whole, food production should be able to meet the majority's demands if no wide-spread adverse weather events and when farming is profitable for those major cereal exporters.**
- **Climate change will increase the frequency of extreme weather events, which in turn will increase the fluctuation of international cereal markets and chances of global food crisis.**
- **A sustainable agriculture must meet the food demand of the present generation but not sacrificing the needs/benefits of future generations.**



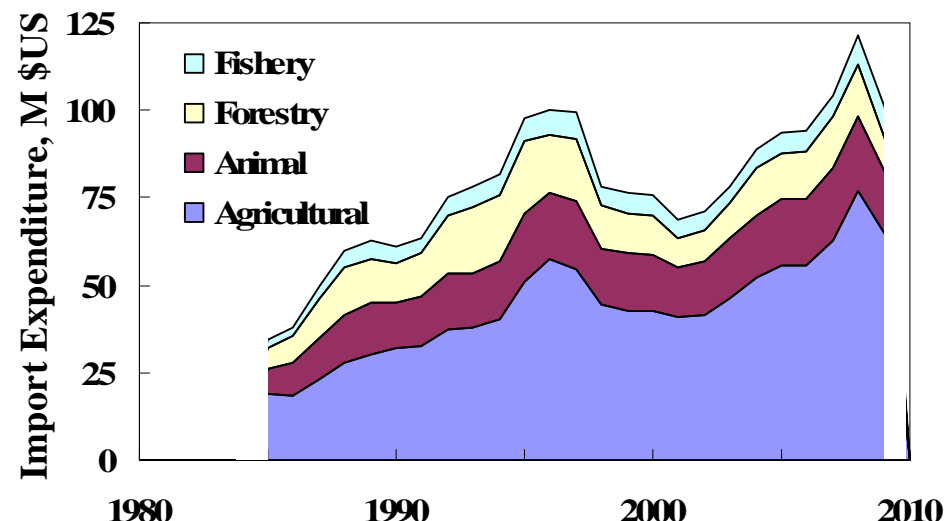
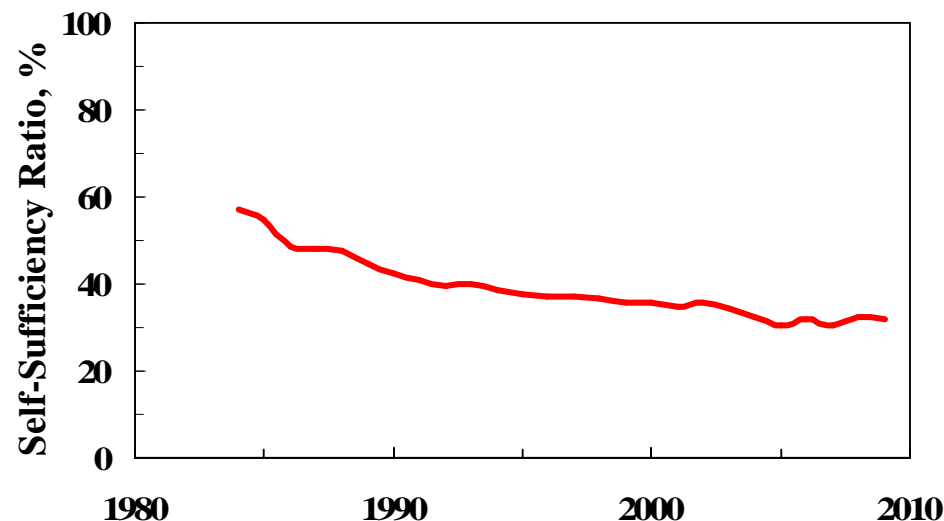
Unit: 10^8 m^3

Precipitation	1098.0
Utilization	179.2
Reservoirs	42.4
Rivers	80.3
Ground water	56.5

WRA, 2004-2008

Food Demand/Supply

COA



	Demand			Supply	
Cereal	Total	Food	Feed	Domestic	Import
Rice	1317	1246	4	1201	121
Wheat	1207	1092	34	0	1189
Maize	4770	99	4652	83	4714

Unit: 1000 tons y⁻¹

COA, 2005-2009

Major Food Importing Countries & Taiwan, China, Japan, S. Korea

Wheat

Rank	Country	Mt
1	Italy	5.0
2	Brazil	4.5
3	Egypt	4.4
4	Spain	4.0
5	Japan	4.0
6	Algeria	3.9
7	Netherlands	3.0
8	Indonesia	2.9
9	Mexico	2.6
10	Belgium	2.6
11	S. Korea	2.6
16	China	2.0
23	Taiwan	1.2

Maize

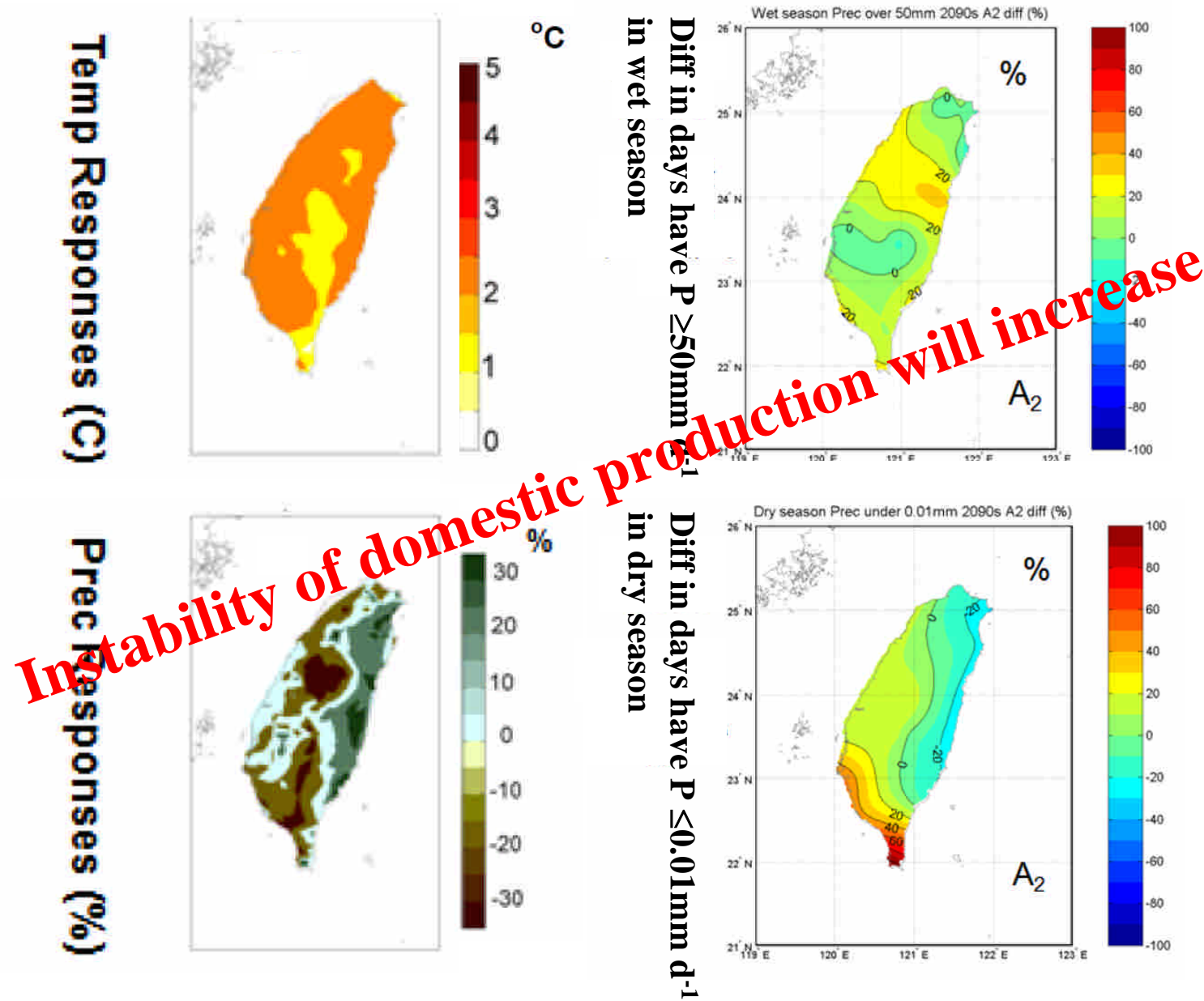
Rank	Country	Mt
1	Japan	12.5
2	S. Korea	6.4
3	Mexico	5.3
4	Taiwan	4.8
5	Spain	3.8
6	China	3.7
7	Egypt	3.3
8	Colombia	2.3
9	Malaysia	2.1
10	Netherlands	2.0
11	Iran	1.9

Meat

Rank	Country	Mt
1	Russia	2.1
2	Japan	2.0
3	UK	1.7
4	China	1.5
5	Germany	1.5
6	USA	1.5
7	Italy	1.3
8	Mexico	1.0
9	France	1.0
10	Netherlands	0.9
11	S. Korea	0.5
19	Taiwan	0.3

Predicted Climatic Change

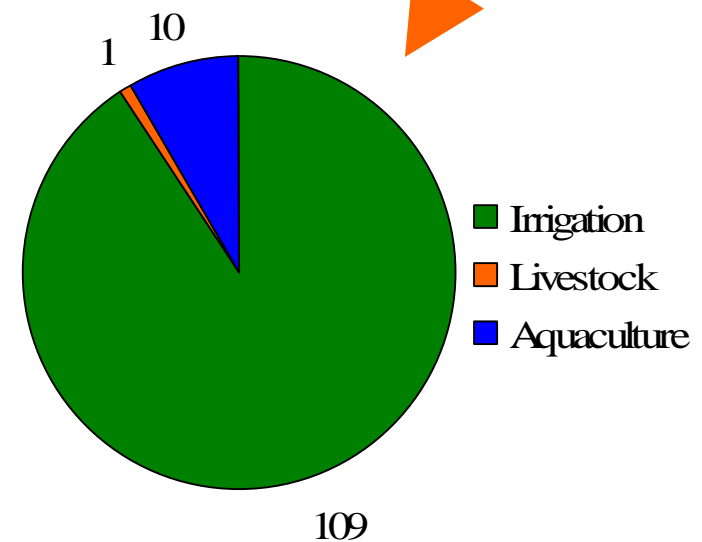
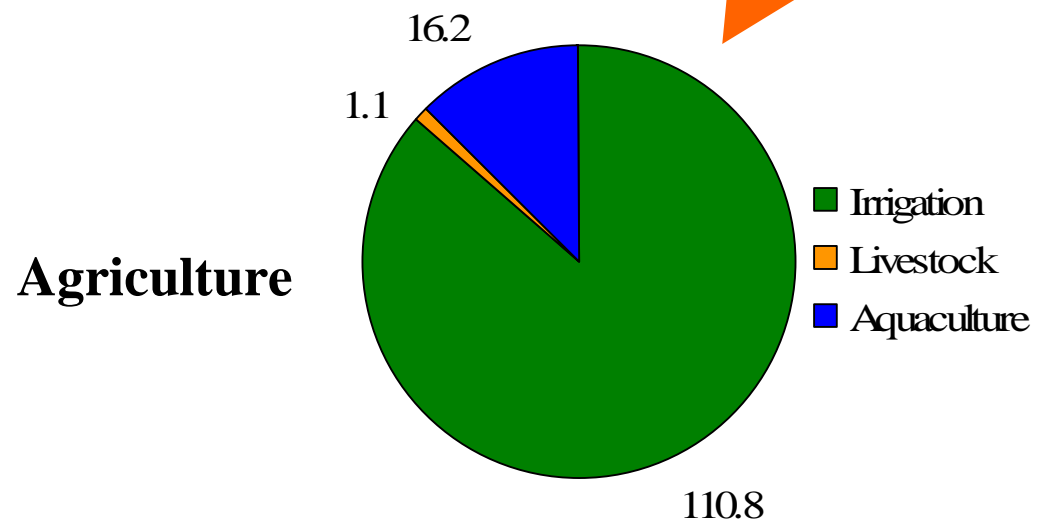
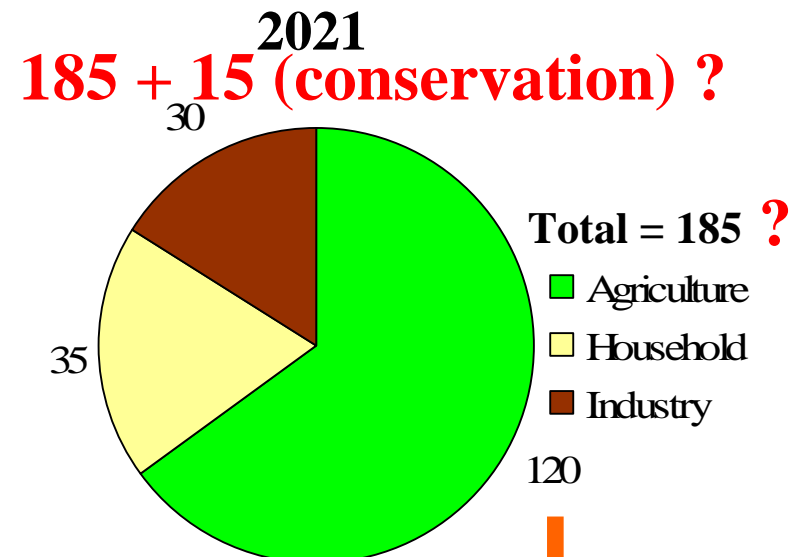
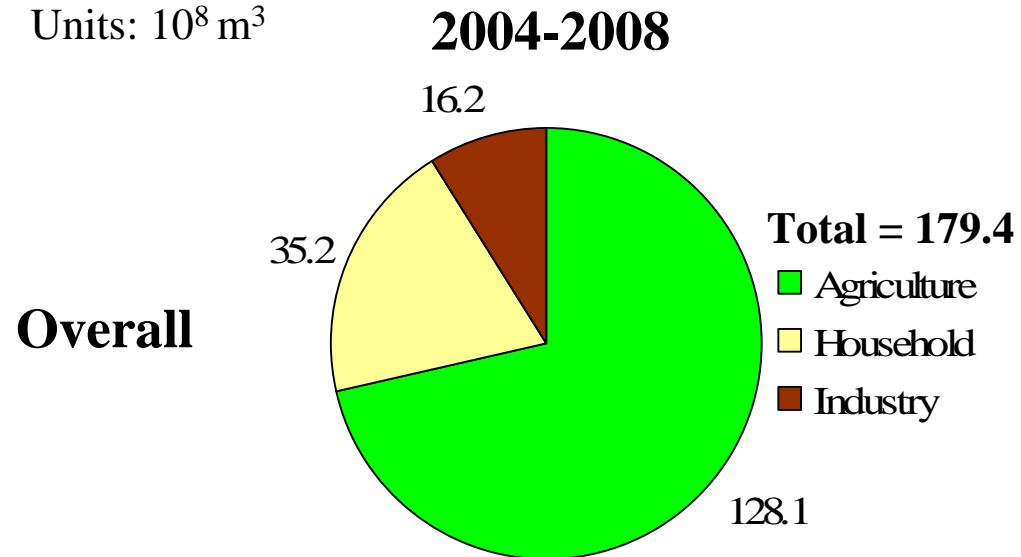
Liu et al. (2008)



Water Resource Allocation

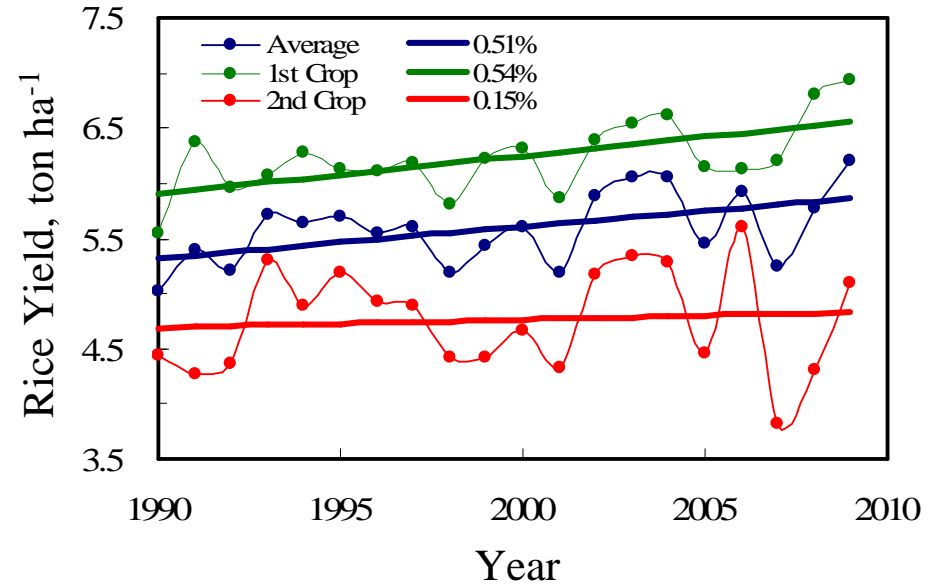
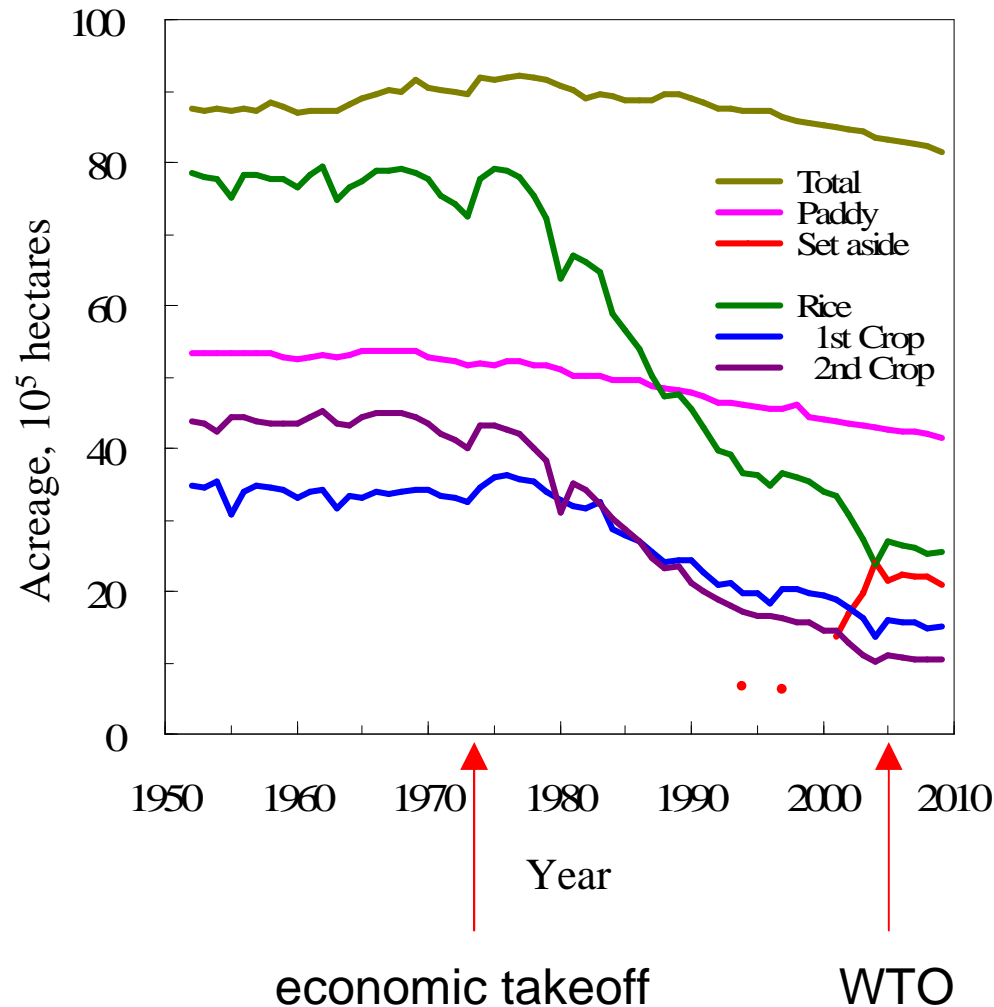
WRA

Units: 10^8 m^3



Changes of Arable Lands & Rice Yield

COA



Acreage Decreasing

1m sea level rise: ~ 5000 ha

Plain Afforestation: 60000 ha

Arable land release: ~3000 ha y^{-1}

Soil Degradation

OM decomposition ← higher T

Acidification ← more fertilizers

Pollution ← more development

- **Taiwan's food security is already very vulnerable even not considering the effects of climate change.**
- **Taiwan needs to raise food self-sufficiency ratio in order to regain flexibility and maneuverability in mitigating the impacts of climate change on food insecurity.**
- **Improved arable land rehabilitation and preservation, greater water conservation and better water management, and development and application of new technologies are key issues in achieving sustainable agriculture.**

A photograph capturing the aftermath of a tsunami in Thailand. A massive, white, churning wall of water is crashing over a sandy beach. Several people are seen in the foreground, running away from the water. A man in a pink shirt and dark pants is running towards the left. A man in a dark shirt and light pants is running towards the right. A man in a white shirt and dark pants is running towards the right. The background is filled with palm trees and a clear blue sky.

Thanks for Your Attention

Food Crisis = Silent Tsunami

Economist, UN WFP (2008)

The 2004 tsunami in Thailand