WASCAL

West African Science Service Center on Climate Change and Adapted Land Use

Zentrum für Entwicklungsforschung
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The Energy and Carbon Conundrum in Sustainable Agricultural Production

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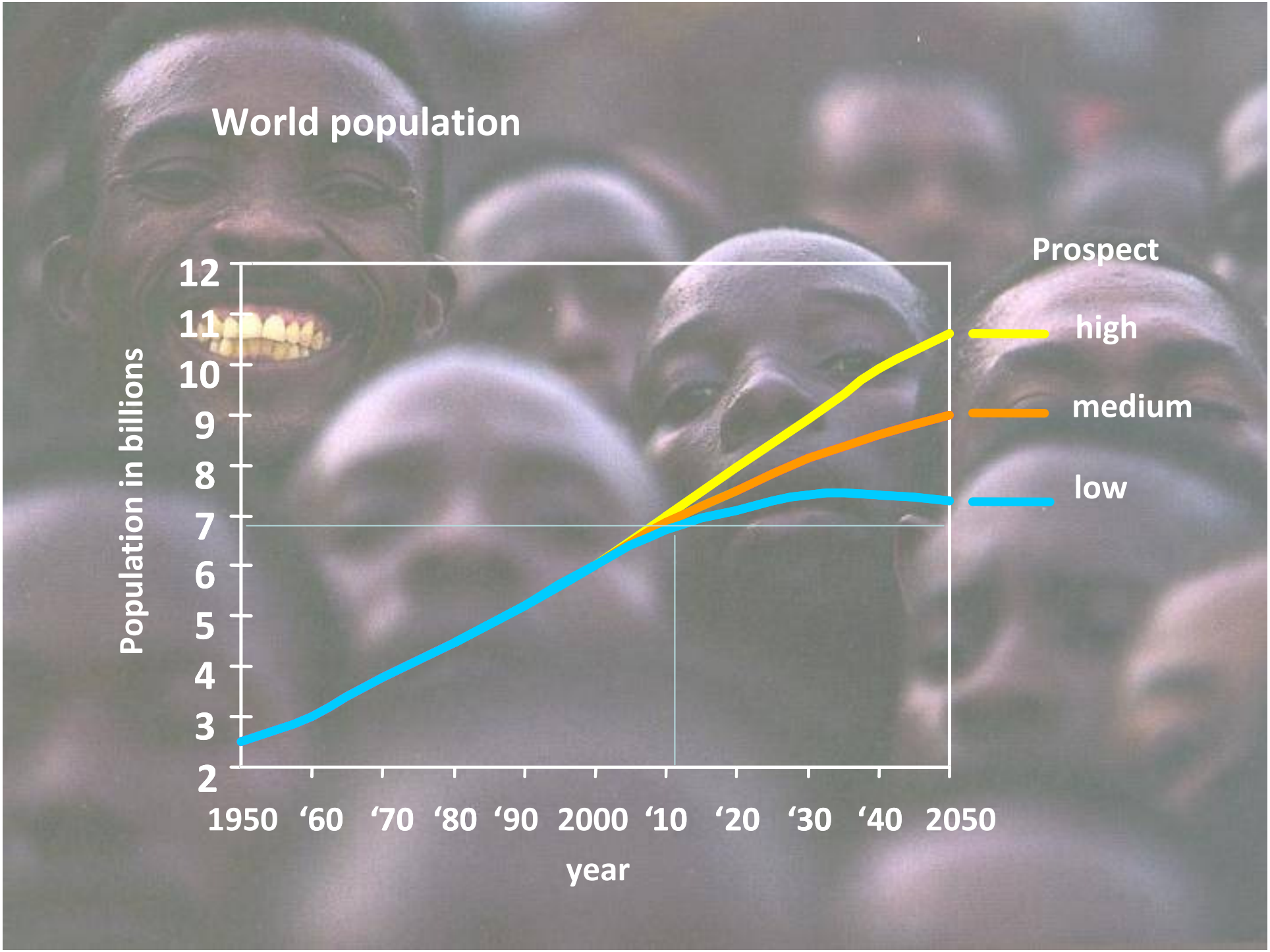
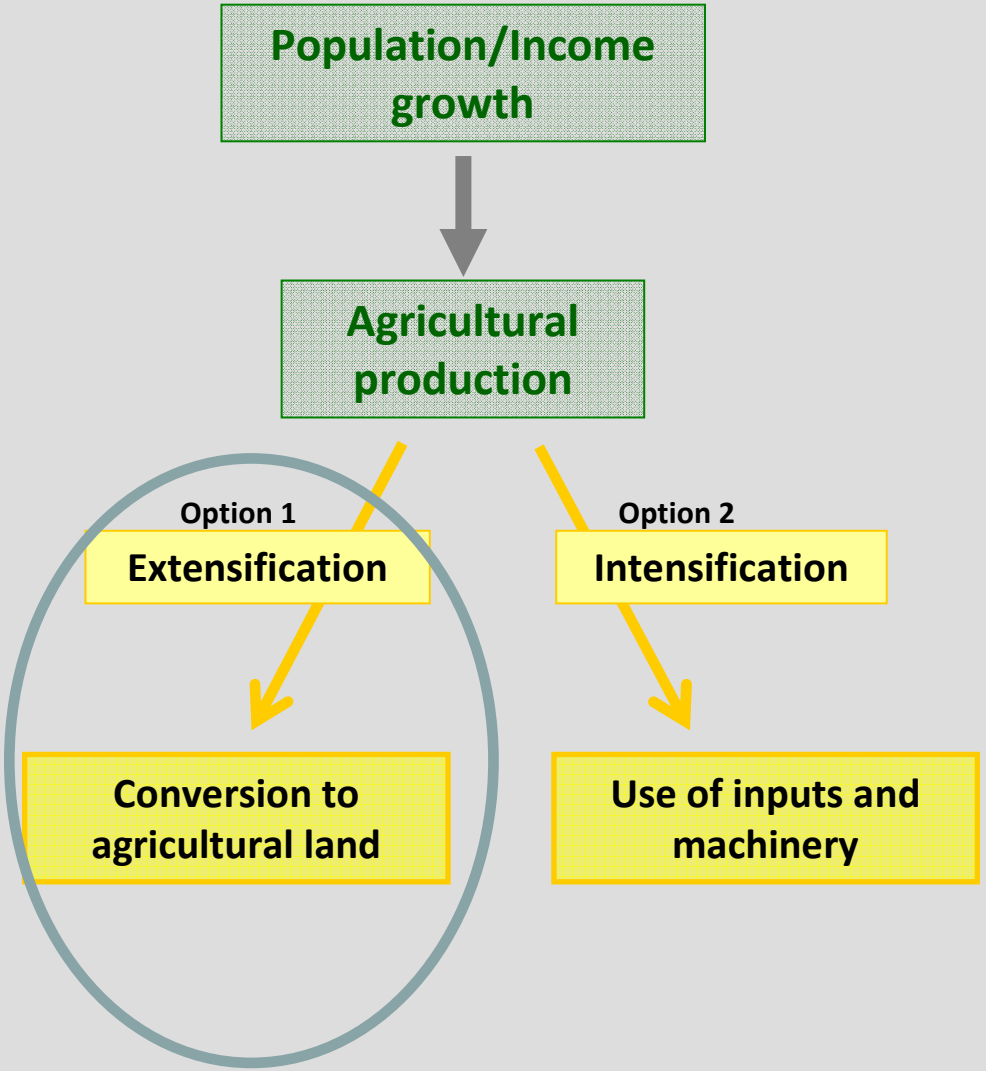

World population
Prospect
high
medium
low
Population in billions
12
11
10
9
8
7
6
5
4
3
2
1950
‘60
‘70
‘80
‘90
2000
‘10
‘20
‘30
‘40
2050
year

The options to meet food demand

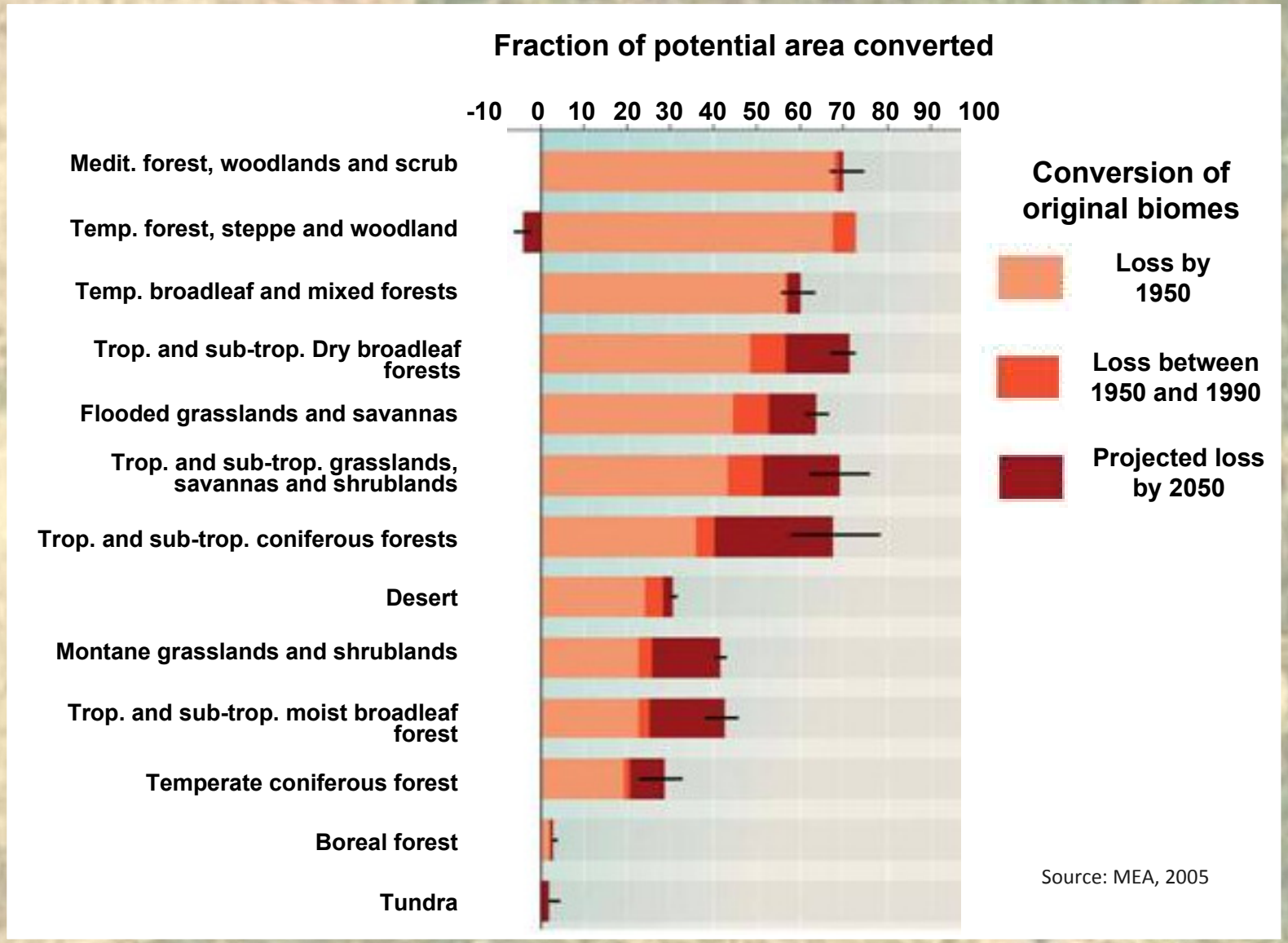


Changes in agricultural land use 1960 - 2000

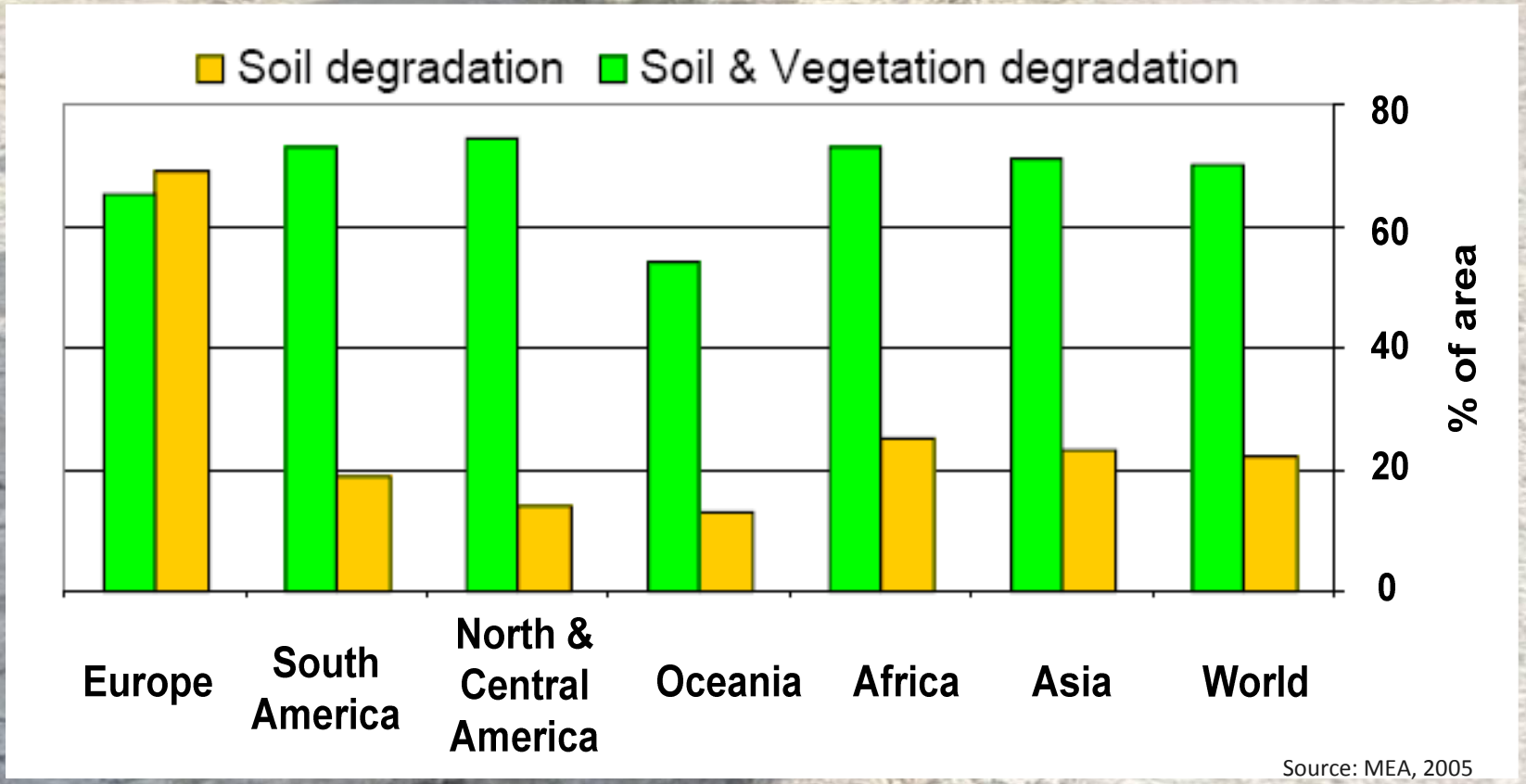
	Area 1961-1970 (10^6 ha)	Changes 1961-2000 (%)
Developed countries	3760	-2
Developing countries		
Agriculture	2682	19
Permanent pasture	1973	16
Arable land	650	22
Permanent crops	59	81

Smith et al., 2007

Conversion of terrestrial biomes

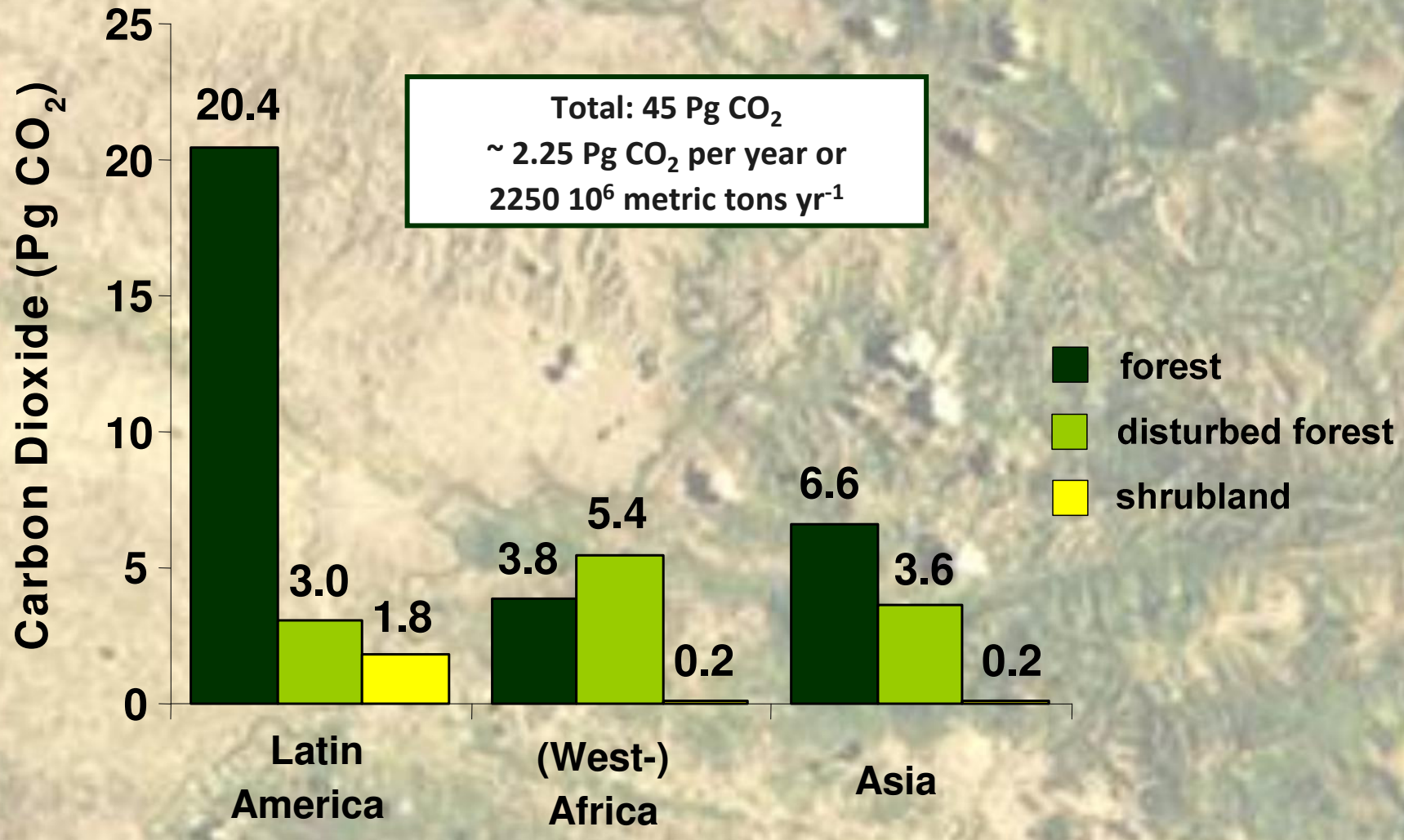


Land degradation in various parts of the world

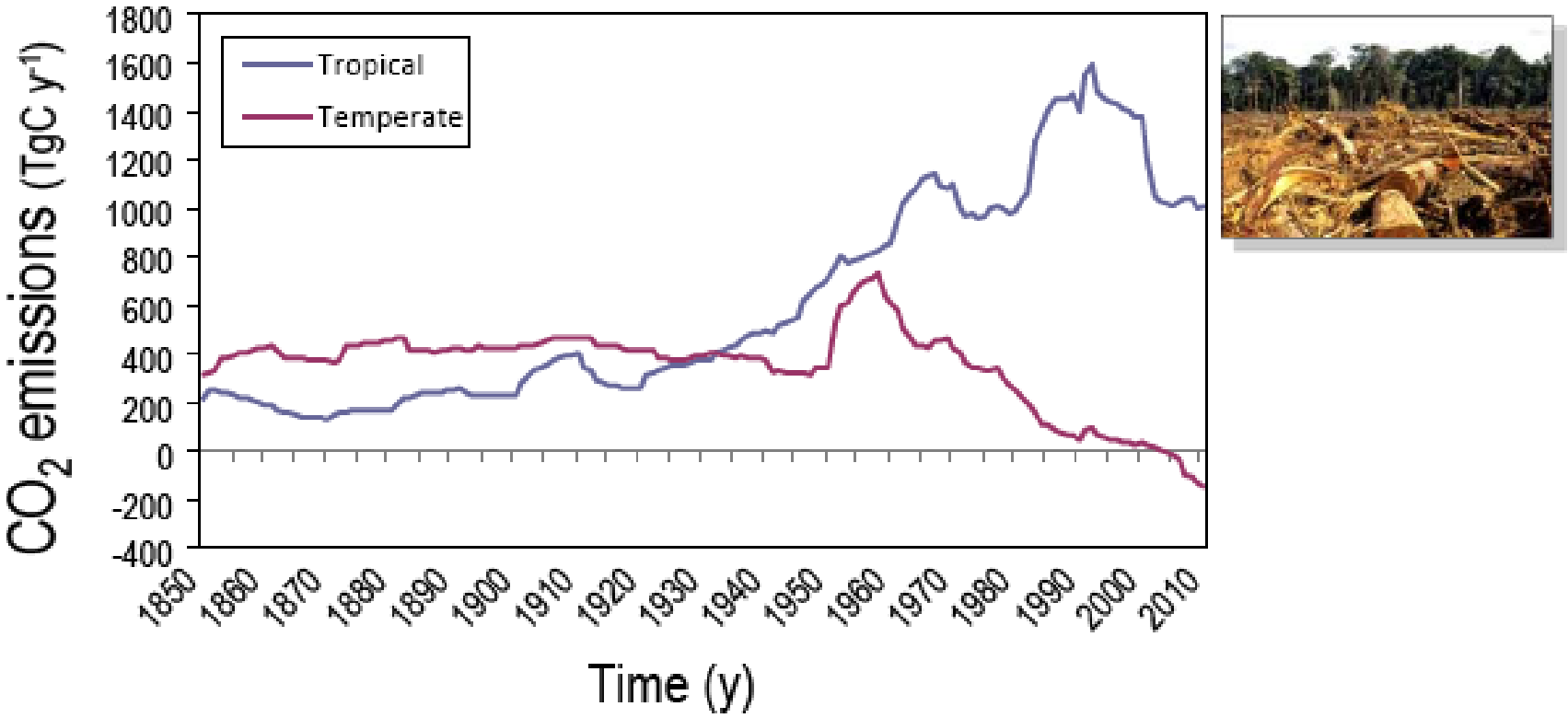


Source: MEA, 2005

Release of CO_2 for agricultural expansion (1980 – 2000) for selected regions

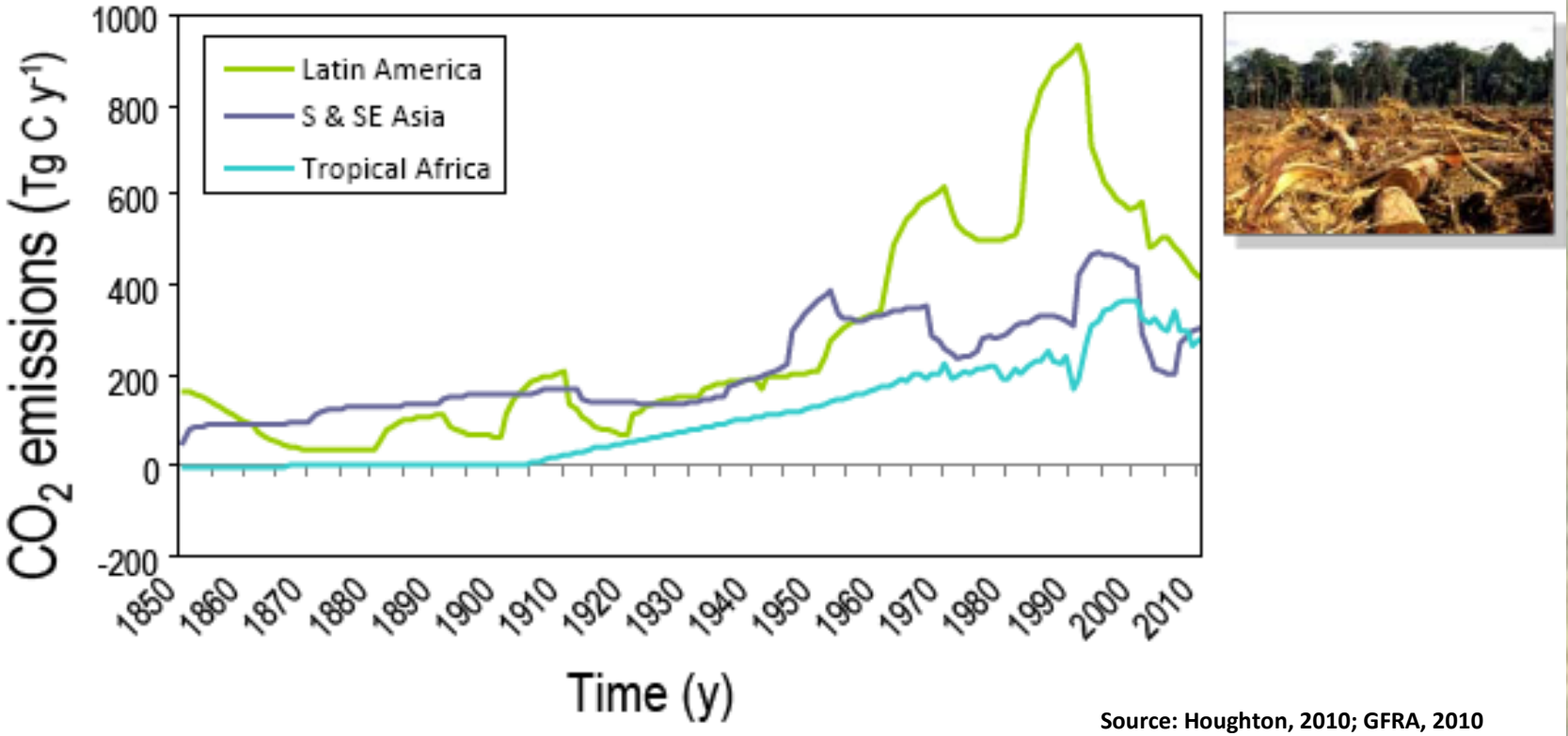


CO_2 emissions from land use change



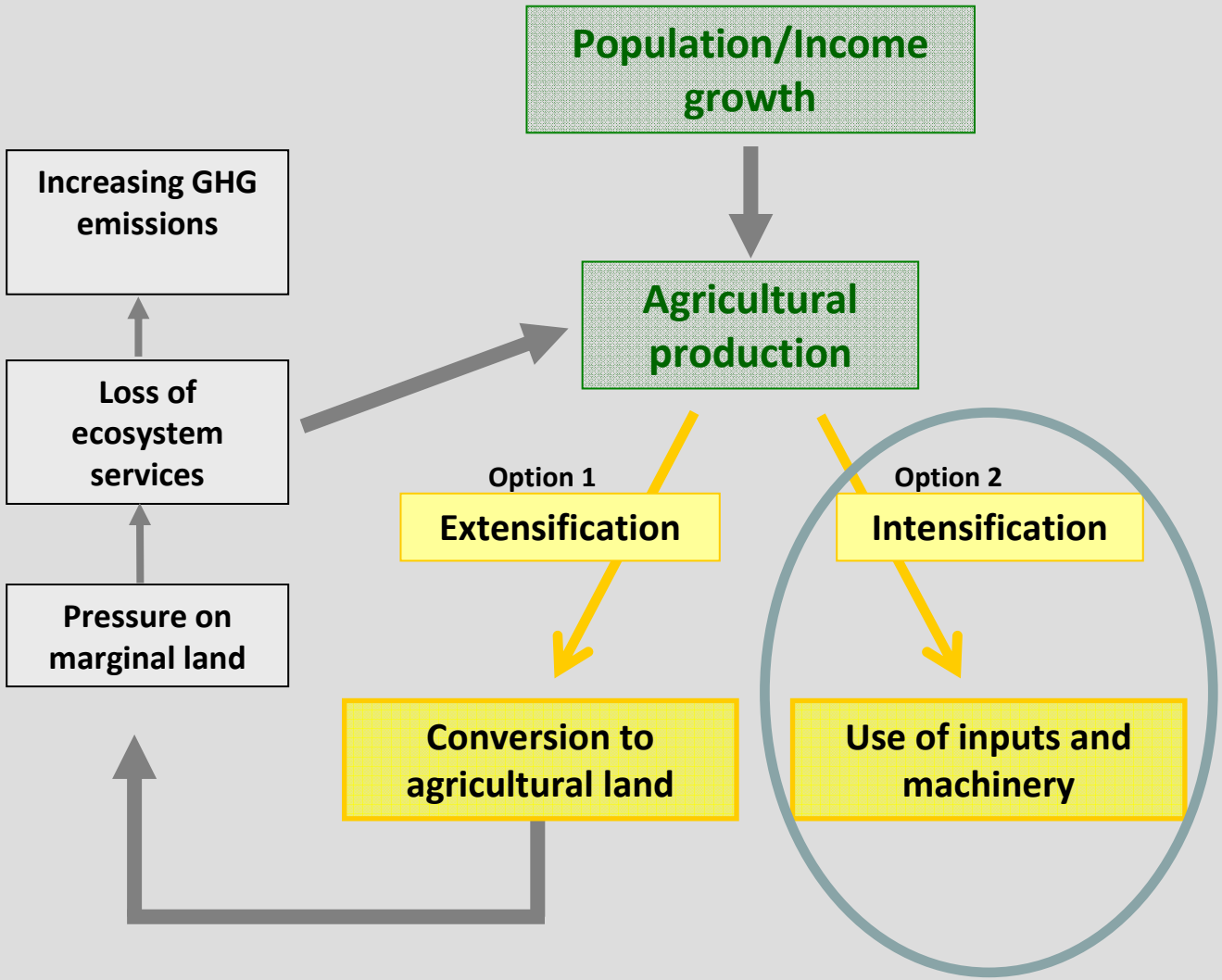
Source: Houghton, 2010; GFRA, 2010

CO_2 emissions from land use change



Source: Houghton, 2010; GFRA, 2010

The options to meet food demand

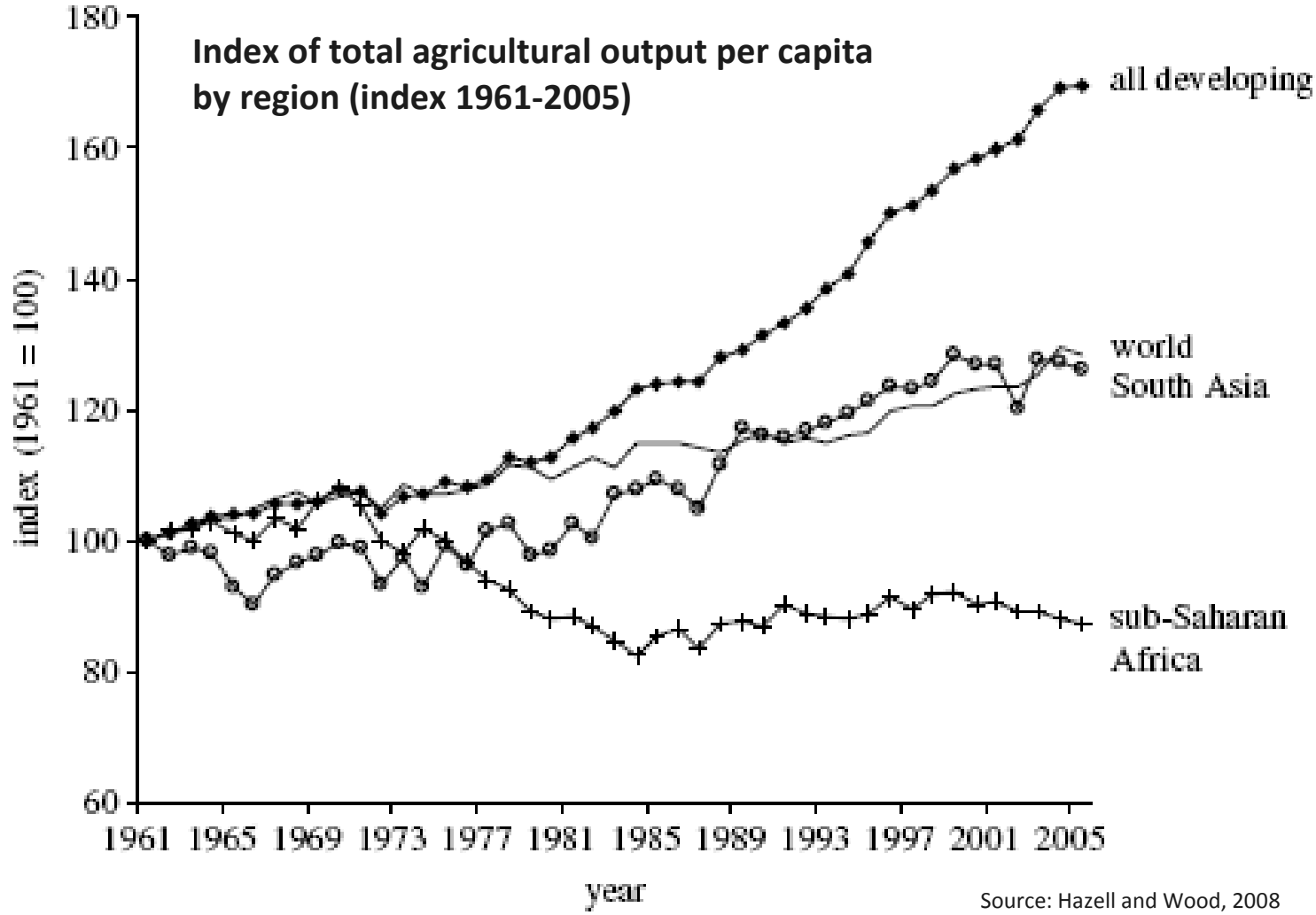


Option 2

Intensification

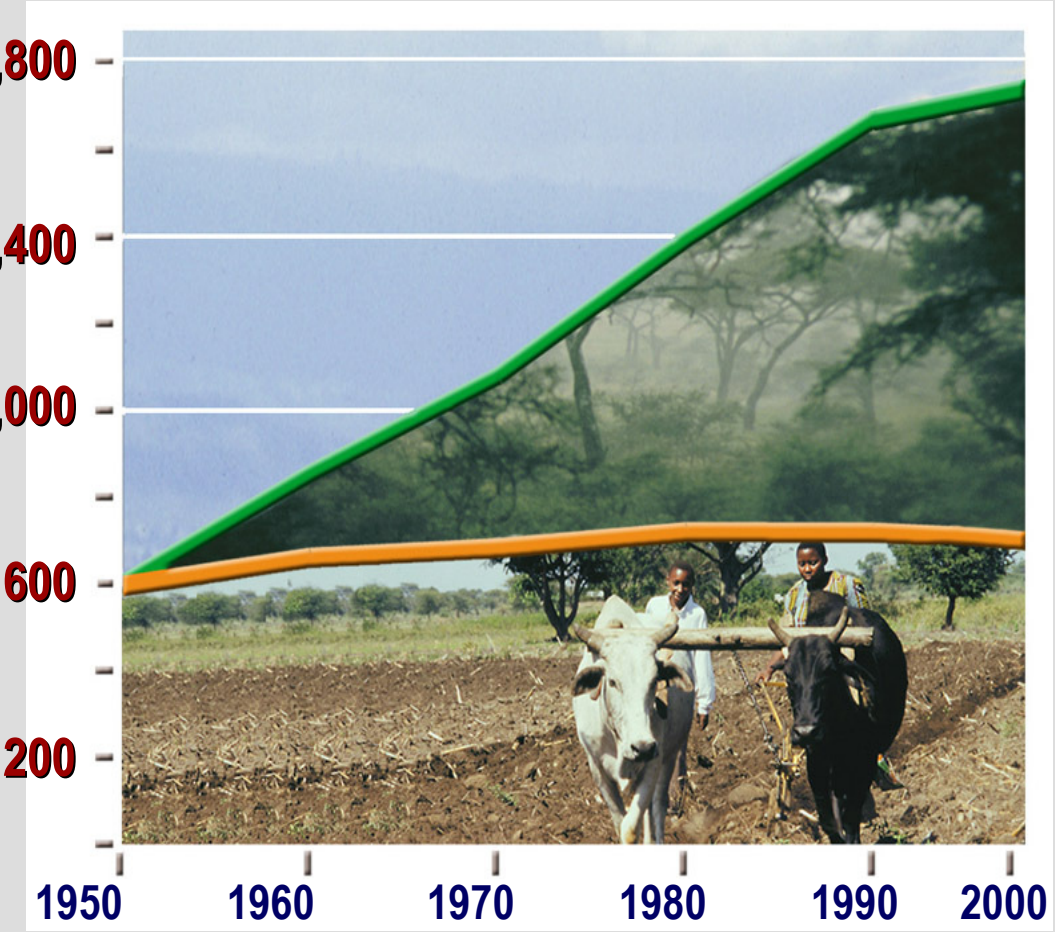
What are the consequences and ecological cost of agricultural intensification?

Index of total agricultural output per capita by region (index 1961-2005)



Source: Hazell and Wood, 2008

Tripled World Cereal Production–Areas Spared Through Improved Technology, 1950-2000



LAND SPARED
1.1 billion ha

LAND USED 660 million ha

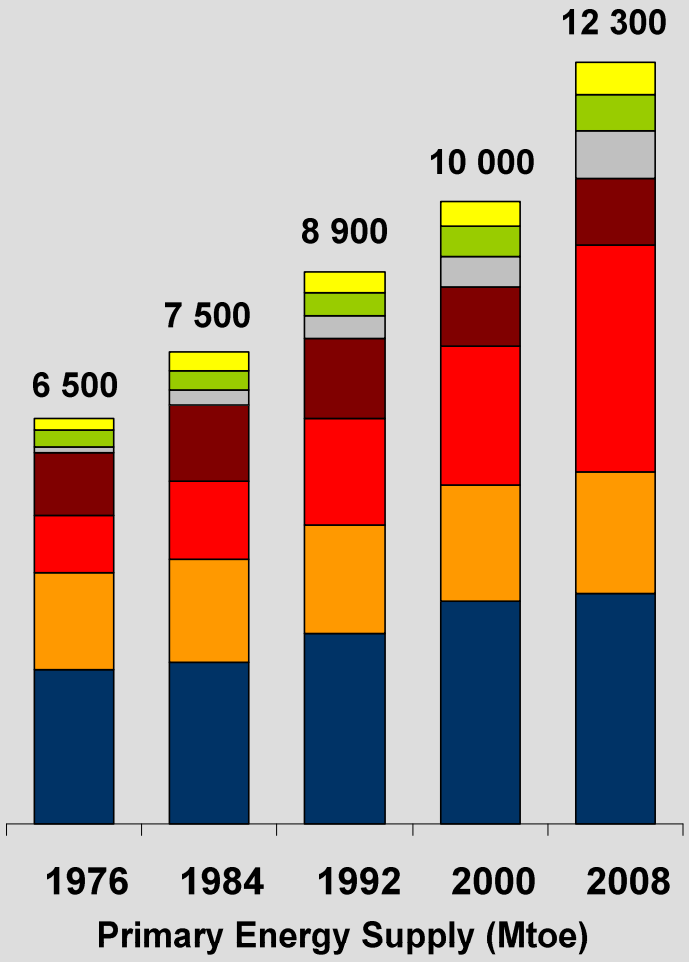
Source: FAO Production Yearbooks and AGROSTAT

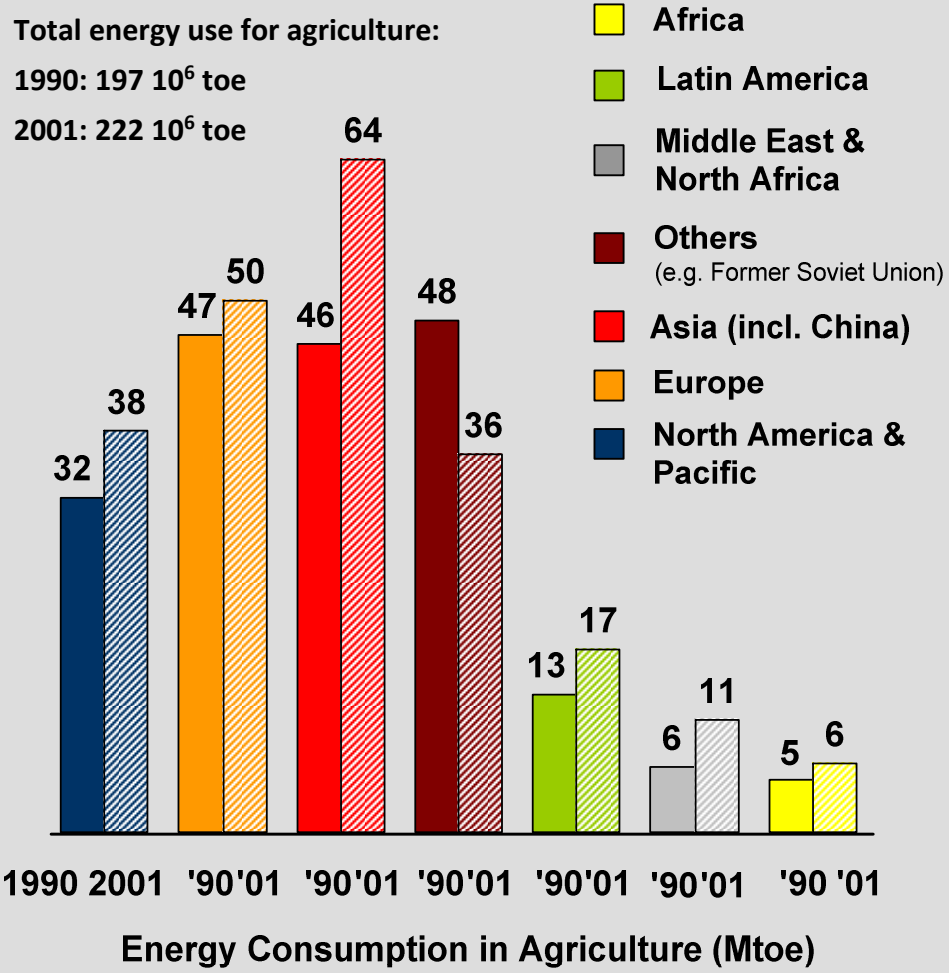
See also: Rudel et al., 2009: Proc Natl Acad Sci 106(49)20675

Rising energy consumption for agriculture

Energy use in agriculture amounts to ~2% of the total energy use worldwide

- especially in developing countries a higher demand is expected in the future





Source: IEA, 2010

Commercial energy consumption in different regions (2001)

	Commercial energy use (10^6 toe yr^{-1})	Commercial energy use in agriculture (10^6 toe yr^{-1})	Share of energy use in agriculture (%)
Sub-Saharan Africa	400	6	1.6
Latin America	460	17	3.8
Middle East & North Africa	500	11	2.1
Asia (incl. China)	2 200	64	2.9
Developing countries	3 560	98	2.7
Europe	1 900	50	2.7
North America & Pacific	3 400	38	1.1
Others (e.g. Former Soviet Union)	1 200	36	3.0
World	10 060	222	2.2

Source: IEA, 2005

Food production is dependent on fossil energy

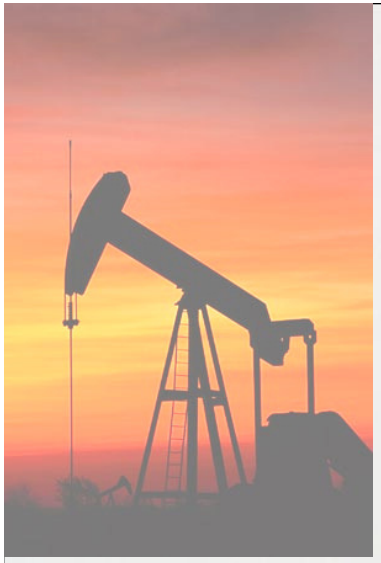
	Commercial energy use in agriculture (10^{13} kcal yr^{-1})	Total annual food energy produced (10^{13} kcal yr^{-1})	Fossil energy efficiency (Ef) in agriculture
Sub-Saharan Africa	6	56	9.3
Latin America	17	56	3.3
Middle East & North Africa	11	46	4.2
Asia (incl. China)	64	346	5.4
Developing countries	98	480	4.9
Europe	50	86	1.7
North America & Pacific	38	43	1.1
Other	36	105	2.9
World	222	640	2.9

The energy efficiency ratio is the total annual food energy divided by the total energy input

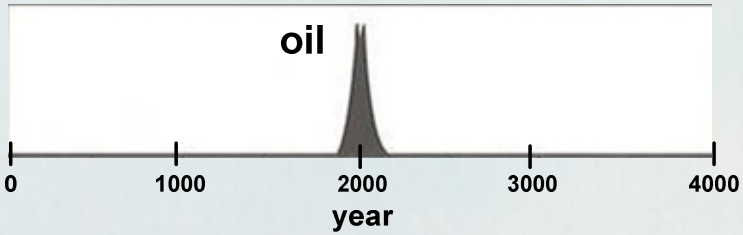
Source: IEA, 2005

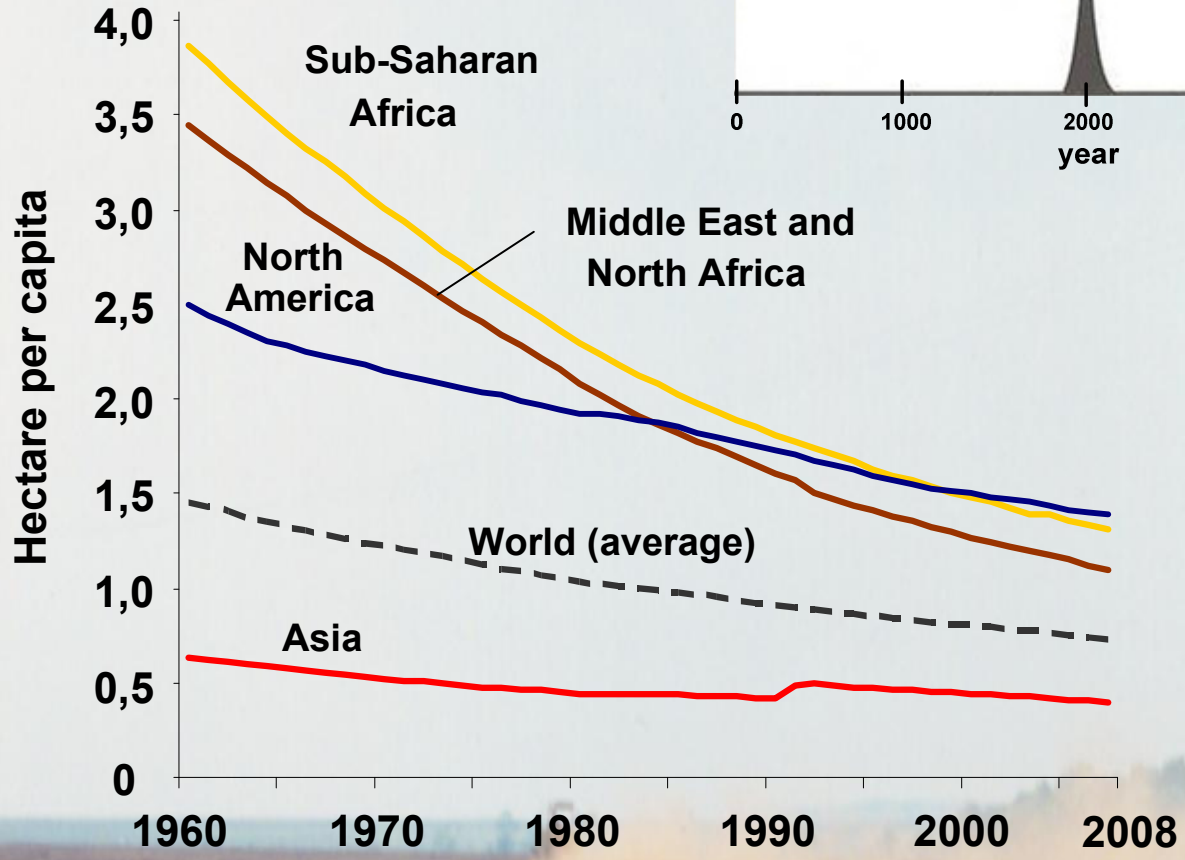
Total Energy Input and Output and Energy Efficiency (Et) in Agricultural Production Systems

Region	Cropping system	Energy (kJ/ha and year)		Total energy efficiency (Et) in agriculture
		Output	Input	
New Guinea	Mixed root crops	41	2.5	16.5
Mexico	Semi -intensive maize	14.2	2.9	4.9
Surinam	Intensive rice	51.5	41.1	1.3
USA	Maize	76.9	29.9	2.6



Availability of agricultural land per capita and region

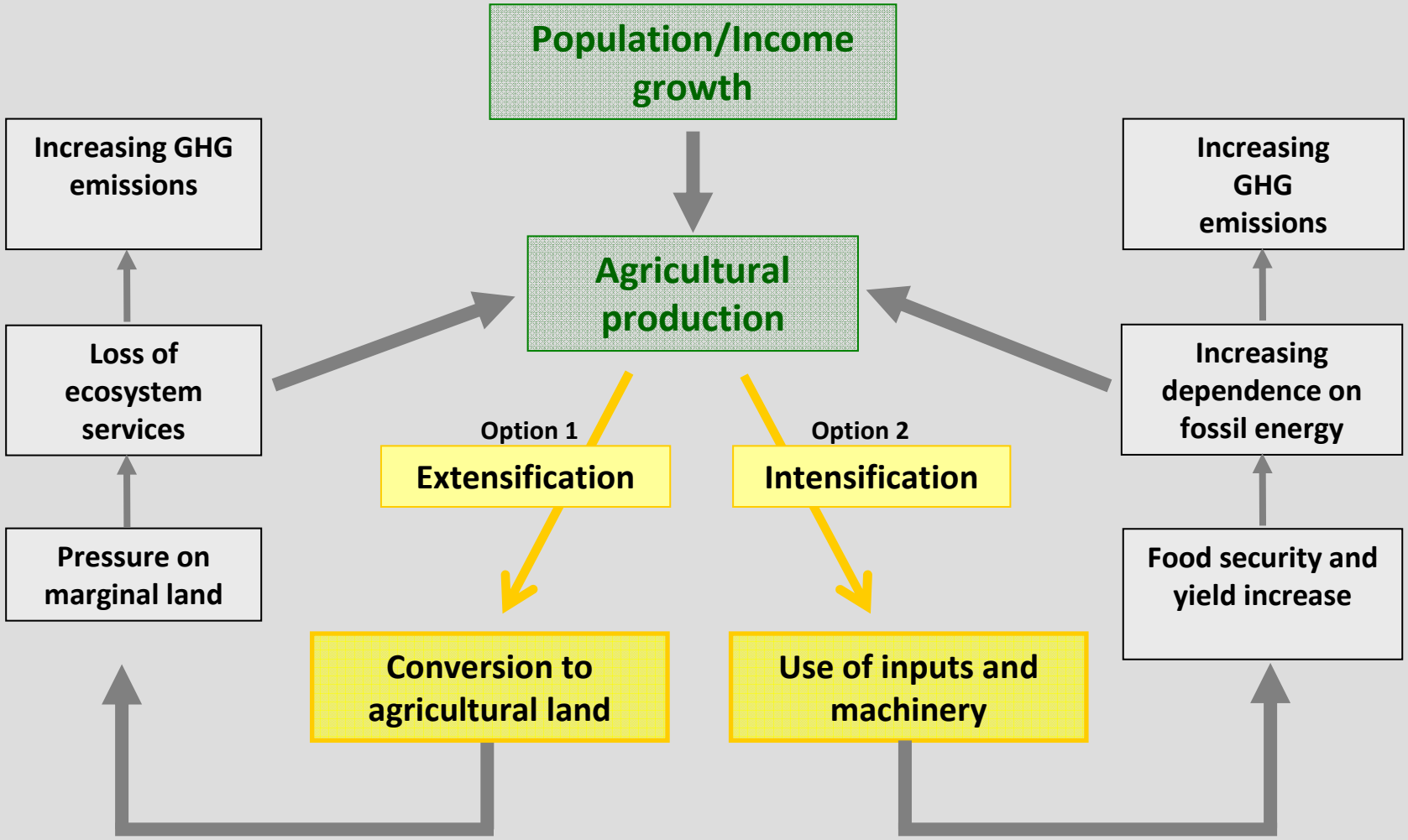


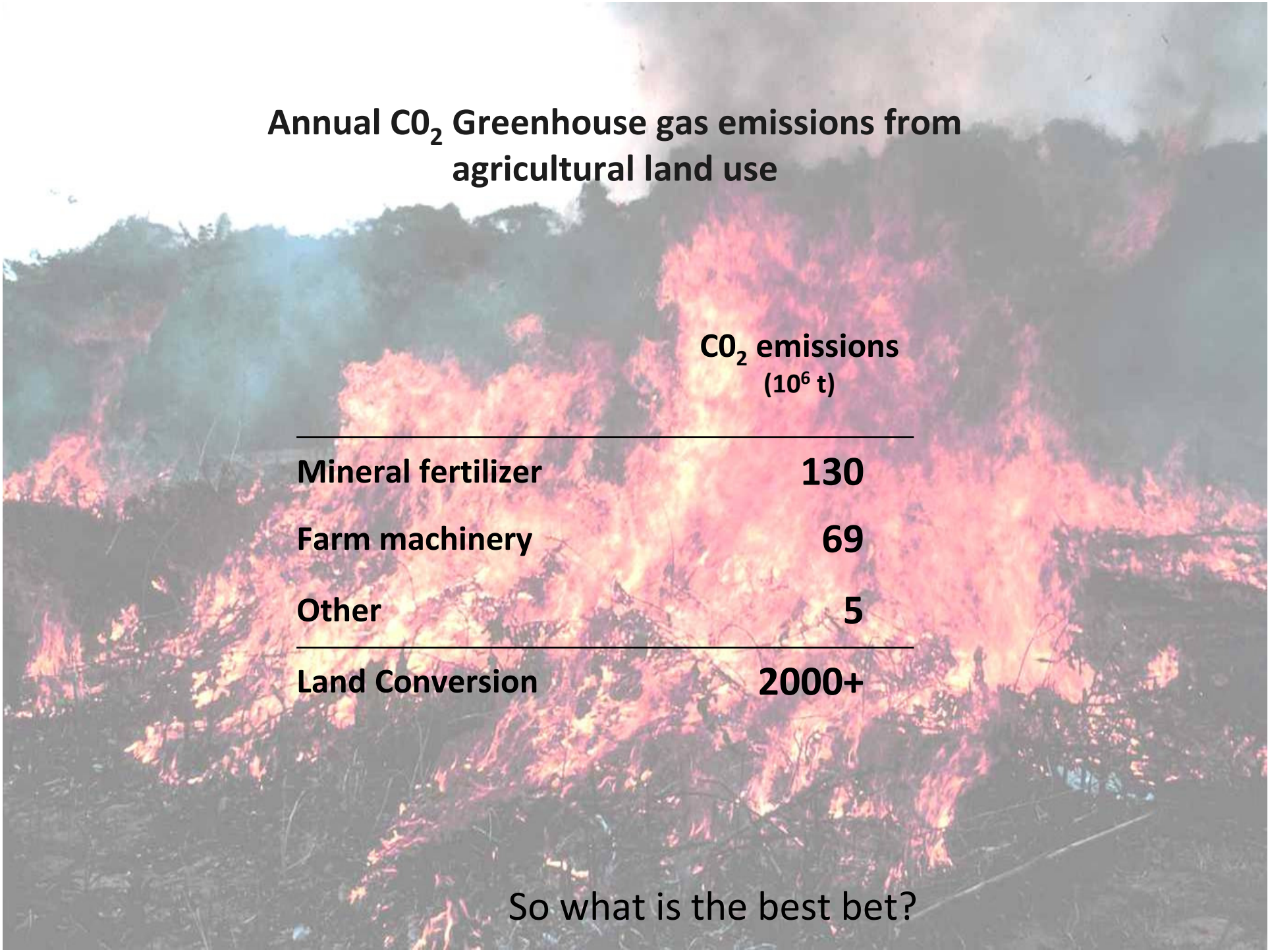


Source: FAOSTAT database, 2008

Problem Statement

The energy use and carbon conundrum in the agricultural sector



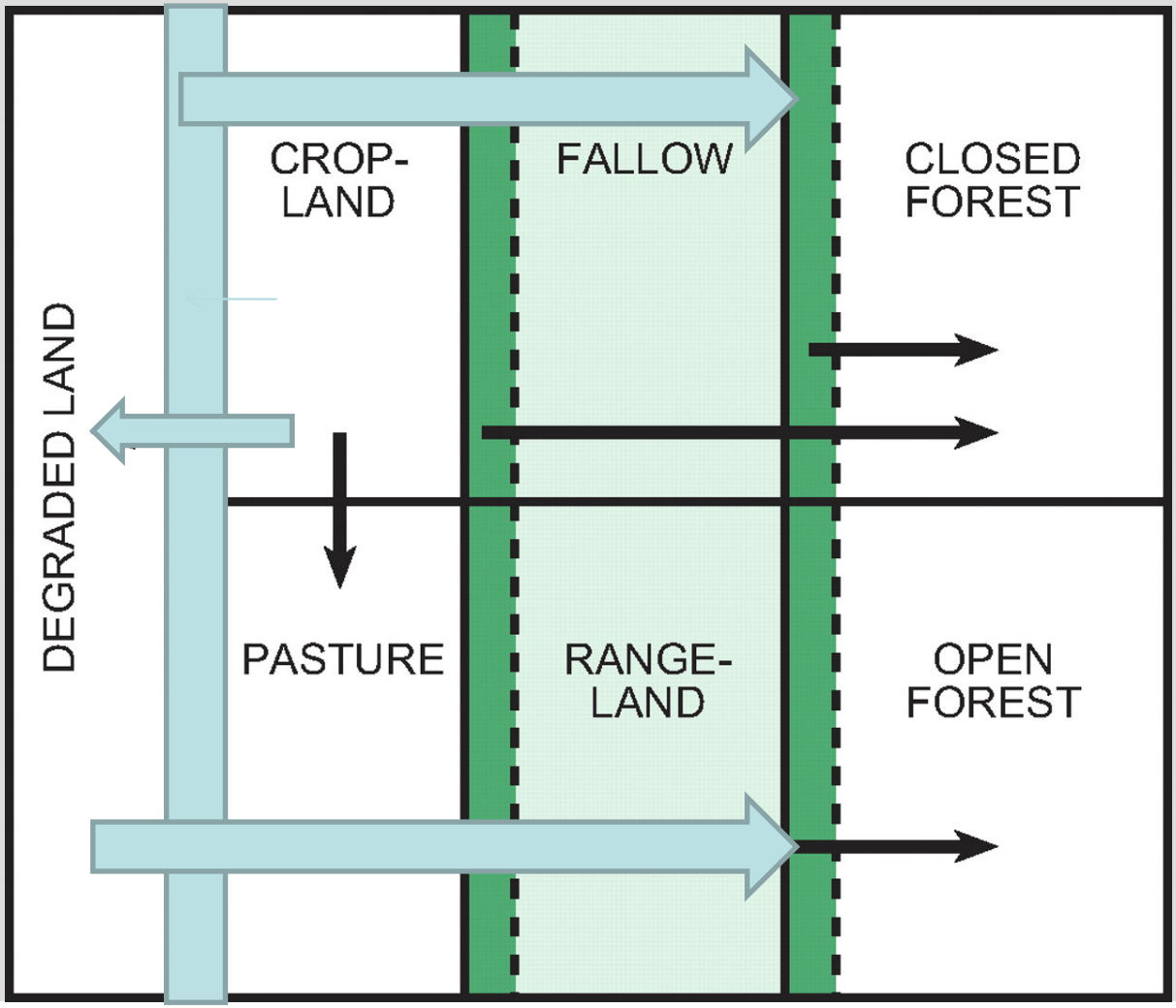


Annual $C0_2$ Greenhouse gas emissions from agricultural land use

	$C0_2$ emissions (10^6 t)
Mineral fertilizer	130
Farm machinery	69
Other	5
Land Conversion	2000+

So what is the best bet?

Options for reducing the climate footprint of agriculture



Paths

Potential for sparing land

Potential for afforestation

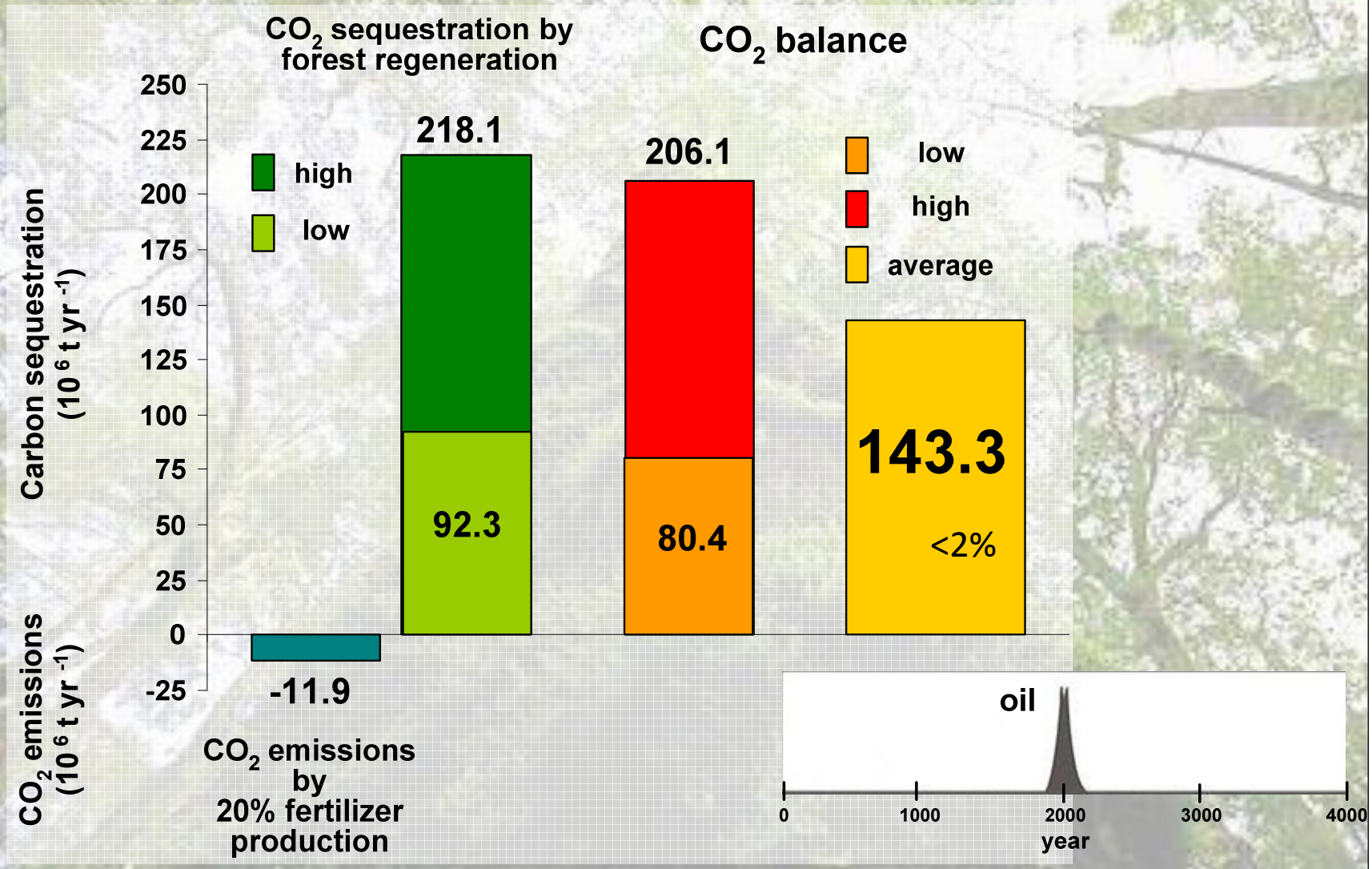
Cropland includes permanent and shifting cultivation.

Modified after: Grainger A PNAS 2009;106:20557-20558

AFFORESTATION AS AN ADAPTIVE AND MITIGATING LAND USE STRATEGY - Uzbekistan

•Khamzina, Lamers and Vlek 2008 Forest Ecology and Management, 255.

Total annual CO_2 emission for 20% additional fertilizer use in the production of rice, maize and wheat and C sequestration on marginal land without loss of overall production



Conclusions

- Agriculture production is fossil fuel depended and carbon intensive
- There is a high demand of agricultural land, especially in developing countries
- The cost in CO_2 release in land conversion is substantial -**REDD**
- The alternative is intensification which is cheaper in CO_2 loading
- Sequestration of carbon with afforestation would far outweighs the emissions associated with production of extra fertilizer - **CDM**
- This route will make agriculture ever more dependent on fossil fuel.
- In the long run, alternative energy sources are needed to sustain agriculture.....