Agriculture and Global Climate Change

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Global Climate Change

Is it happening ?

YES

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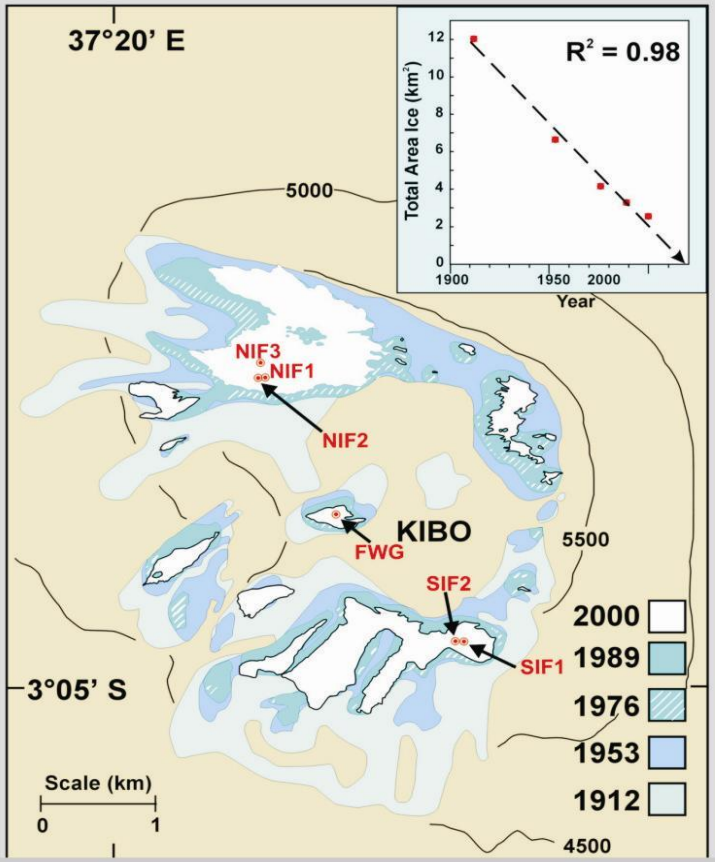
Total Area Of Ice On Kilimanjaro (1912, 1953, 1976, 1989, 2000)



1989 to 1912 maps are from Hastenrath and Greischar.
The 2000 map was produced at Ohio State Univ.

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How is it happening ?

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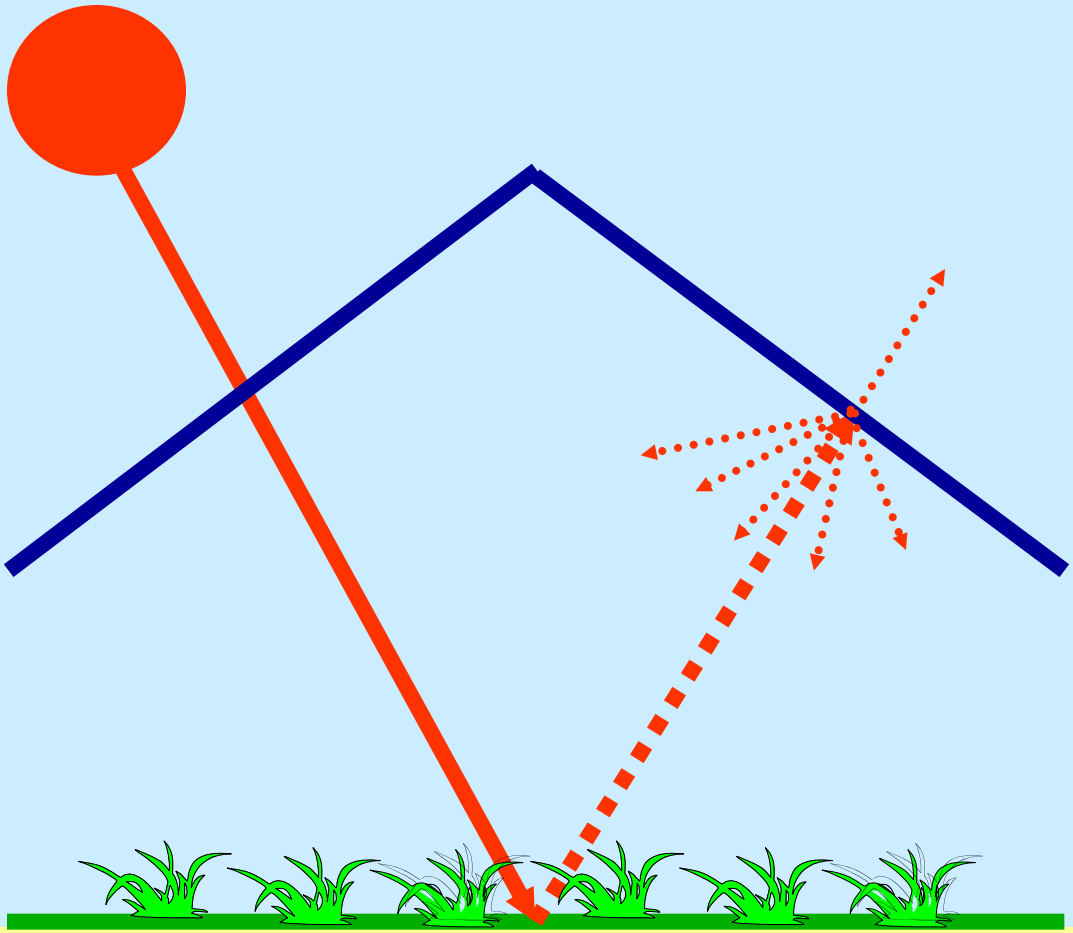
The Greenhouse Effect



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Agriculture and Global Climate Change
Relevance, Consequences & Perspectives

Why do we practice agriculture?

Is agriculture a victim of climate change?

Is agriculture a causal agent of climate change?

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Why do we practice agriculture ?

Food security

Production of renewable resources

Income generation

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Development of total and urban human population

Year	Human Population [billion]	Urban Population [%]
1000 AD	0.5	5
1800 AD	1.0	6
2000 AD	6.8	48

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Numbers and biomass of domestic animals and humans

Species	Numbers (million)	Biomass (million t)
Cattle & Buffalo	1 480	740
Sheep	1 065	40
Goats	780	27
Equines	118	42
Camelids	24	8.5
Pigs	936	122
Poultry	14 711	15
Total		**994.5**

Humans	**6 800**	**374**

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Main functions of the environment (nature) for agriculture

Production base

Production reserve

Emission depository

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Agricultural emissions affecting climate originate out of:

- primary production
- secondary production
- cultivation of virgin land
- burning of agricultural biomass
- machine times
- agricultural transports

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Climate affecting emissions from agricultural production

Gaseous emissions

- CO_2, carbon-dioxide
- CH_4, methane
- NH_3, ammonia & other nitrous oxides
- Sulphur compounds
- Noxious odours

Dust

Ash

Soot particles

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CO_2

Carbon Dioxide

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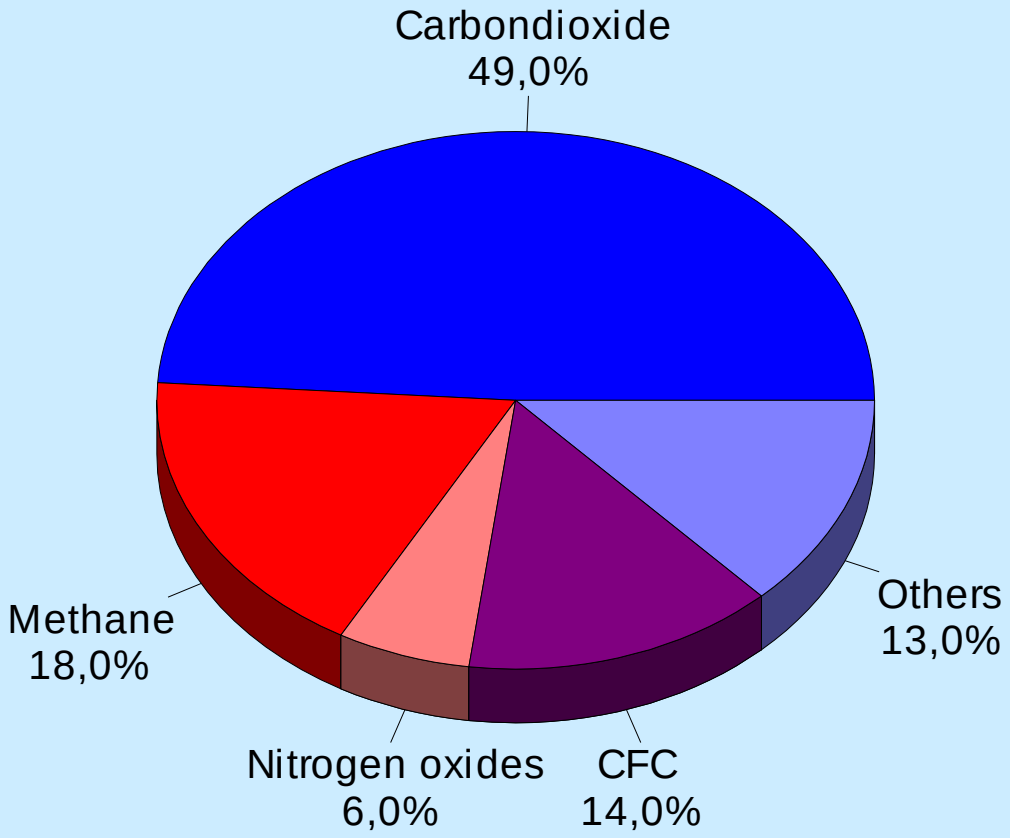
Contribution of various „Greenhouse Gases“ to global warming of the atmosphere



Source: Preston & World Resources Institute, 2002

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Projected consequences of global warming for agriculture

(doubling atmospheric CO_2-content, temperature increase 1.5 to 5^0C)

- Shift of eco-climatic zones several 100 km towards the poles;
- considerable widening of the tropical/subtropical dry belts;
- substantial loss of agricultural land;
- widespread permanent flooding of coastal areas due to rise in sea levels;
- slow but inevitable breakdown of temperate and boreal forest ecosystems with additional release of CO_2;
- uncertain effects of increased CO_2 on abundance and vitality of pests and weeds;
- resultant catastrophic decrease of agricultural production.

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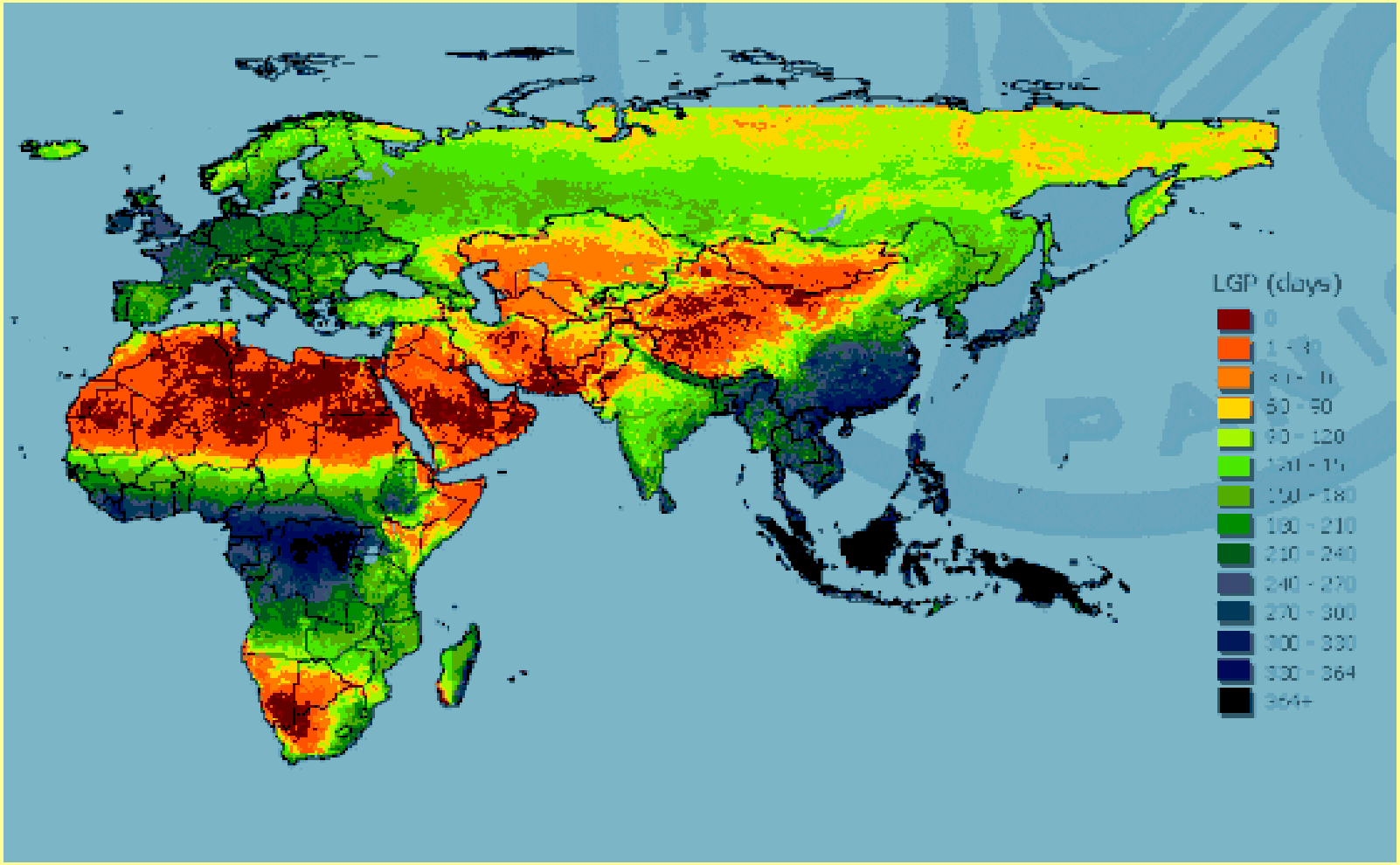
The Large Eco-zones* of the Old World



* Defined by length of growing period of natural vegetation [days/year]

Global climate change has regional winners and regional losers in agriculture

(doubling of CO_2 - concentration, temperature increases of 1,5 - 5,5 ^oC)

Humid and sub-humid tropics

little change in temperature and precipitation, positive effects of CO_2 - fertilisation and improved water use efficiency (WUE) of plants, increased productivity

Semi-arid and arid tropics and subtropics

little change in mean temperature and precipitation, considerably increased inter-annual variability of precipitation, expansion of the dry-belt towards the poles, in the lowlands increased aridity, in the highlands similar effects as in the humid tropics

Mediterranean areas and temperate zones

sharply increasing temperatures, decreasing precipitation, increased evapo-transpiration, increased inter-annual variability of precipitation, reduced productivity not compensated for by CO_2 - fertilisation effects

Sub-arctic latitudes

substantial positive effects by CO_2 - fertilisation, higher temperatures, increased growing period, substantial increase of productivity

Coastal lowlands

widespread flooding due to increasing sea levels

Source: Adams, 1989; Reilly, 1995

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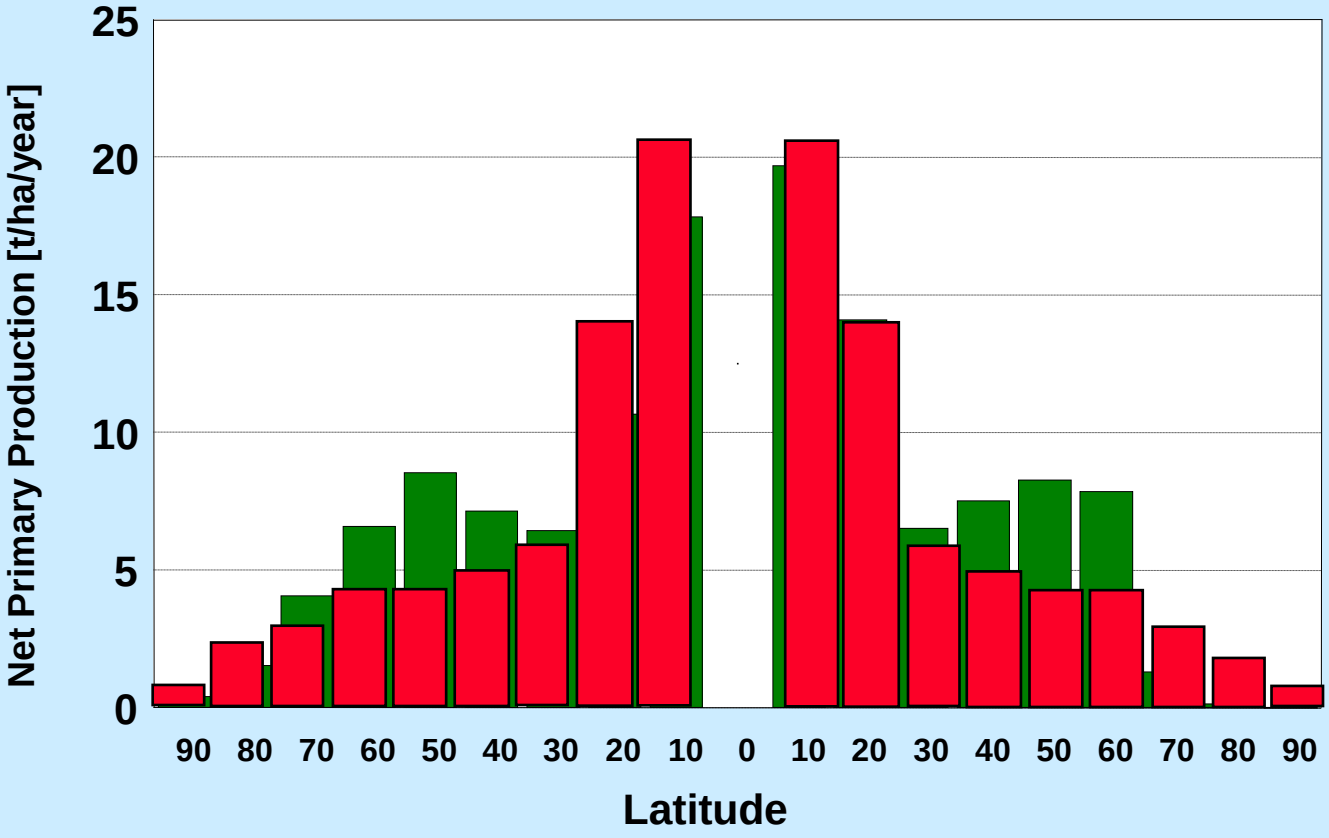
Estimated Net Primary Production (NPP) of all natural vegetation in latitudinal belts of 10° before and after global warming



Source: Pearson, C.J. & Ison, R.L. 1987, modified

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Economic surplus and price and quantity indices for climate change scenarios in US agriculture

Climate model	Field crops		Livestock commodities		Change in economic surplus
	Quantity	Price*	Quantity	Price*	[US$ billion]
GISS	0.90	1.18	0.99	1.02	- 6.5
GISS + FE	1.10	0.82	1.06	0.84	+ 9.9
GFDL	0.61	2.09	0.88	1.35	- 35.9
GFDL + FE	0.81	1.28	0.98	1.07	- 10.5

* = relative change of price (base = 1.00) by change of supply; GISS = Goddard Institute of Space Science (NASA); GFDL = Princeton Geophysical Fluid Dynamics Laboratory; FE = Fertilizer effect of increased CO_2 - concentrations

Global warming reduction initiatives

Carbon sequestration

CH_4

Methane

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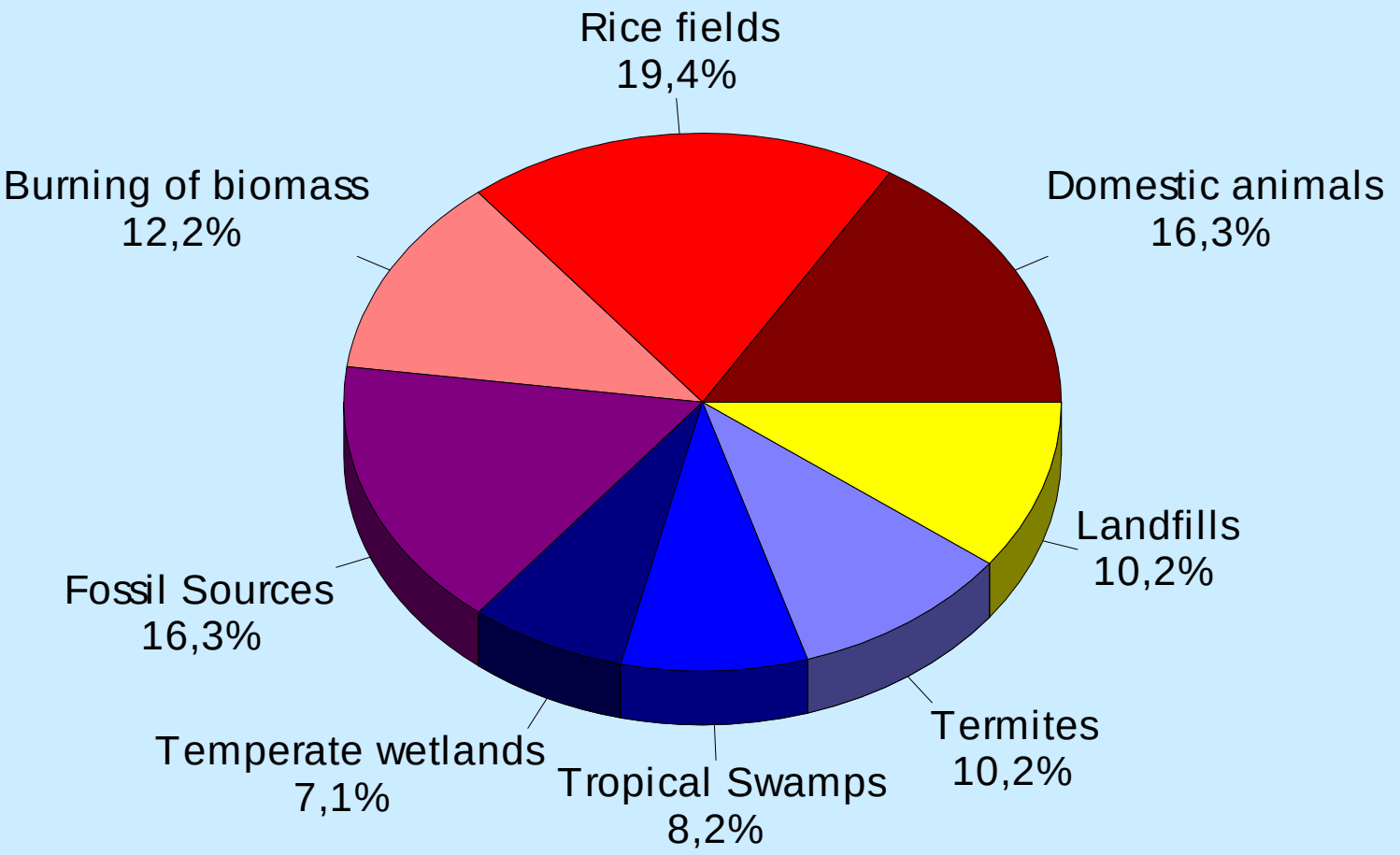
Proportion of various sources in the global methane emission



Source: Walker, 1994

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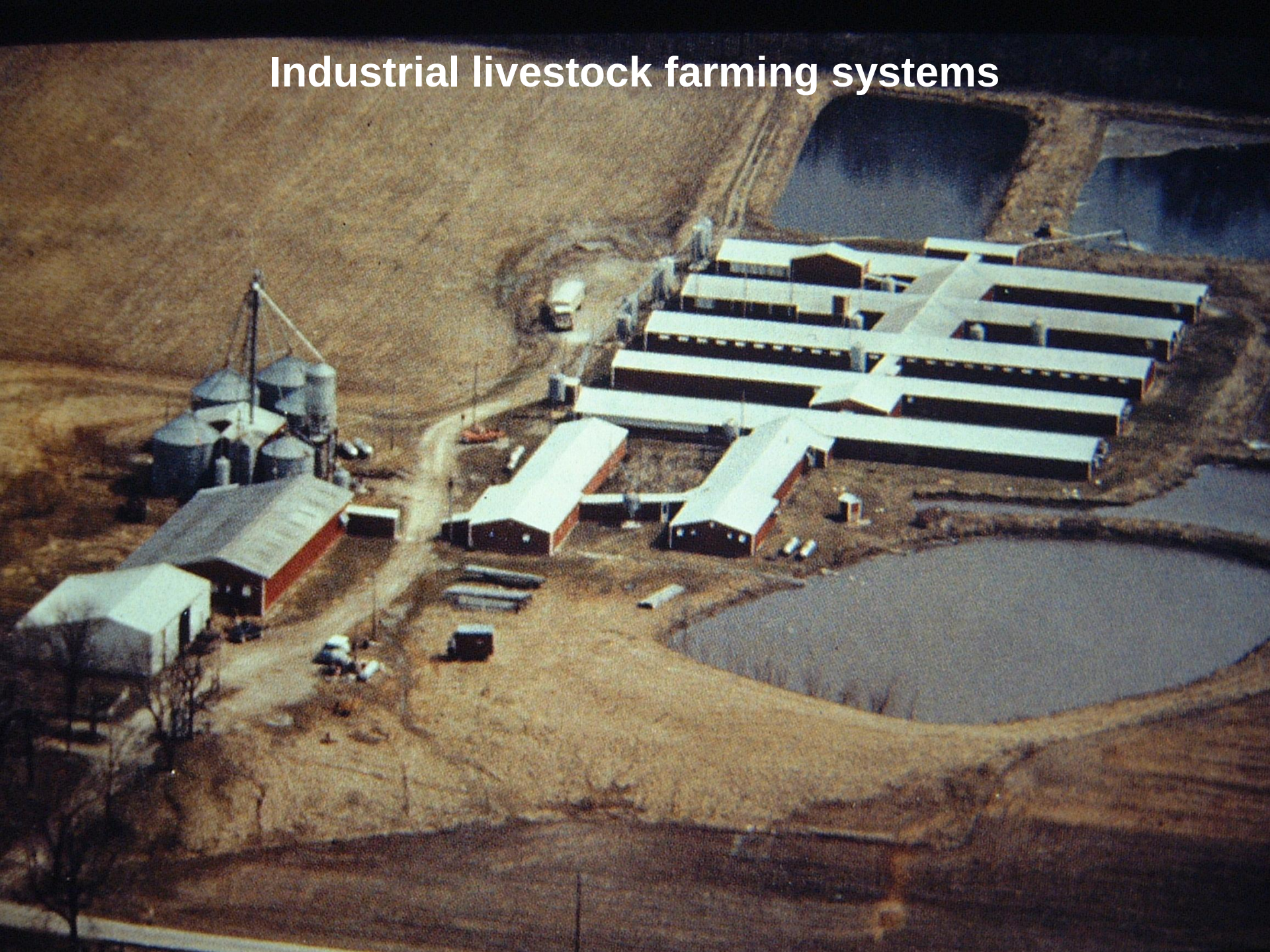
Migratory livestock farming

Industrial livestock farming systems



Annual methane losses from a model livestock production system:

dairy farming in S.W. England

(102 cows, 110 others, stall feeding of silage and concentrate)

type of loss	total emission kg CH_4 - C $year^{-1}$
losses from ruminants	6775
losses from stored wastes	2285
losses from silage effluent	2596
losses from dirty water	332
total losses	11988

Source: after Jarvis & Pain, 1994

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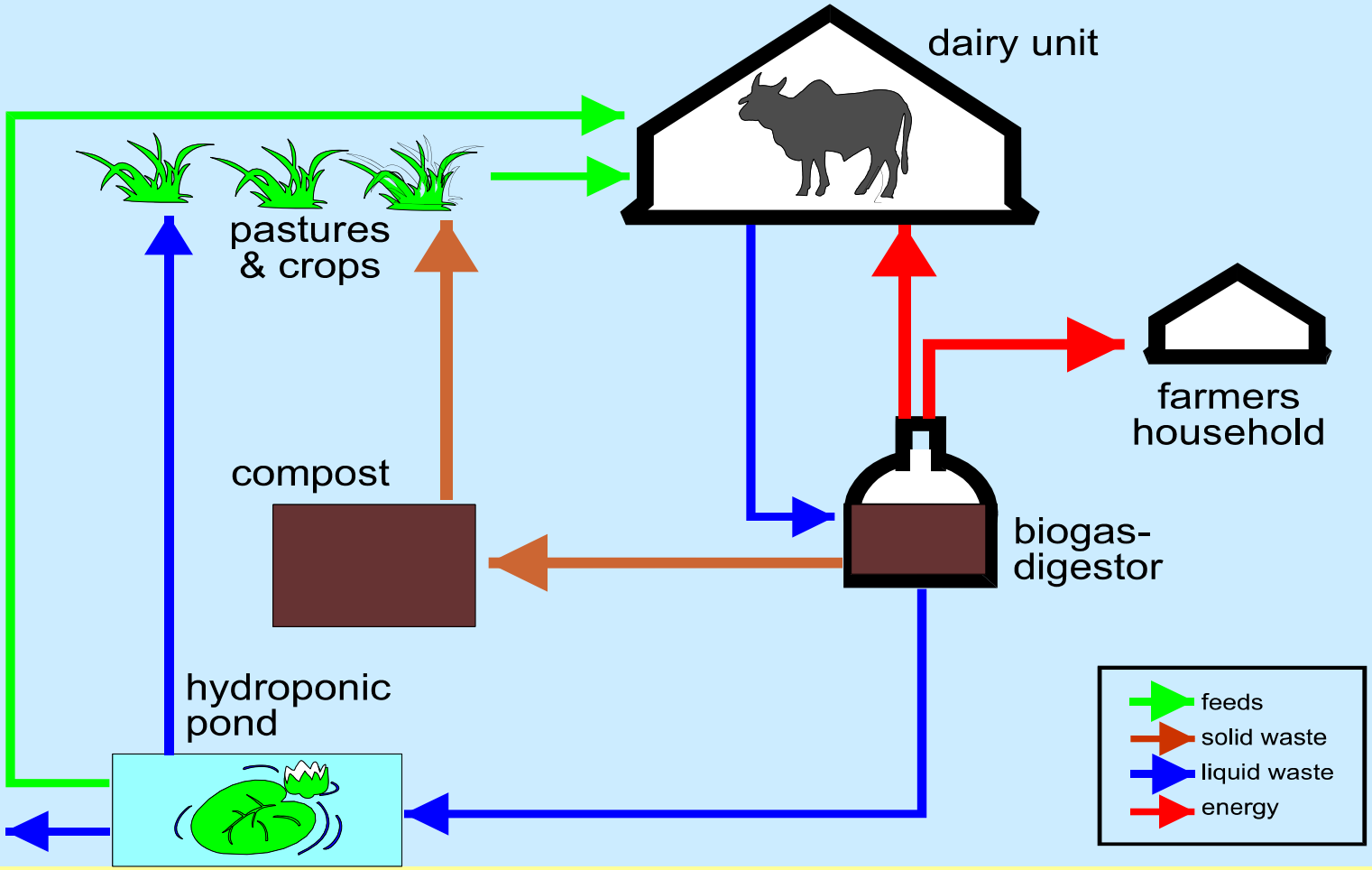
An example for a post-industrial organic farming system



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Biomass Burning

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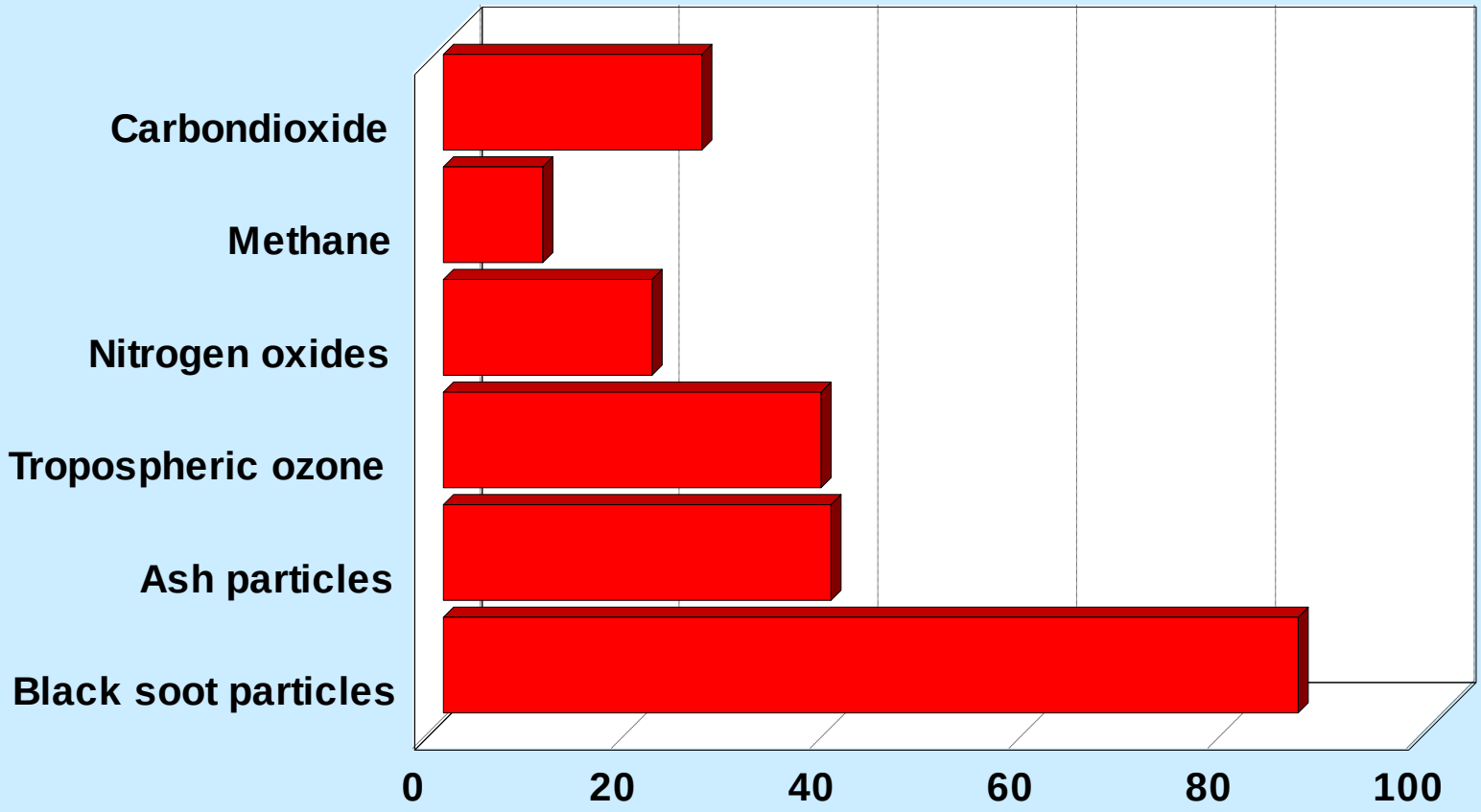
Relative contribution of biomass burning to various climate affecting emissions [% of all emissions]



Source: Levine et al.; 1995

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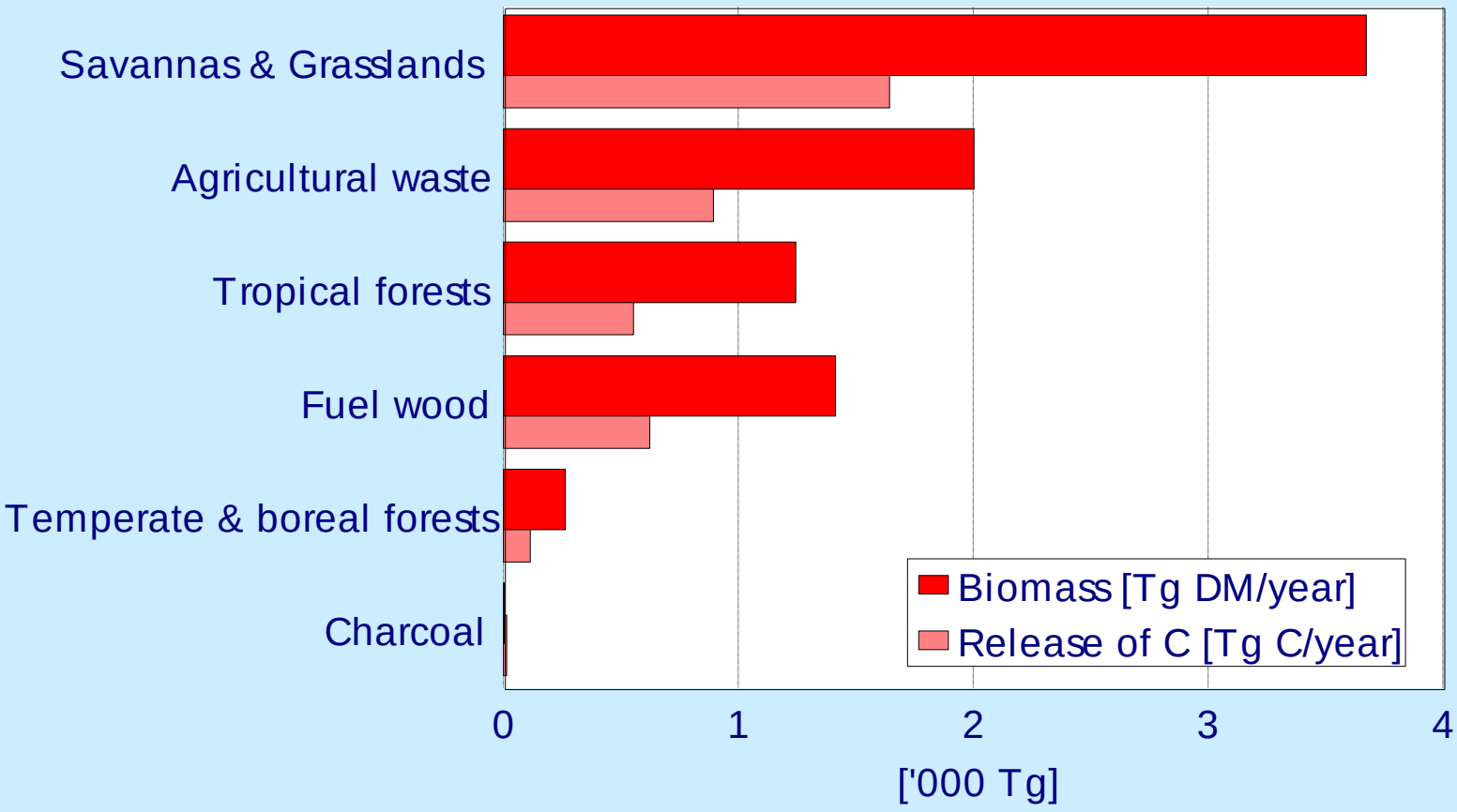
Contribution of burning various types biomass and the resulting release of carbon into the atmosphere



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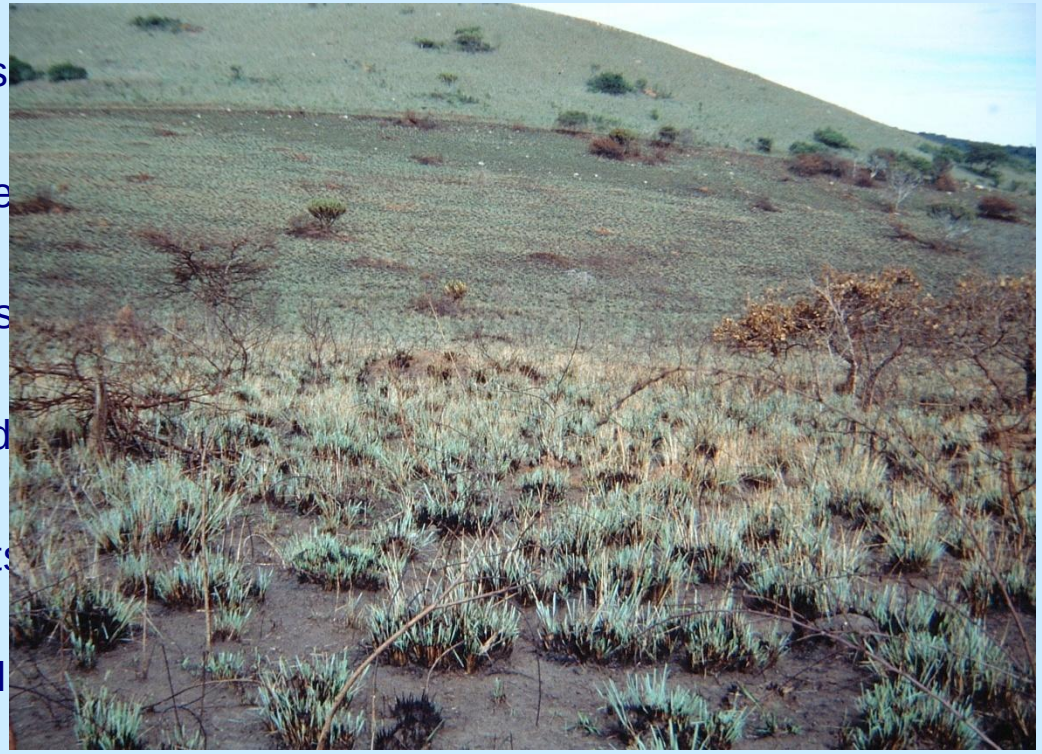

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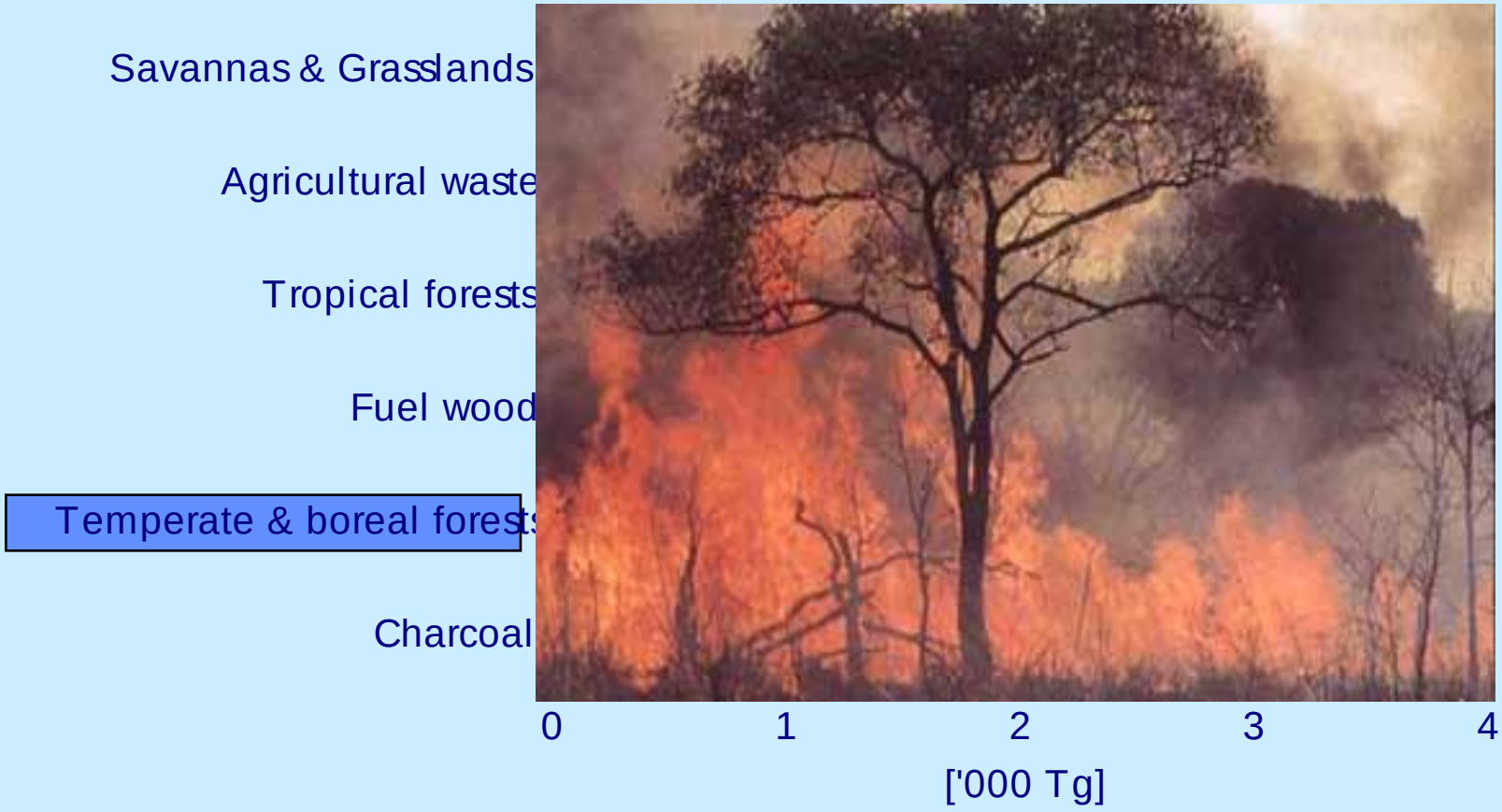

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Global Transport of Nutrients

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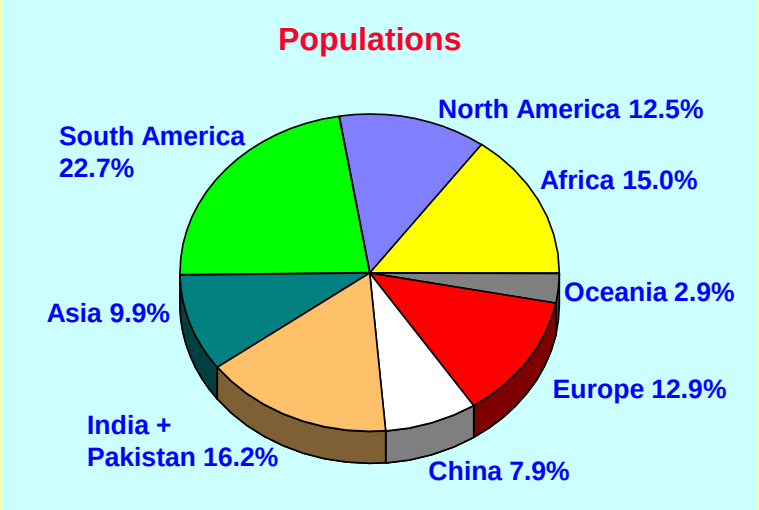
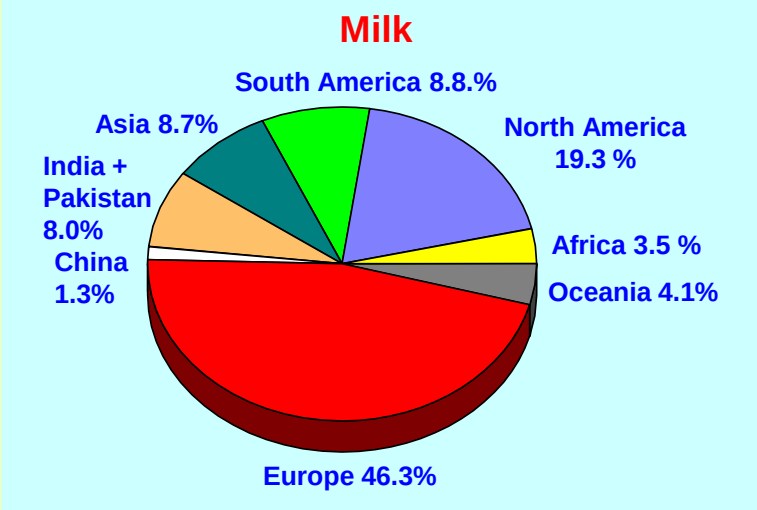
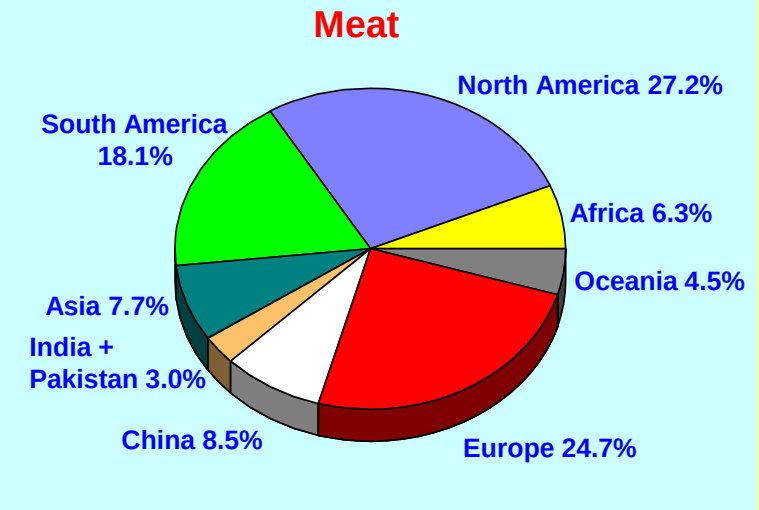
Regional distribution of CATTLE populations and proportion of regional production of meat and milk

Source: FAO Production Yearbook 2004







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Black-and-white dairy cattle yielding from 6000 to 10000 litres of milk in a lactation of 9 months

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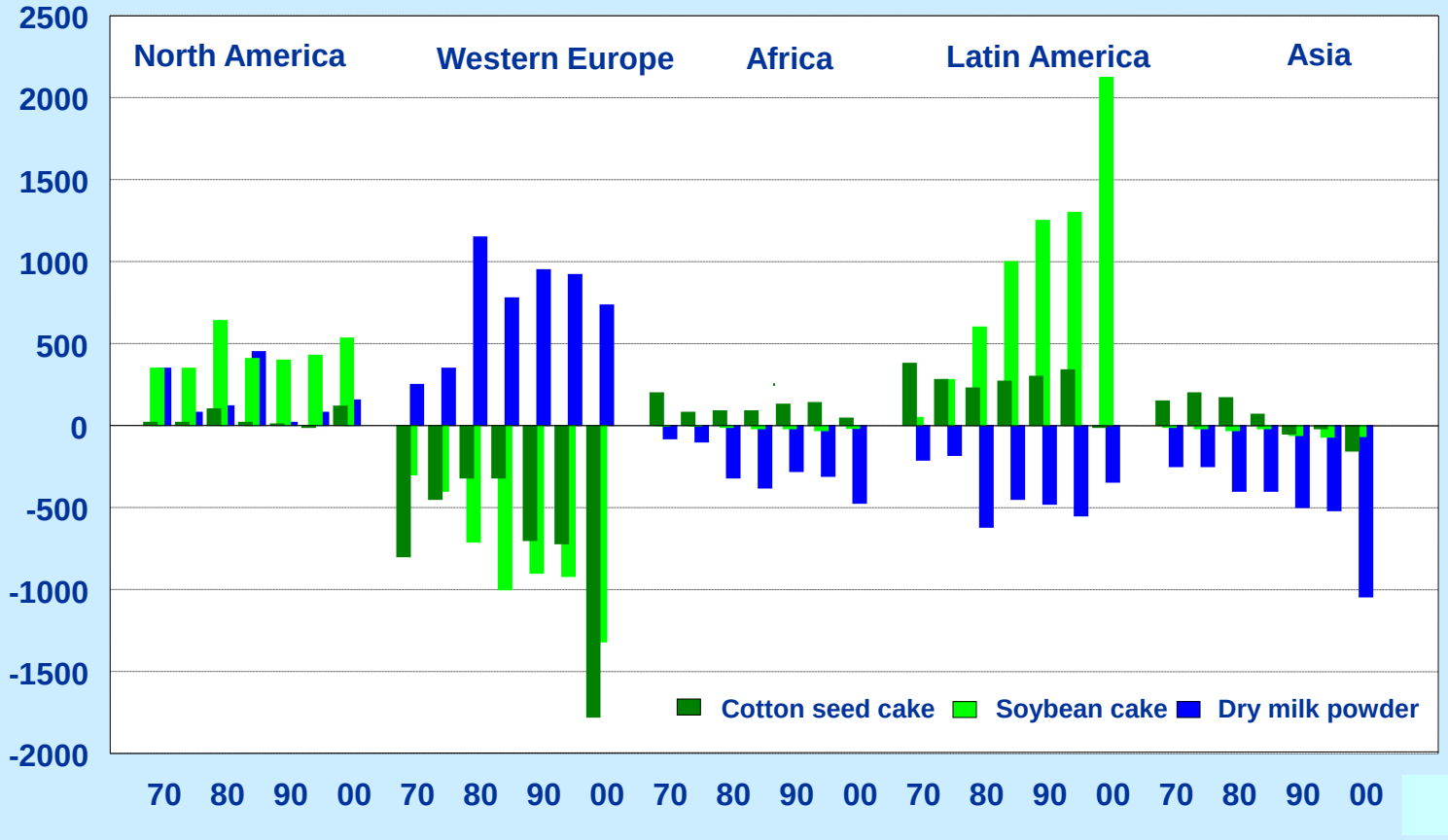
Annual net trade ['000 t] of feeds and dry milk powder between the major economic regions of the world from 1970 to 2000



Source: FAO Trade Yearbooks 1970-2000

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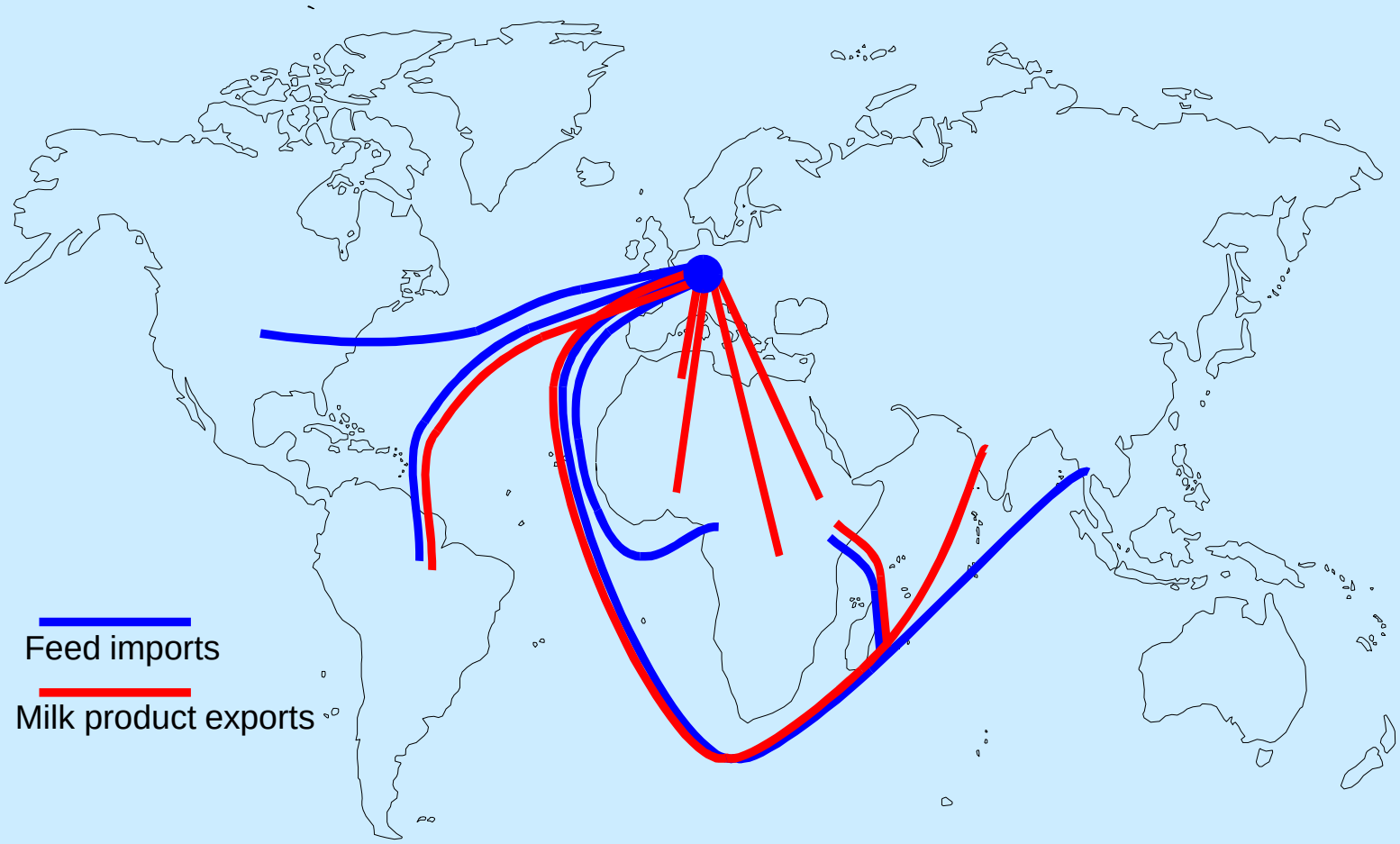
Transport routes of importance for Western European dairy production



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Adaptation and tools to control climate change

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Necessary adaptations of agricultural production systems to projected climate change

(doubling of CO_2 - concentration, temperature increase of 1.5 to 5.5 ^oC)

Irrigation agriculture (tropics)	none
Rain fed crop production (humid tropics)	none
Rain fed crop production (dry tropics)	flexible planting times, different cultivars, different cultivation techniques, water harvesting
Perennial crops, plantations (dry tropics)	water harvesting, change of crops, different cultivation techniques
Pasture based livestock production (dry tropics)	possibly change of herbivore species and/or breed, flexible stocking densities, increased mobility
Rain fed crop production (temperate zones)	irrigation, different cultivars, different planting times, different cultivation techniques
Crops under glass	none
Pasture based livestock production (temperate zones)	decreased and highly flexible stocking densities
Intensive livestock production indoors	none

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Possible strategies for the control of agricultural emissions

technical measures

biological measures

economic and political controls

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Technical emission control in agricultural production systems

- Storage and transport of stocks and wastes
- Distribution of waste materials on farm land
- Reduction of agricultural transports
- Mechanical processing and decontamination of waste materials
- Minimum tillage

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Biological emission control in livestock production systems

- Feeding and feeding systems
- Biotechnology in feed production and feed processing
- Adjustment of performance targets
- Promotion of nutrient recycling within farms

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Political and economic emission control in livestock production systems

- Taxes or fees on emissions
- Taxes on certain production inputs (fossil fuel, fertiliser)
- Product taxes
- Subsidies for “clean“ production
- Emission quotas
- Transferable emission quotas
- Legal control of emissions

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Three strategies to cope with the consequences of projected global warming

I Avert further global warming

II Slow down global warming to give time to develop strategies to cope with the consequences

III Accept whatever warming occurs and concentrate on development of adaptive strategies

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Thank You for Your Attention

Three intervention levels:

Impact assessment, how, how much, where, what

Adaptation processes, new breeds and varieties, new production techniques

Mitigation, how to reduce CO_2 and CH_4 production in agriculture

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