Land Use Efficiency
versus
Energy efficiency
in the context of
climate change

Main messages for agriculture in the context of Global Change

(World Population Growth and Climate Change)

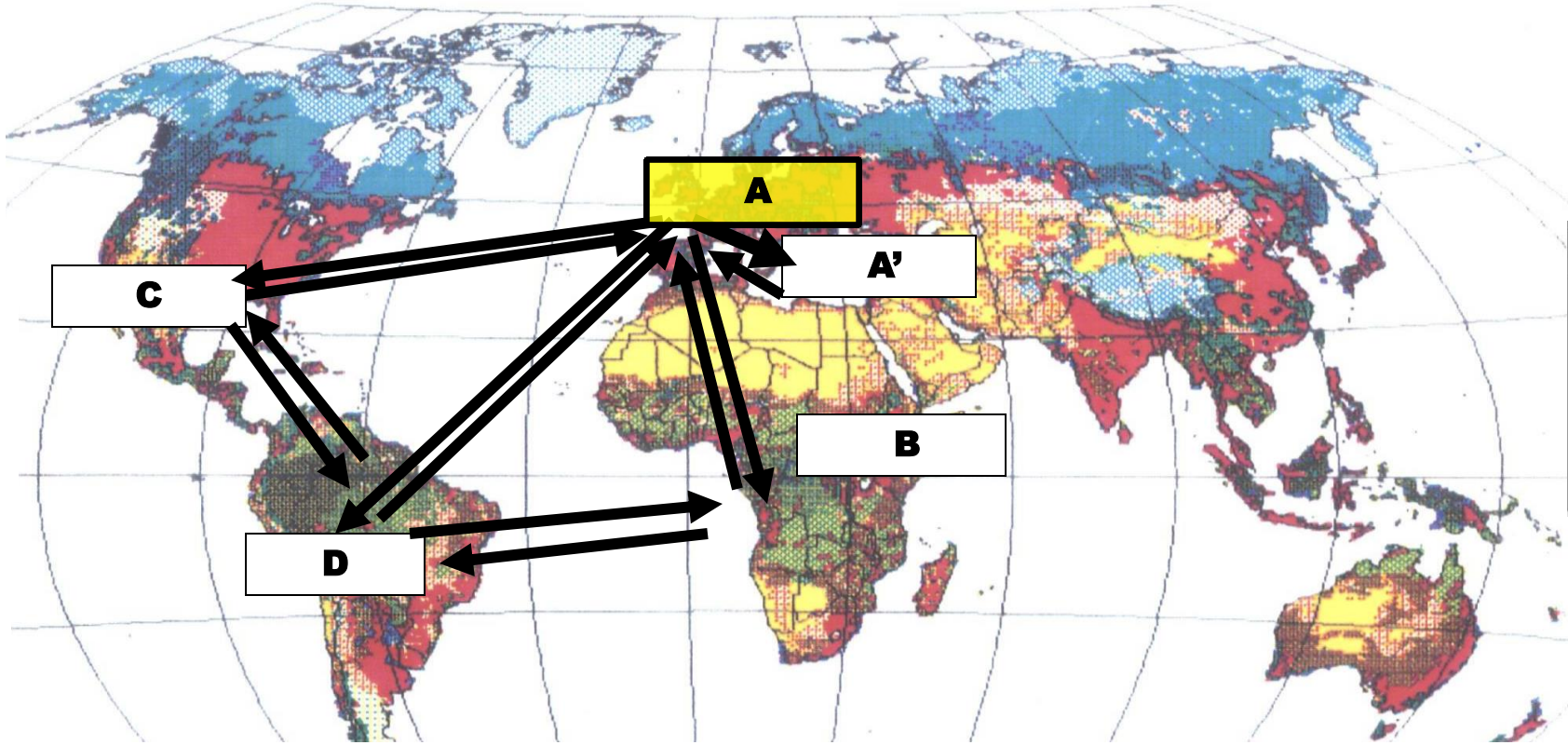
Increasing fertilization to double crop production is more climate friendly

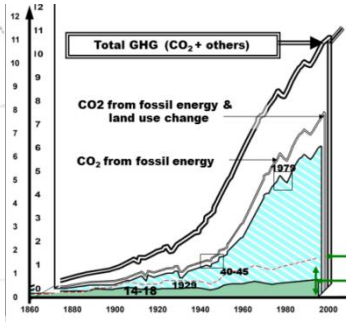
during at least 2 centuries

than increasing cropland area

Increasing « Land use efficiency » is to be considered before increasing energy

We have but one planet .....





Possible impact of climate change

Beddington

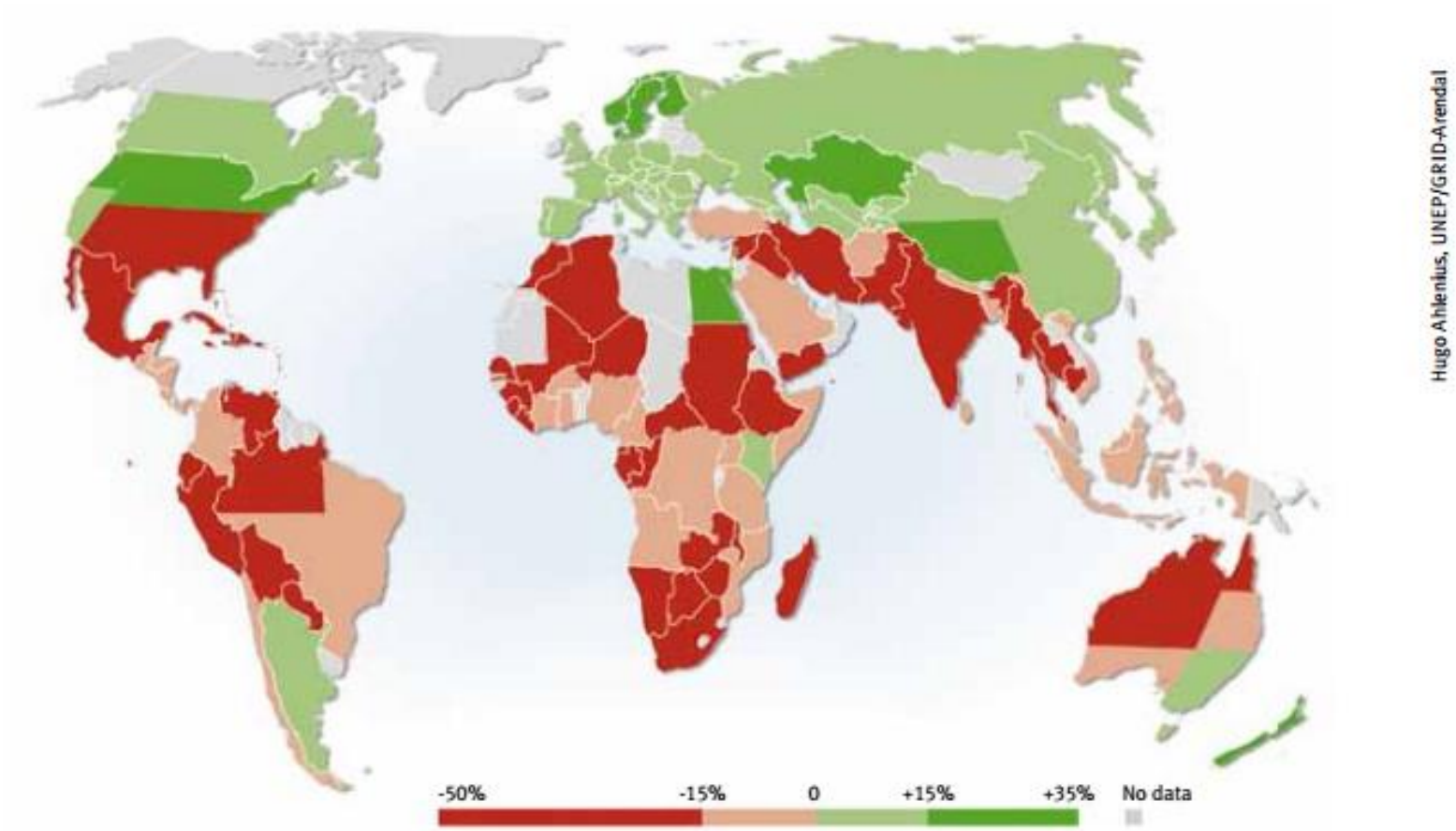
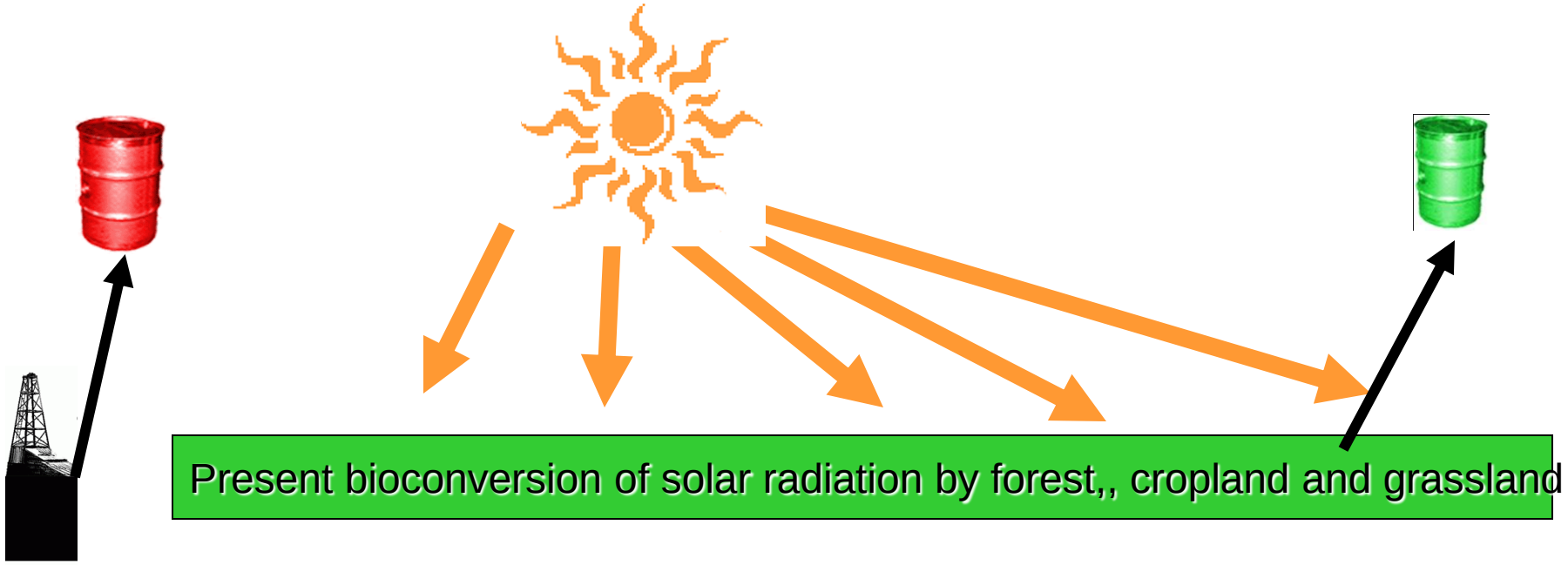


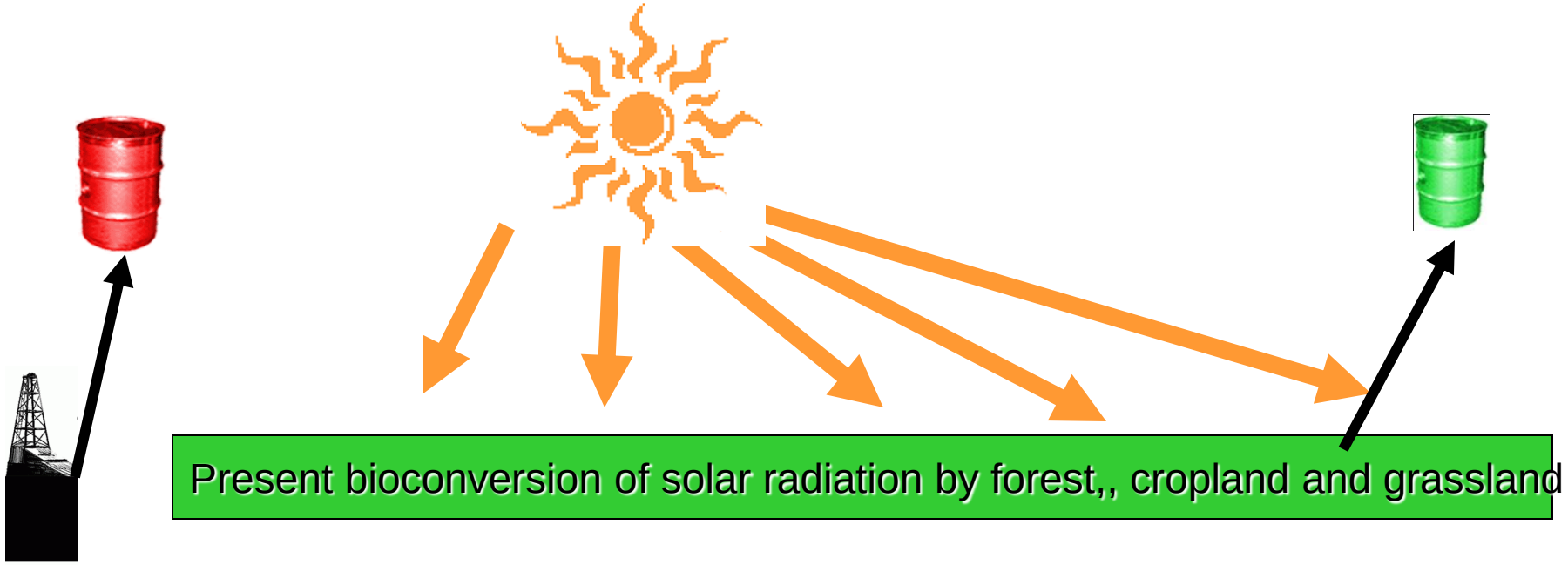
Figure 6. Projected changes in agricultural production in 2080 due to climate change. Source: Cline. 2007. Projections assume a uniform 15% increase in yields due to the fertilization effect of rising carbon dioxide in the atmosphere on some plant species.

Difference between fossil fuel and biomass



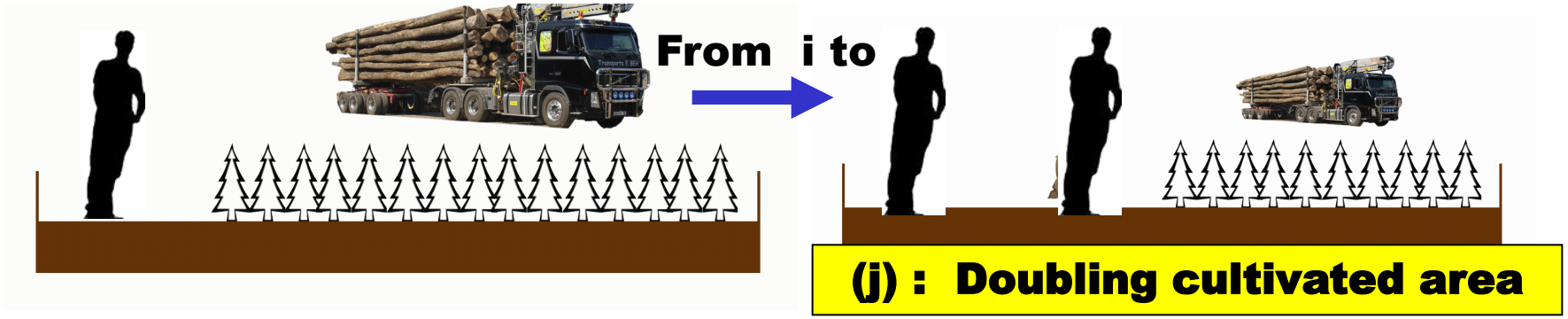
Difference between fossil fuel and biomass

Need of land

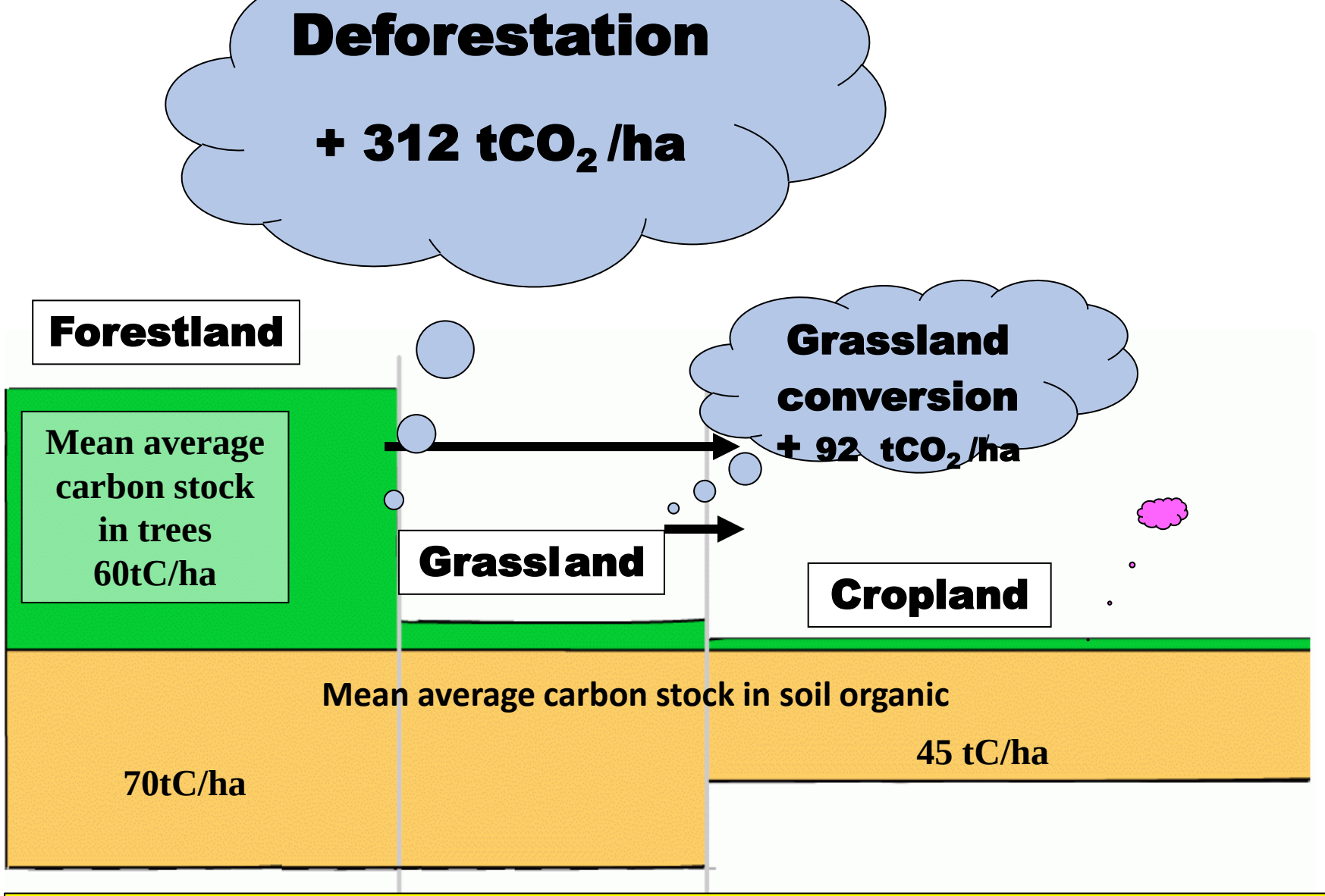


When the population is increasing :

doubling cropland

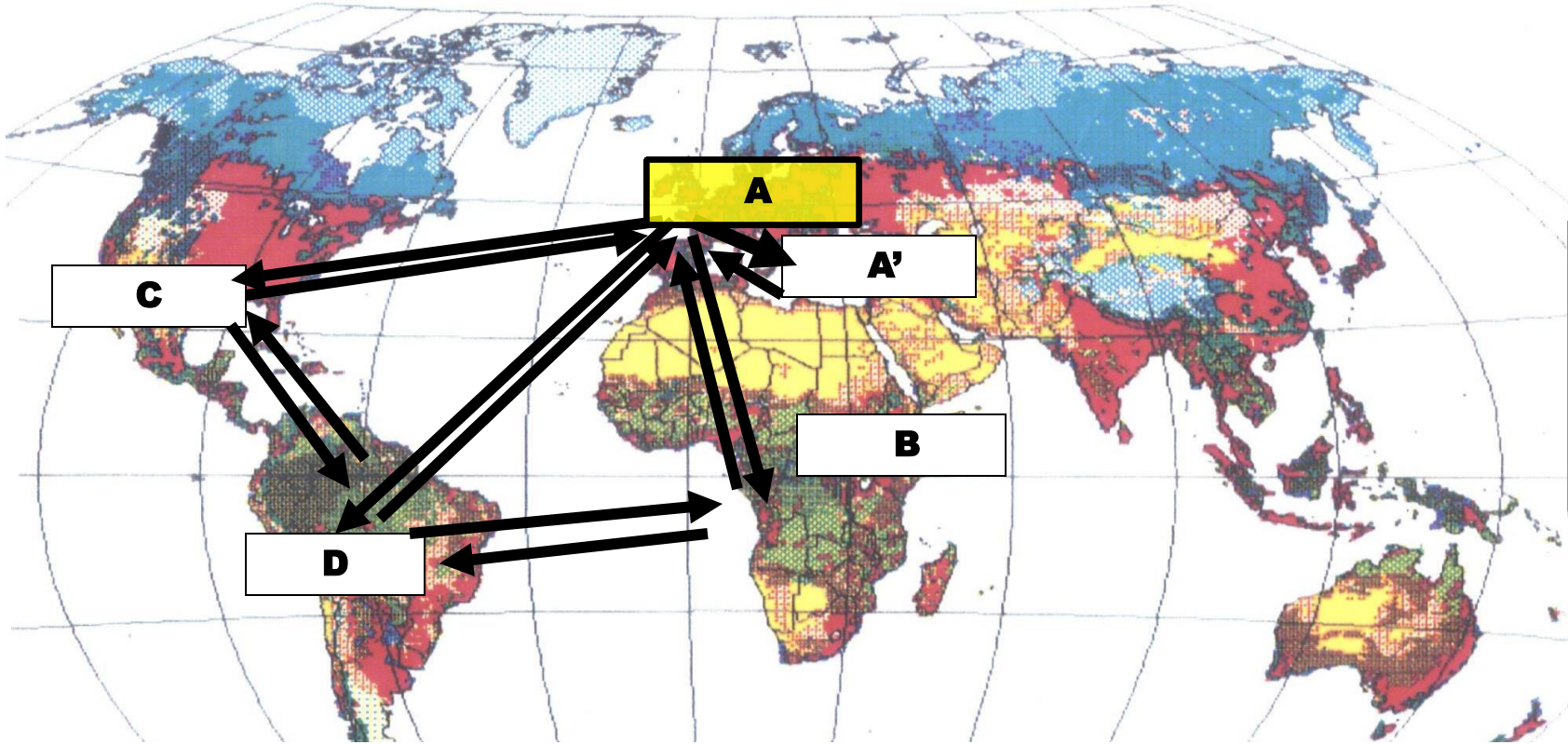


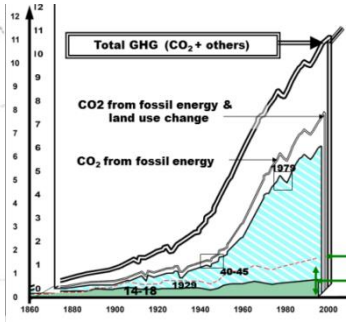
(j) : Doubling cultivated area

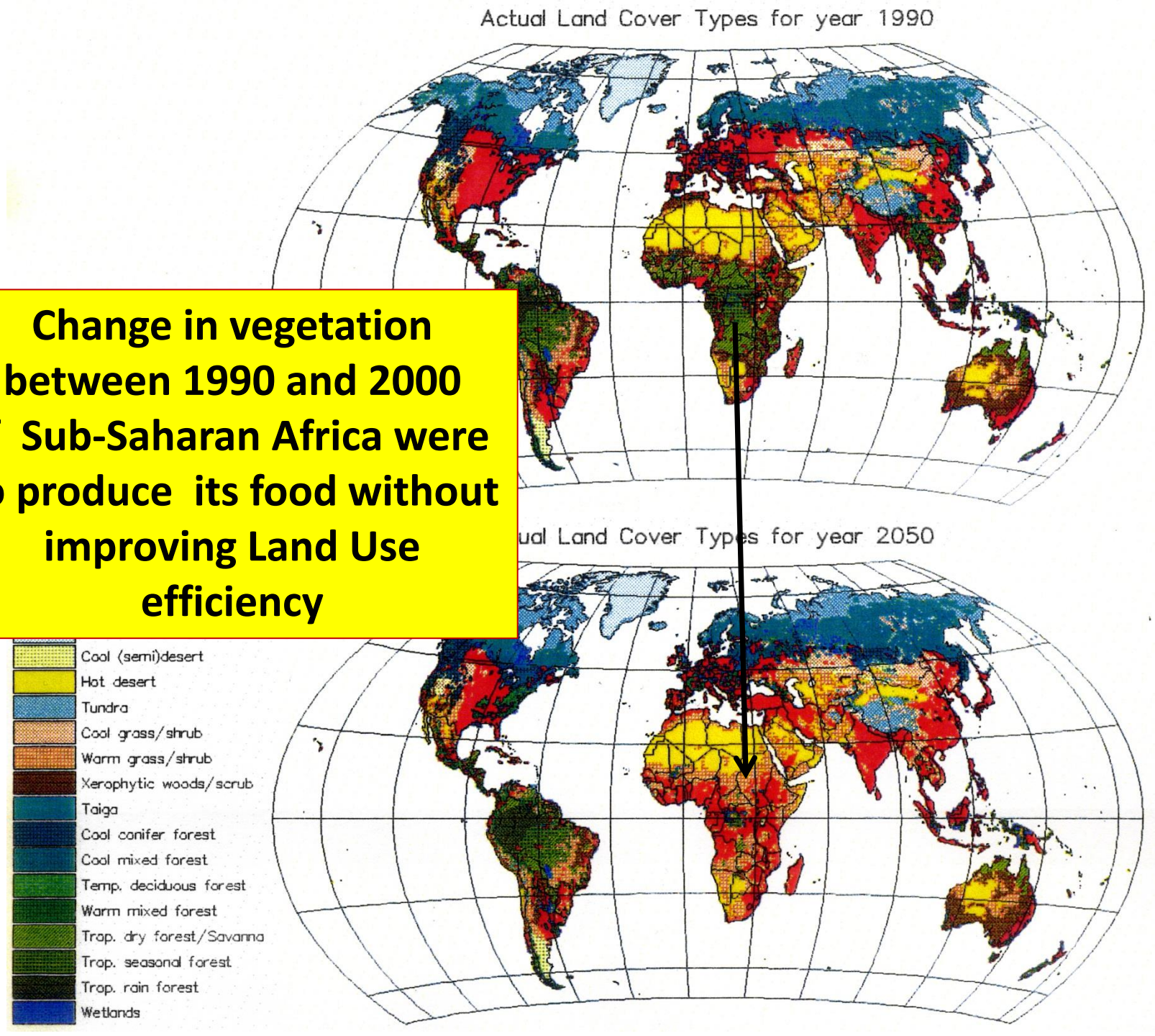


An average land use change
(½ forest & ½ grassland)
generates about 200 t of CO_2 per ha

We have but one planet .....

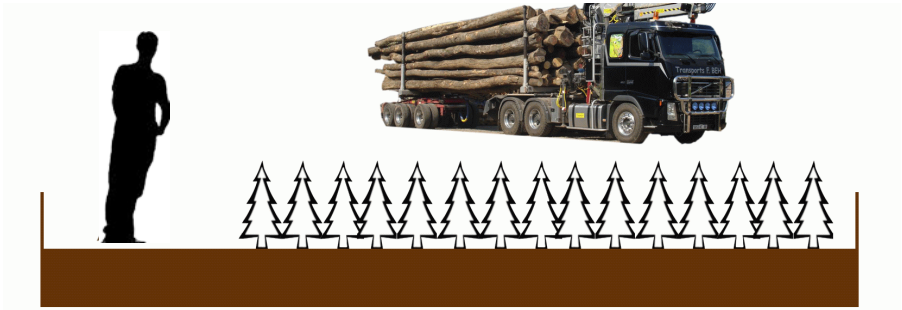




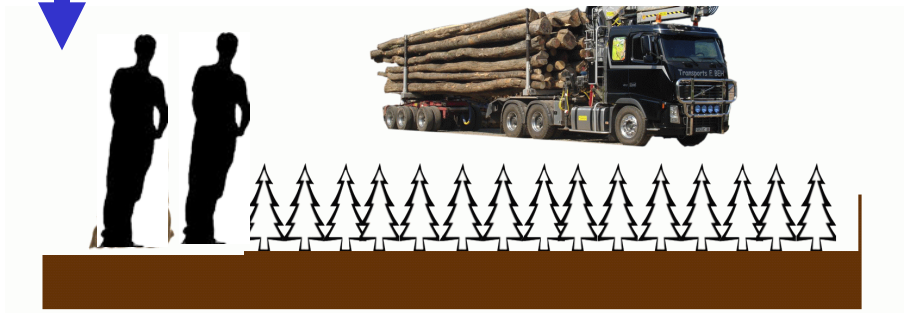


Change in vegetation between 1990 and 2000 if Sub-Saharan Africa were to produce its food without improving Land Use efficiency

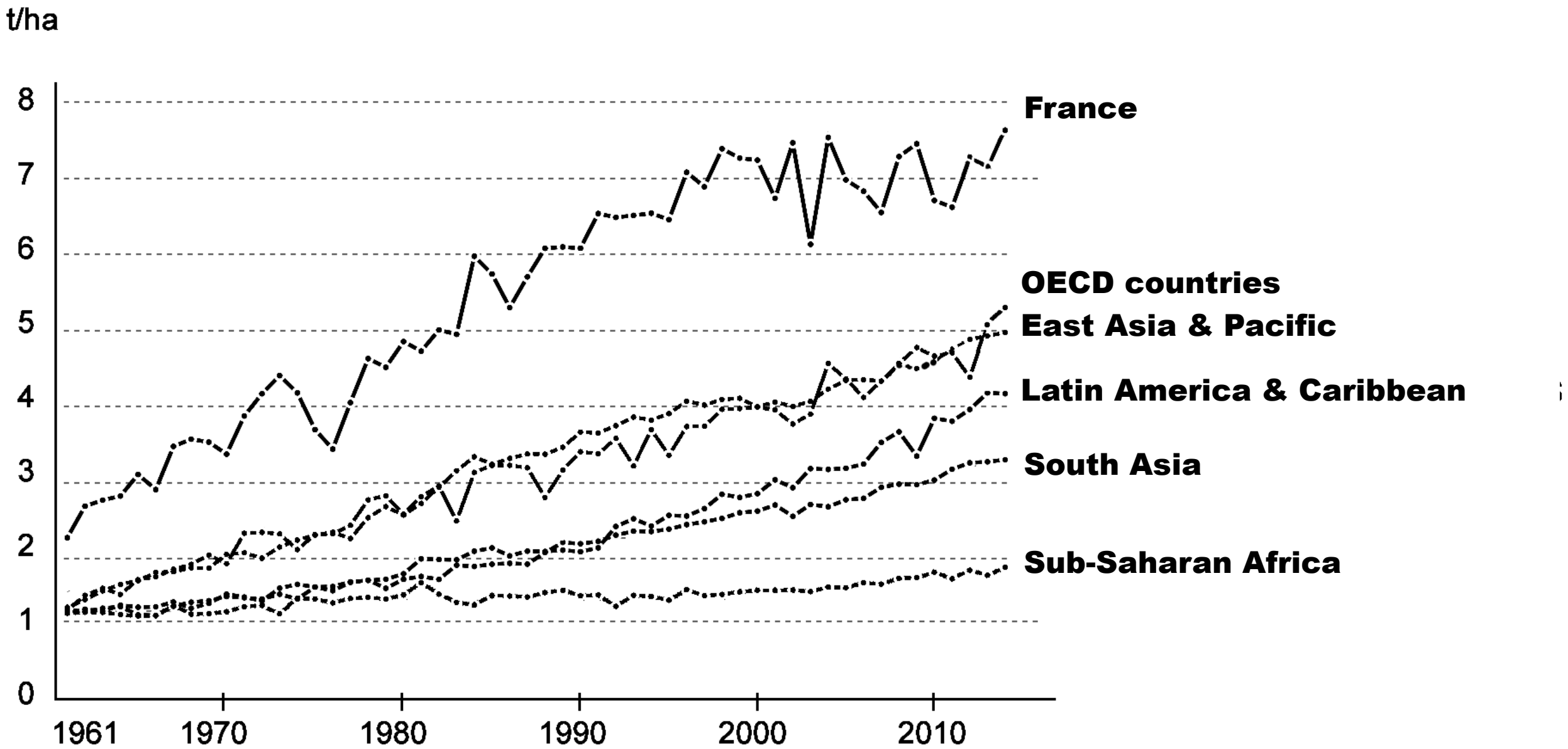
When the population is increasing : doubling yields



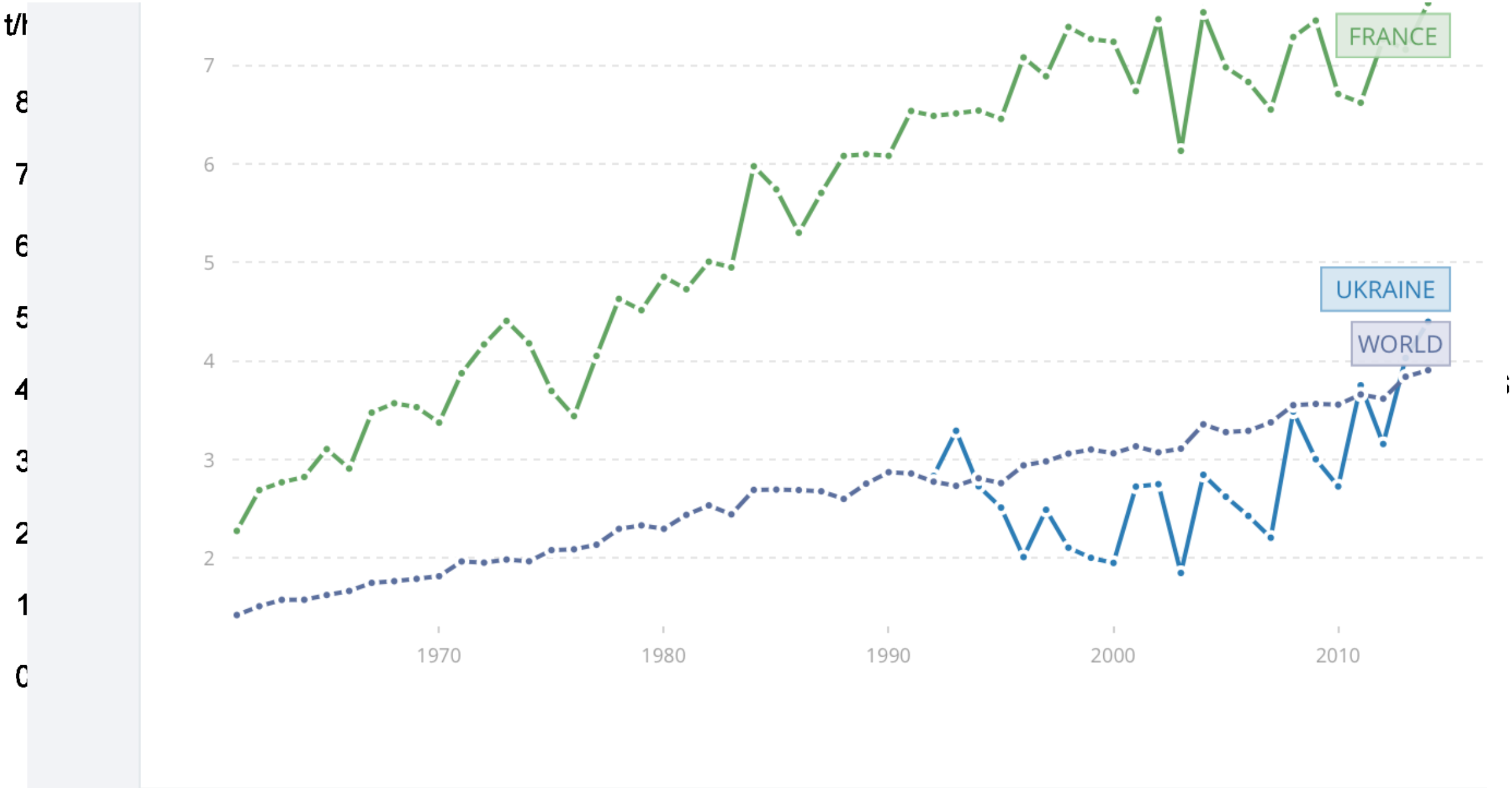
From i to k



(k) : Doubling yields


t/ha
8
7
6
5
4
3
2
1
0
1961
1970
1980
1990
2000
2010
France
OECD countries
East Asia & Pacific
Latin America & Caribbean
South Asia
Sub-Saharan Africa

WB 2017


t/h
8
7
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1970
1980
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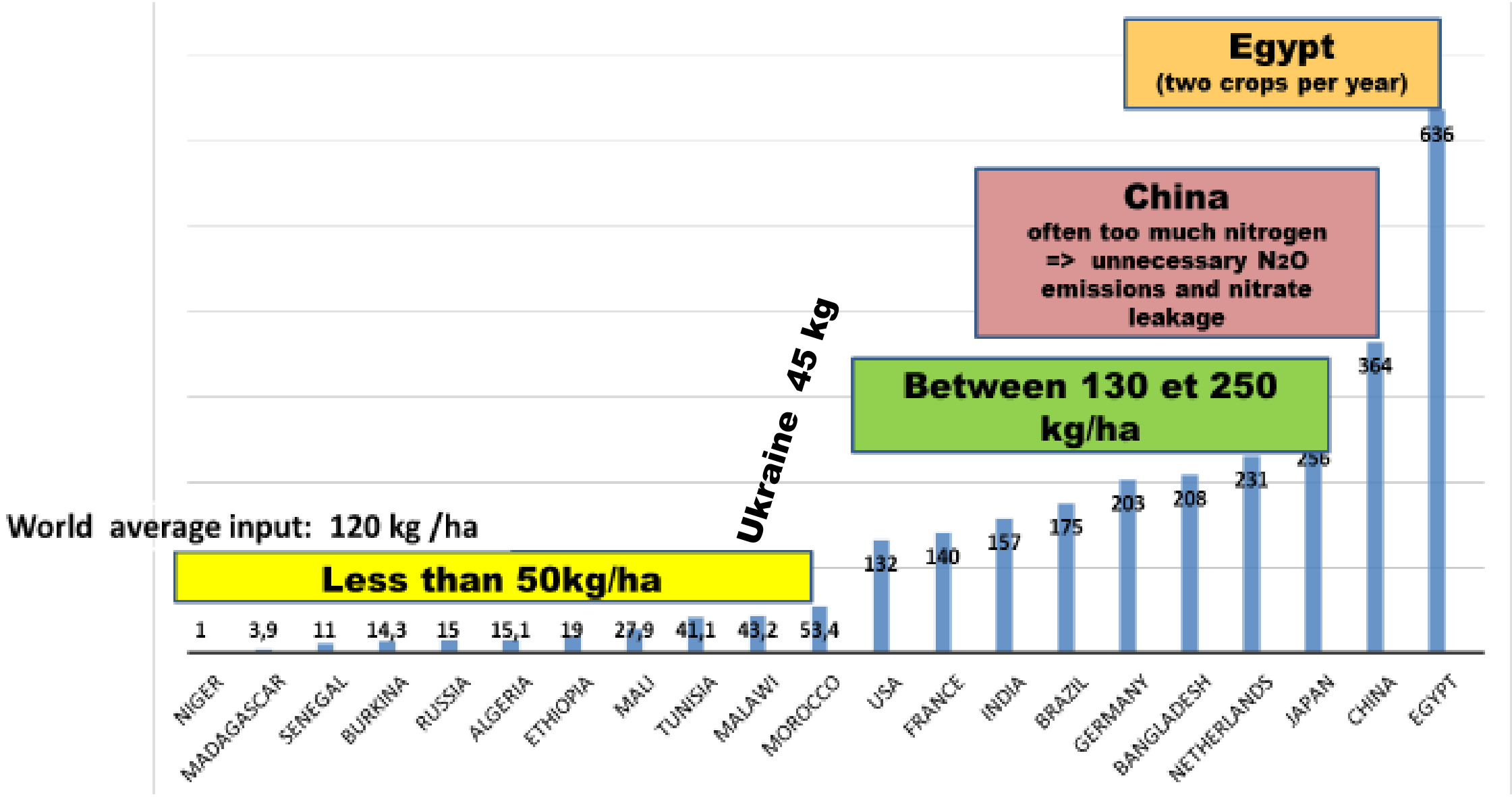
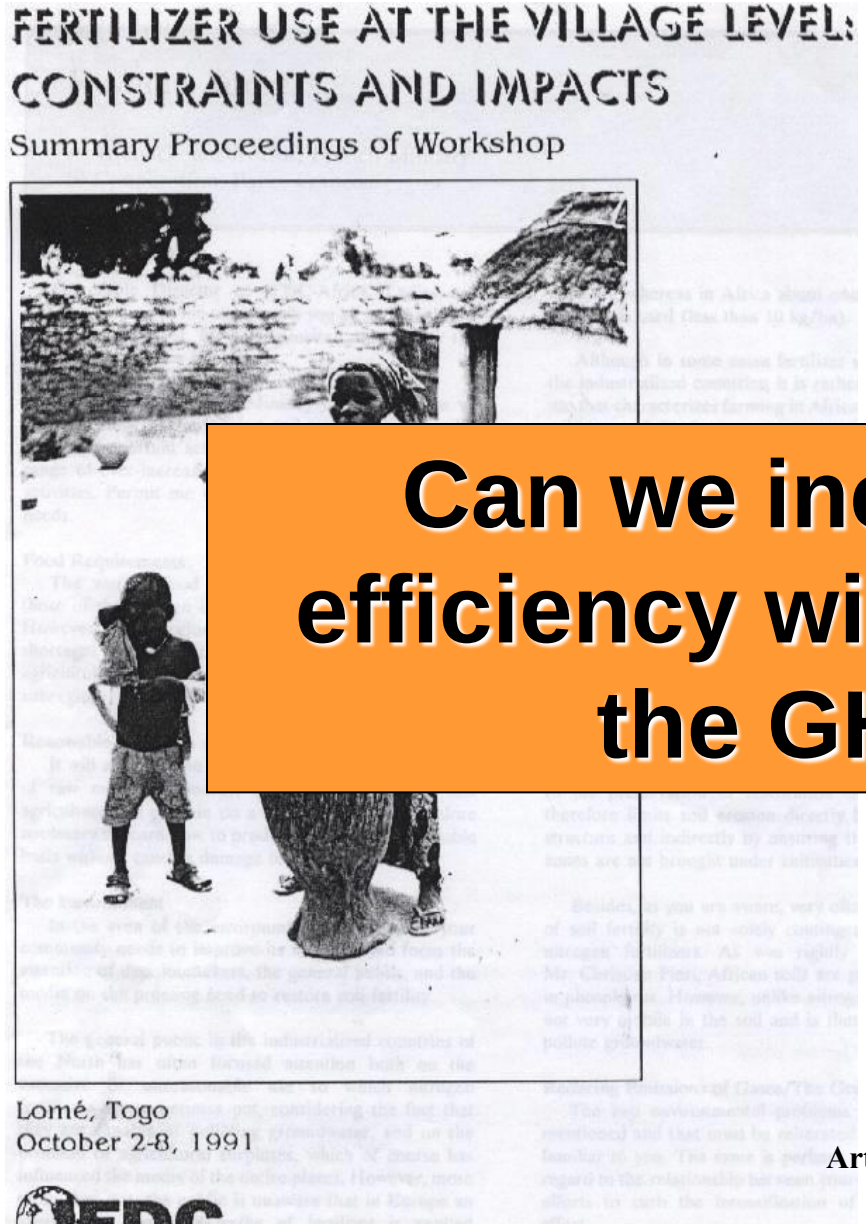
2010
FRANCE
UKRAINE
WORLD

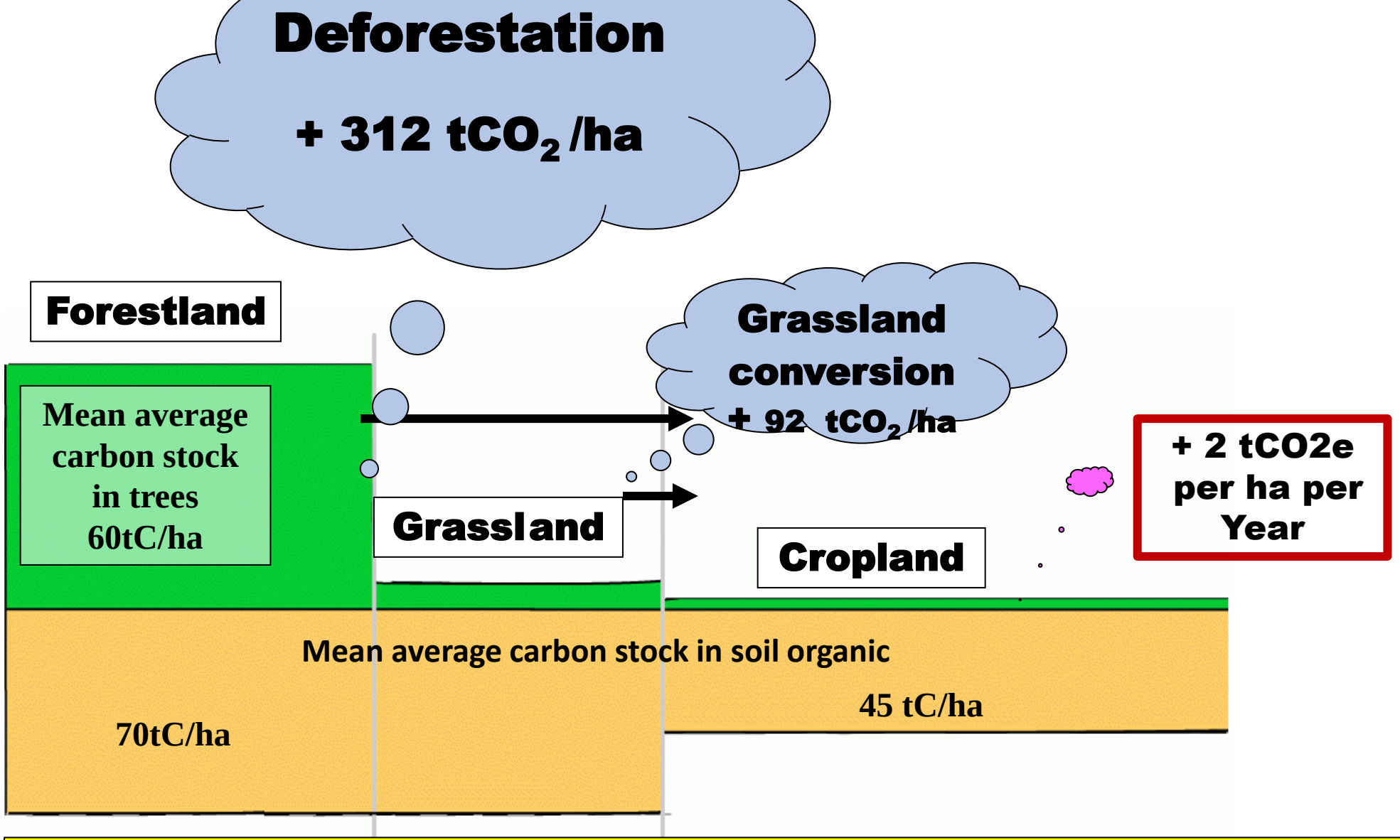
WB 2017


Egypt
(two crops per year)
China
often too much nitrogen
=> unnecessary N2O
emissions and nitrate
leakage
Between 130 et 250
kg/ha
Ukraine 45 kg
World average input: 120 kg /ha
Less than 50kg/ha
1
3,9
11
14,3
15
15,1
19
27,9
41,1
43,2
53,4
132
140
157
175
203
208
231
256
364
636
NIGER
MADAGASCAR
SENEGAL
BURKINA
RUSSIA
ALGERIA
ETHIOPIA
MALI
TUNISIA
MALAWI
MOROCCO
USA
FRANCE
INDIA
BRAZIL
GERMANY
BANGLADESH
NETHERLANDS
JAPAN
CHINA
EGYPT

IFDC 1991 and 2006 IPCC guideline



Can we increase Land Use efficiency without deteriorating the GHG budget ?



An average land use change
(½ forest & ½ grassland)
generates about 200 t of CO_2 per ha

What is land use efficiency ?

- **Not exactly yield**

- **The reverses of the Territorial Intensity (Lueff. = 1/ IT)**

- **IT is the <u>total</u> land needed to produce annually a unit of product**

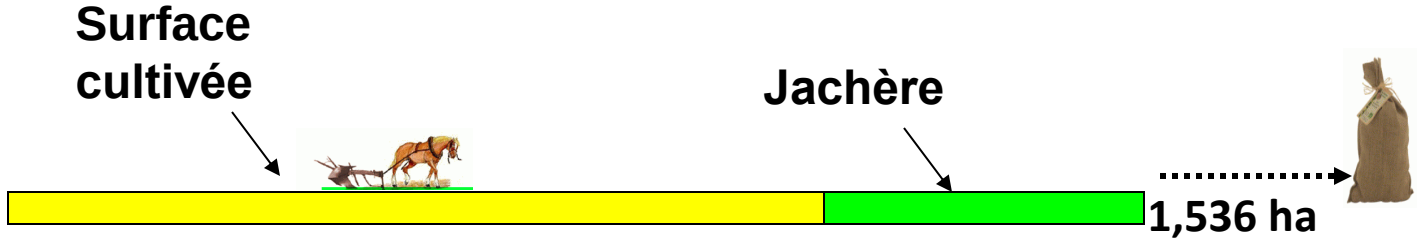
1 ton of cereal  or Dry Matter or Protein

Take into account fallow land, multiple croping, intercroping, land to combat parasites etc.

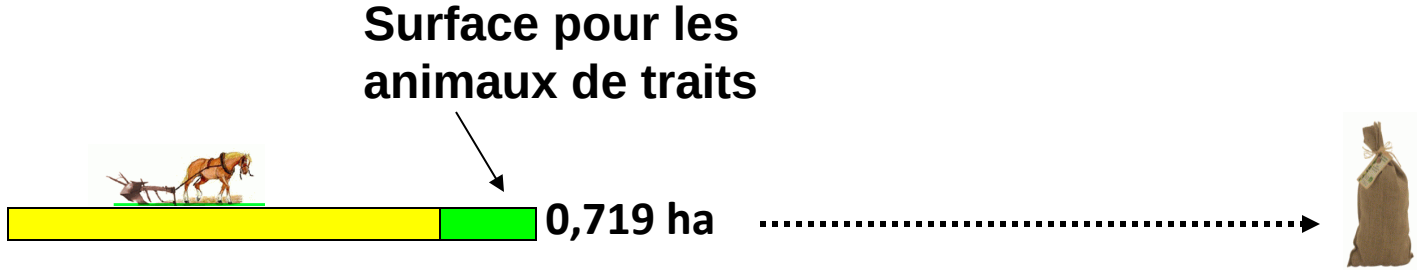
Evolution of Territorial Intensity (TI) in France, between 1850 à 2000

En 1850
(agriculture préindustrielle et souvent encore aujourd'hui en Afrique sub saharienne)
Rendement=0,86 t /ha

(Surface pour produire une tonne de céréale)



En 1950
(agriculture au début du stade industriel)
Rendement=1,59 t/ha



En 1970
(agriculture industrielle à mi parcours)
Rendement 3,18 t /ha

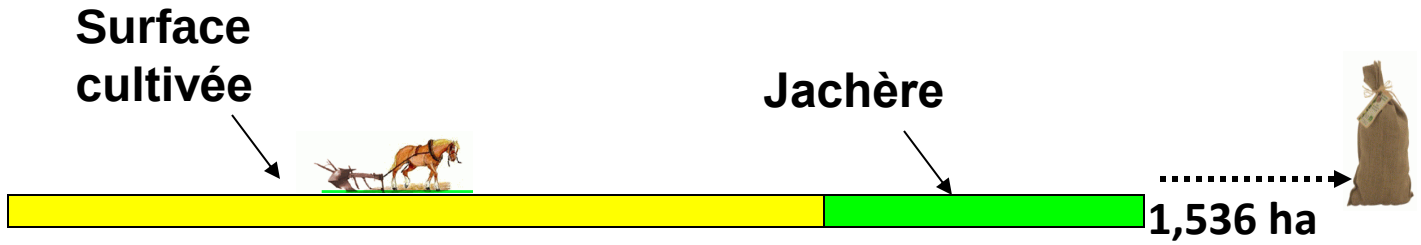
En 2000
(agriculture industrielle optimisée)
Rendement= 6,37 t/ha

Territorial Intensity divided by 9 between 1850 et 200

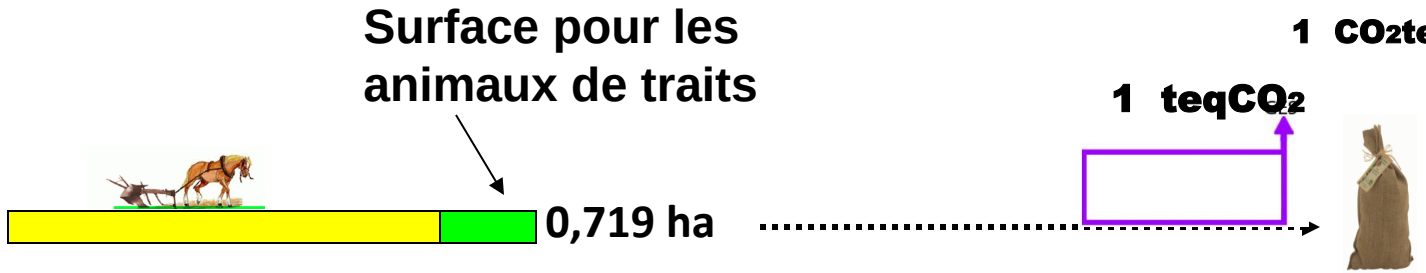
INRA
Riedacker 2008

Evolution of GHG per ton of grain in France 1850 - 2000

1850



1950



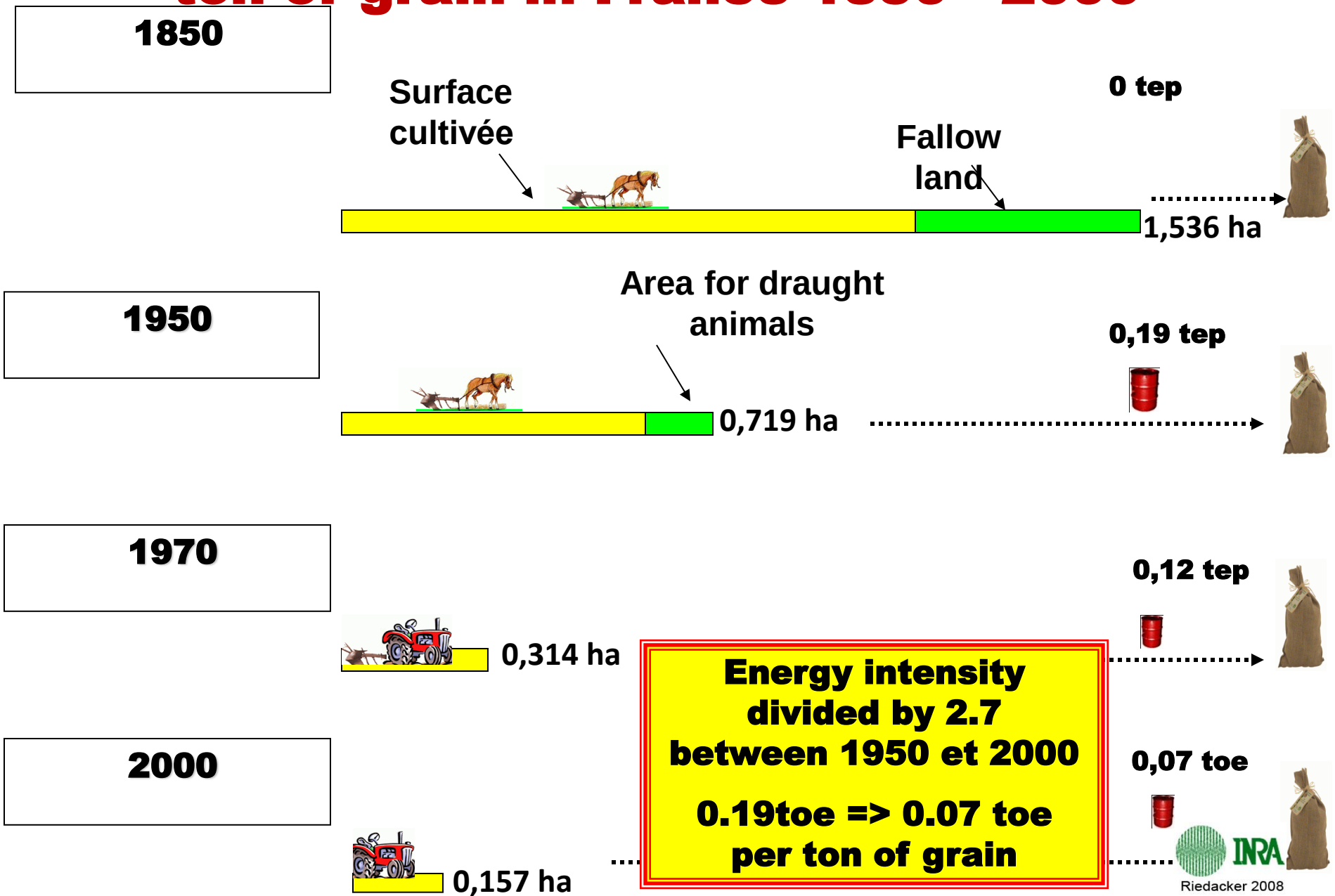
1970

GHG intensity divided by 2 between 1950 and 2000

1 t => 0.5t CO2e per ton of grain

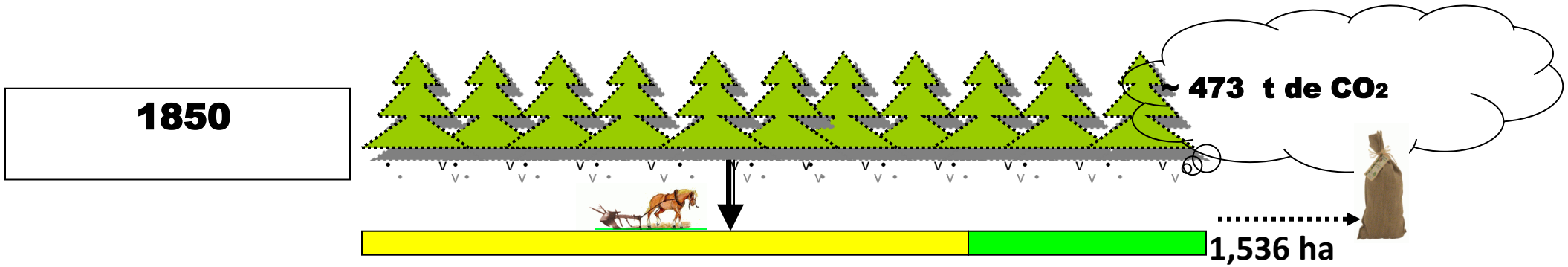
2000

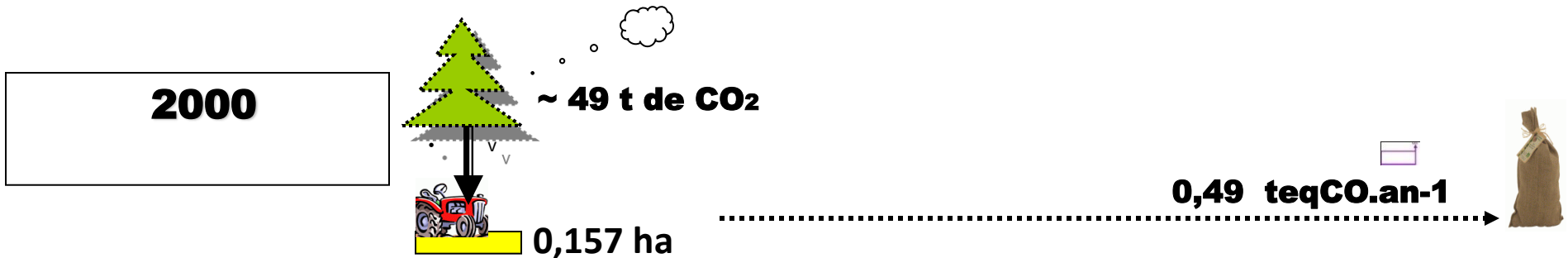
Evolution of fossil energy consumption per ton of grain in France 1850 - 2000



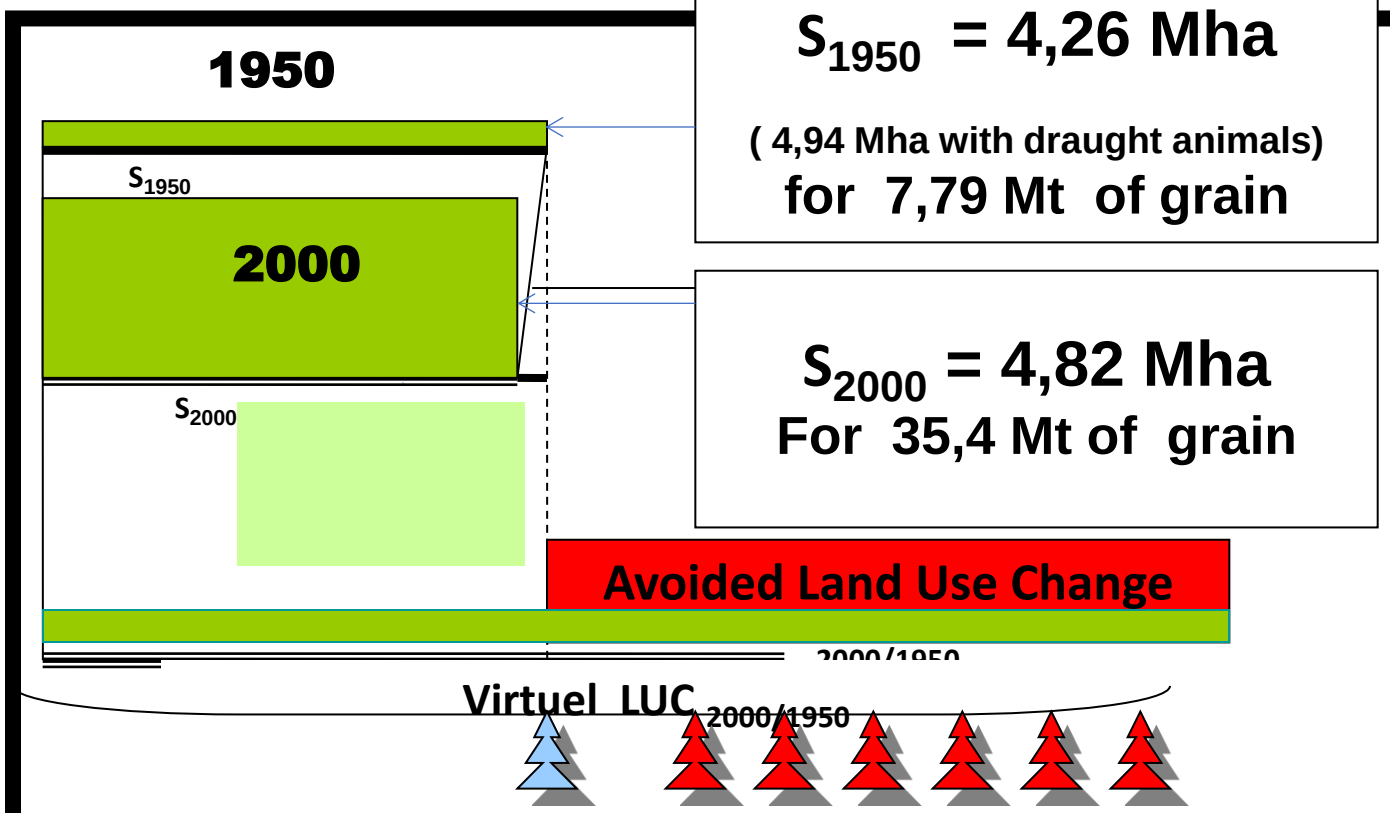
Per additional ton of grain

First increase land use efficiency (e.g. decrease IT) to limit GHG from LUC





Evolution in wheat production in France 1950 and 2000



S_{1950} = 4,26 Mha

(4,94 Mha with draught animals)
for 7,79 Mt of grain

S_{2000} = 4,82 Mha
For 35,4 Mt of grain

Avoided Deforestation
Avoided Land Use Change
$AvLUC_{2000/1950}$

~ 14,4 Mha

Equivalent of the French forest area
~1/4 France

Real Land Use Change between 1950 & 2000 ~ 0

Land Use for grain production of 2000 with of TI_{1950} = 19,33 Mha

Net increase of annual energy gain
9.8 Mtoe (grain) & ~ 7,8 Mtoe (straw)
Avoided GHG emissions between 2000 / 1950 in billion tCO2
4,5 (forest) / 2,88 (mix forest grassland)

For National and Global Sustainable Development

The new constraints

1/Availability of arable land

2/ Climate change (mitigation and adaptation)

3/Fossil energy

4/ Capital