CIRAD

Scenarios and challenges for feeding the world in 2050

bruno.dorin@cirad.fr & patrick.caron@cirad.fr : CIRAD
bernard.hubert@avignon.inra.fr : INRA & IFRAI (Inra-Cirad group)

FAO Expert Meeting « How to feed the World in 2050 », Rome, 24-26 June 2009

The foresight exercise Agrimonde (introduction)

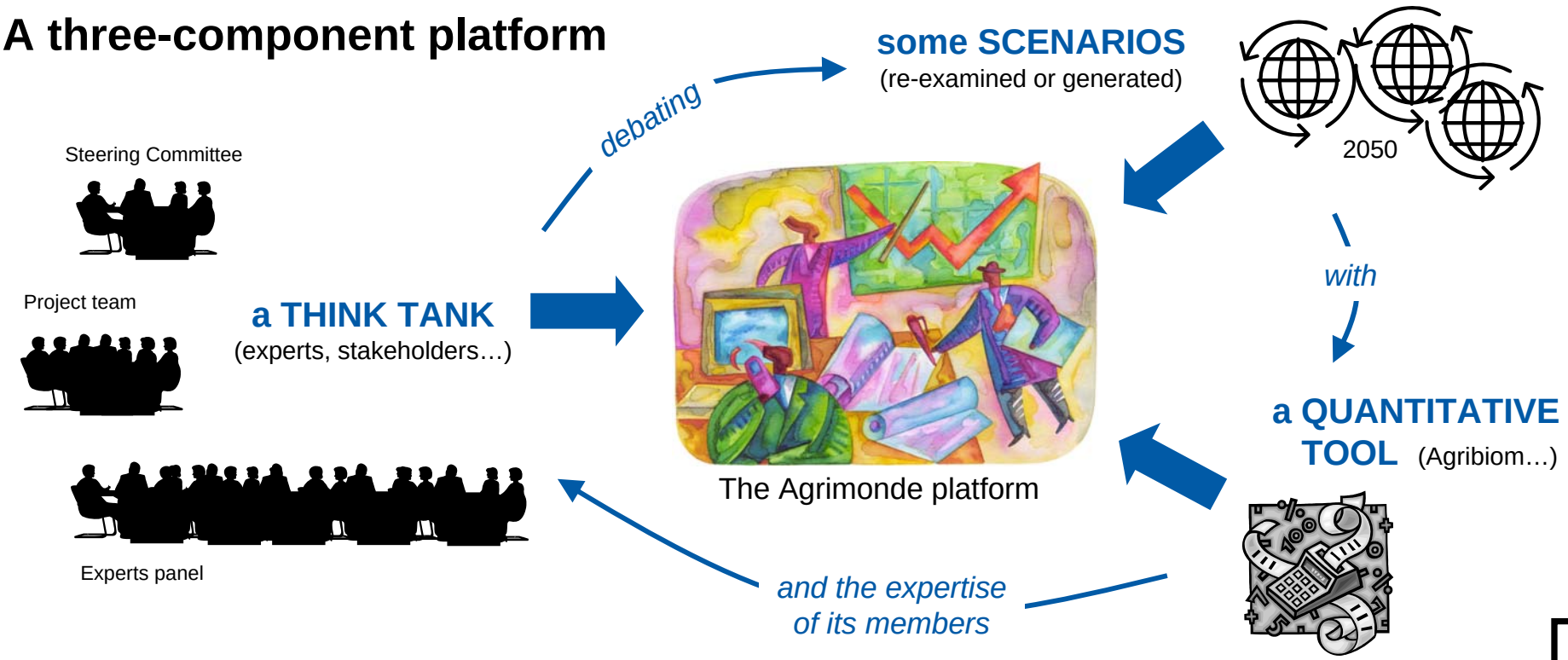
A joint INRA-CIRAD project (2006-2008 = 1st phase)

French National Institute for Agricultural Research (www.inra.fr)
French Agricultural Research Centre for International Development (www.cirad.fr)
→ under their common group **IFRAI** (French Initiative for International Agricultural Research)

Objectives

(1) to explore possible futures of food and farming systems up to 2050
(2) to design and debate orientations and strategies for INRA - CIRAD research agendas
(3) to contribute to international debates on food, agriculture and the environment

A three-component platform



Part I

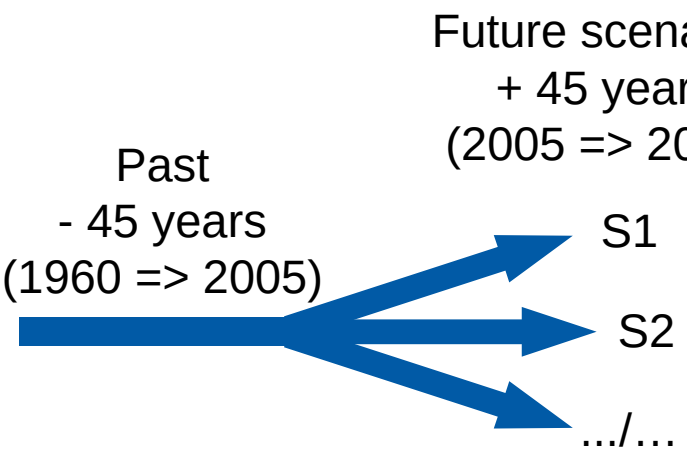
Aims & architecture of Agribiom

A quantitative module designed for facilitating collective explorations and debates as well as hybrid modeling relating to global productions, trade and uses of biomasses

❶ The ambition for Agrimonde

Having a quantitative tool for :

(1) revisiting the past, better understand it (with new estimates, new models…)



(2) debating the future
...from scenarios description (own or external qualitative conjectures)

reflected / summarized into few quantitative parameters (populations, diets, non-food uses land uses, productivities…)

Global Consistency ?
(physical equilibrium between biomass uses & resources)

Implications ? (international trade, energy & water consumptions…)

Impact of variants ?
(populations, composition of diets…)

❷ *The engine*

S/U physical equilibriums of food biomasses
reconstituted (1961-2003, out of FAOSTAT commodity balances in metric tons)
and/or simulated (2030, 2050…)
on more than 97% of the world land surfaces (149 basic «regions»)

Food biomass RESSOURCES

some land & aquatic SPACES

crops, pastures…

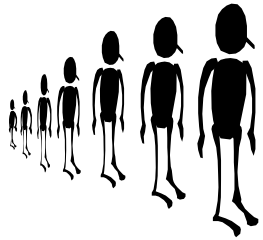
rivers, oceans…

with some levels of PRODUCTIVITY

in calories
- vegetal
- aquatic
per hectare

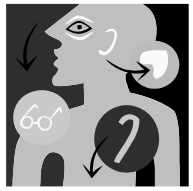
Food biomass USES

some human POPULATIONS



Rural
Urban…

with some levels of FOOD intakes



in calories
- vegetal
- animal
- aquatic
per capita

Exports - Imports

SEED

FEED

Non-Food Uses (biofuels…)

WASTES

some Food PRODUCTION

some Food CONSUMPTION

some co-products (straw…)
some “free” spaces

some non-food productions/potentials

some environmental impacts

some need +/- satisfied

❸ *The items*

- 5 « compartments » of food biomasses (only…)

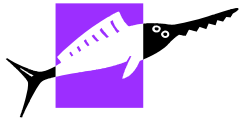
PLANTS (VEGE)

Cereals : wheat, rice, barley, maize…
Sugar crops : sugarcane, sugar beat…
Pulses : beans, peas…
Oilseeds : soybean, groundnut, coconut…
Roots & tubers : cassava, potato…
Fruits & vegetables : apple, onion…
Stimulants : cocoa, coffee, alcohol…

GRAZING ANIMALS (RUMI)
Meats : bovines, goat, mutton…
Milk, Butter, Animal fats…

Non-GRAZING ANIMALS (MONO)
Meats : poultry, pig…
Eggs…

FRESH WATER (AQUA)
Fishes…



MARINE (MARI)
Demersal & Pelagic fishes… Fats…

- Other productions (non-food…)
  Fibres, Tobacco, Rubber… Fodders …Wood

1961-2003 : 120 product lines of Faostat1 (SUA - *Commodity Balances*)

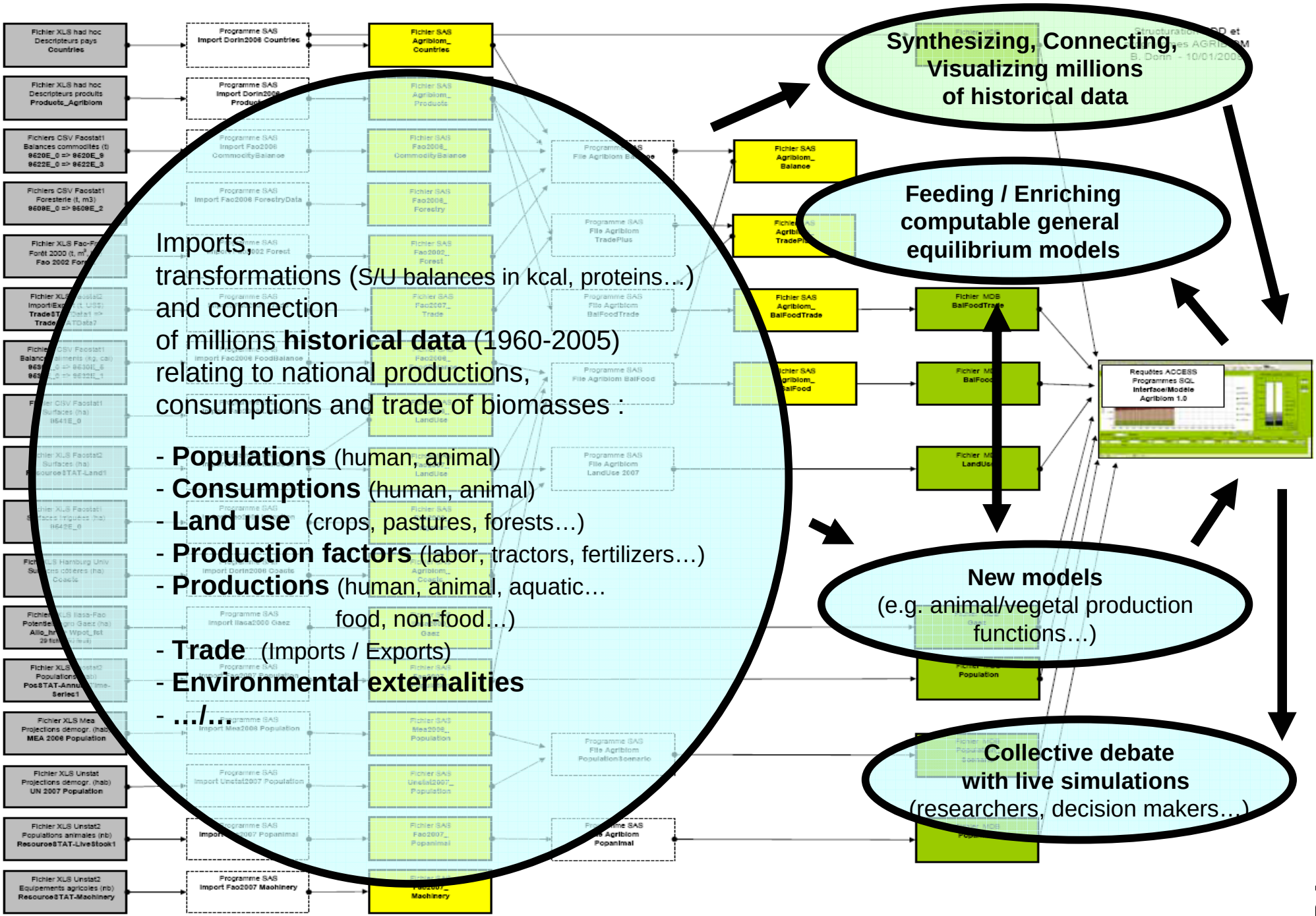
❹ *The unit of account*

- Food CALORIES
  (or equivalent for oilcakes, molasses…)

  Total Calories = Carbohydrates (4 kcal/g)
  + Proteins (4 kcal/g)
  + Fat (9 kcal/g)

- Tonnes (ou m^3) of DM
  - Fibres, rubber…
  - Crop residues…
  - Fodders…
  - Wood (fuel or industrial wood)

❺ *A convergence on an interactive interface*



❻ *A 1st set of robust models*

Cross-country animal production functions

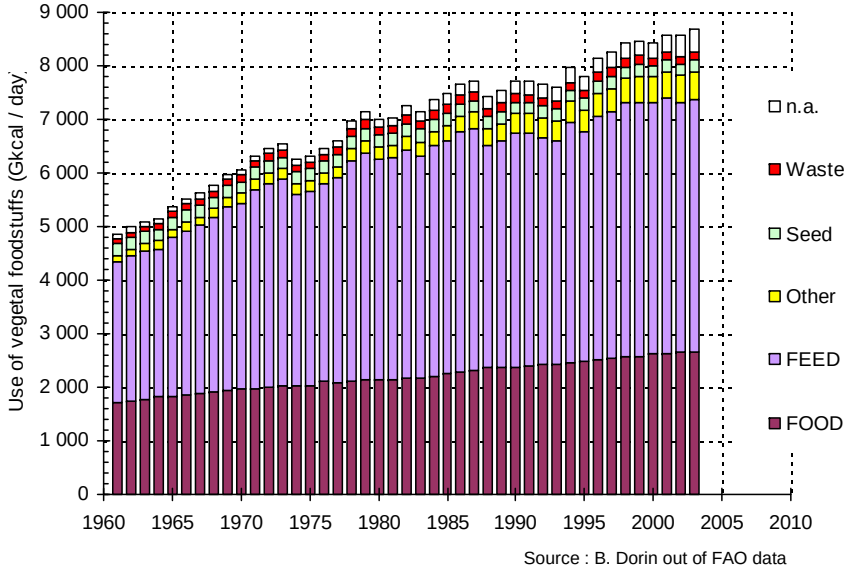
(B. Dorin + T. Le Cotty)

- A model with **2 interdependent functions**
  - Prod_Rumi (Gkcal) = f (x1,x2, x3…, Prod_Mono)
  - Prod_Mono (Gkcal) = f (x1,x2, x3…, Prod_Rumi)

- Key explaining factors (x1, x2, x3…) :
  - **Feed of vegetal origin** (Gkcal)
  - **Feed of animal origin** (Gkcal)
  - **Pasture area** (1 000 ha)
  - Agricultural active population (1,000 cap)
  - Tractors (units)
  - …/…

OECD

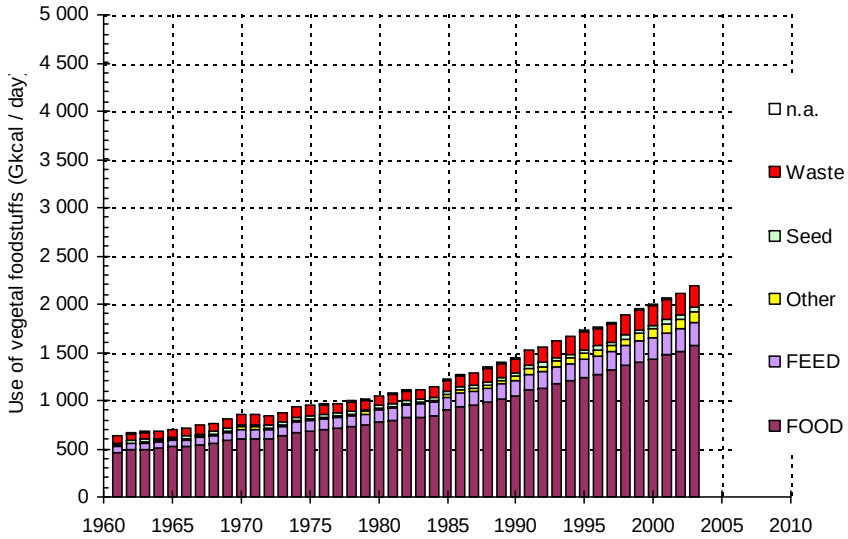
SSA
(Sub-Saharan Africa)



Source : B. Dorin out of FAO data

(in 2003, the OECD cattle ate 3 times as much foodstuff as the SSA human population did)

- Several models now available :
  - **linear** / quadratic
  - CalTot / **CalPro** (unit for the feed and for the outputs…)
  - with/**without «Dummies»** (region, years…)
  - with/**without «Trend»** (“technical progress”)
  - «**Region-based**» (MEA regions…) or «Type-based» (agricultural/industrial, extensive/intensive…)
  - …/…



- Results :
  - replicate very-well the past 40-year of national/regional/global animal productions
  - “on-line” tests and modeling (choice of model, change of parameters/coefficients, simulations…)

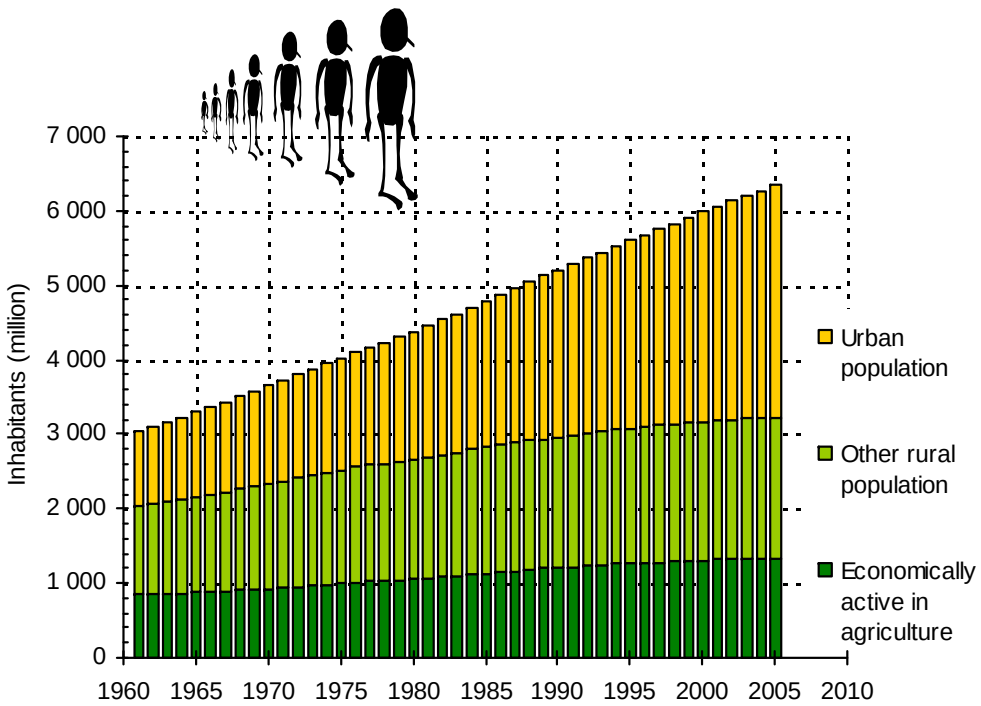
Part II

From past trends to scenarios

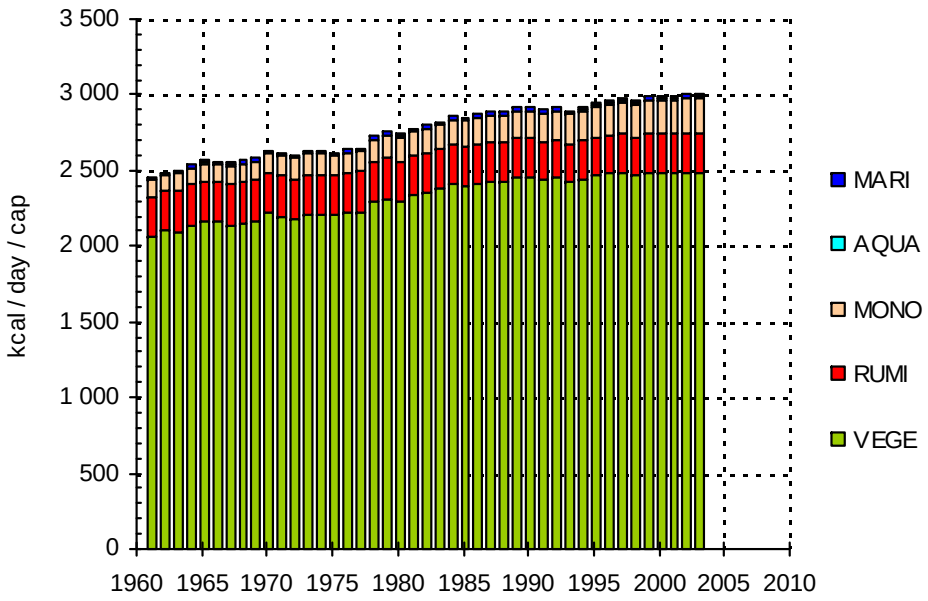
A 1961-2003 brief overview of the world food economy through Agribiom eyes…

❶ From average world increases…

- The population doubled



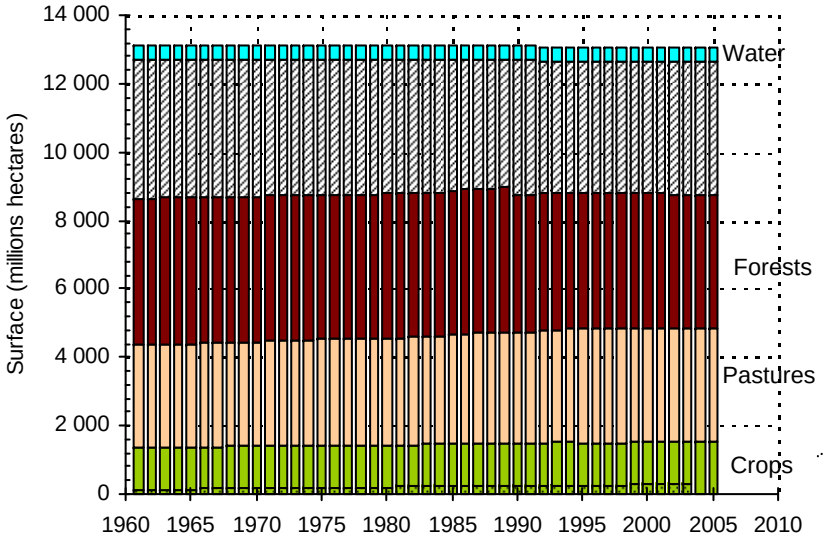
- The per-capita food availability increased too…



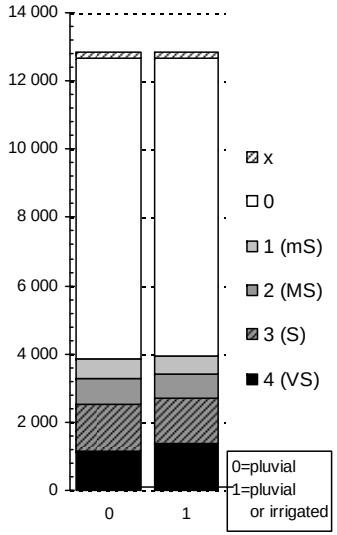
Source : B. Dorin out of FAO data

On the resources side:

- Agricultural area ↗
  - Pastures : + 11%
  - Crops : + 13%

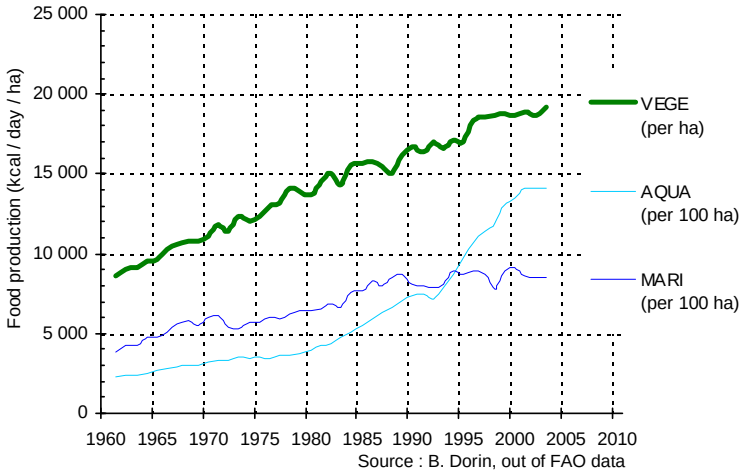


Up to (potential)



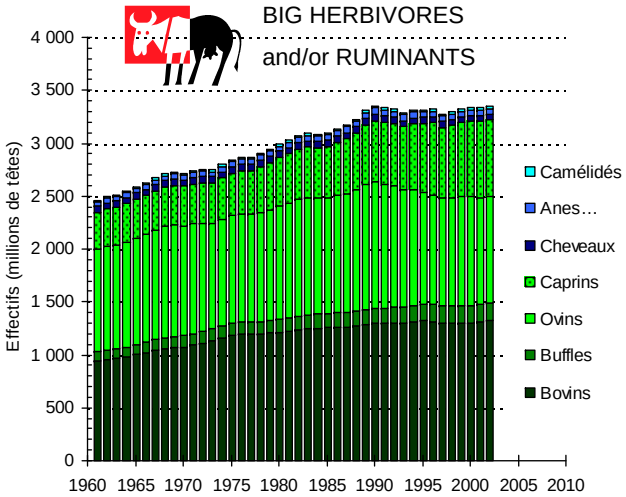
Source : B. Dorin, out of Fischer *et al.* data

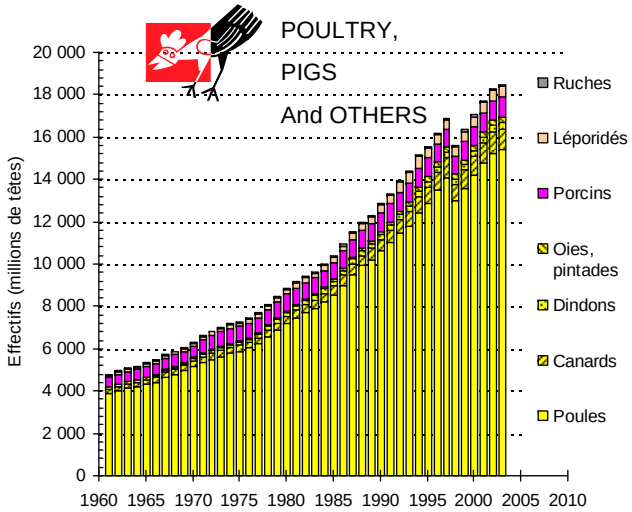
- Land and labour productivities ↗
  - Veg calories / cultivated ha : + 123%
  - Veg calories / farmer : + 53%



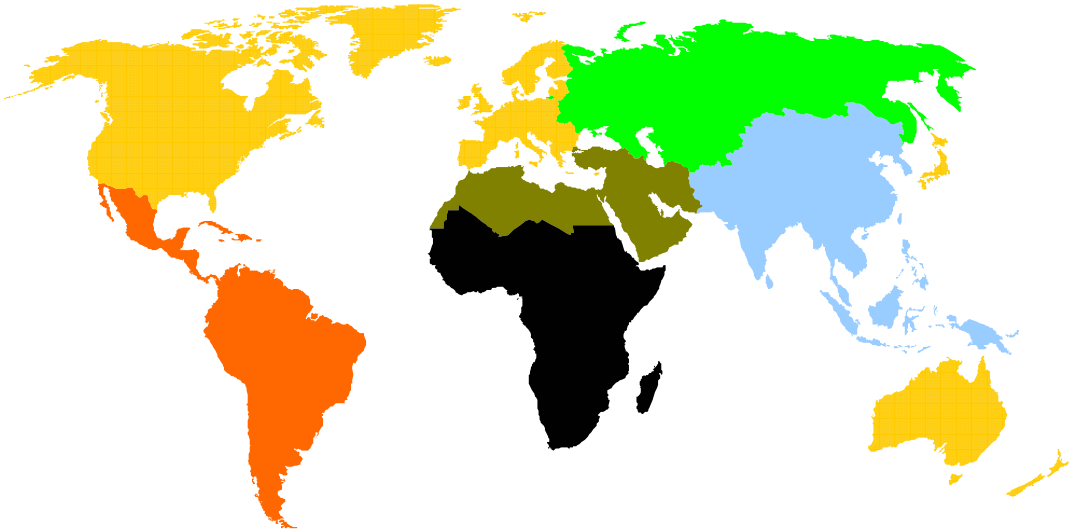
Source : B. Dorin, out of FAO data

- Livestock ↗





❷ ...to regional disparities

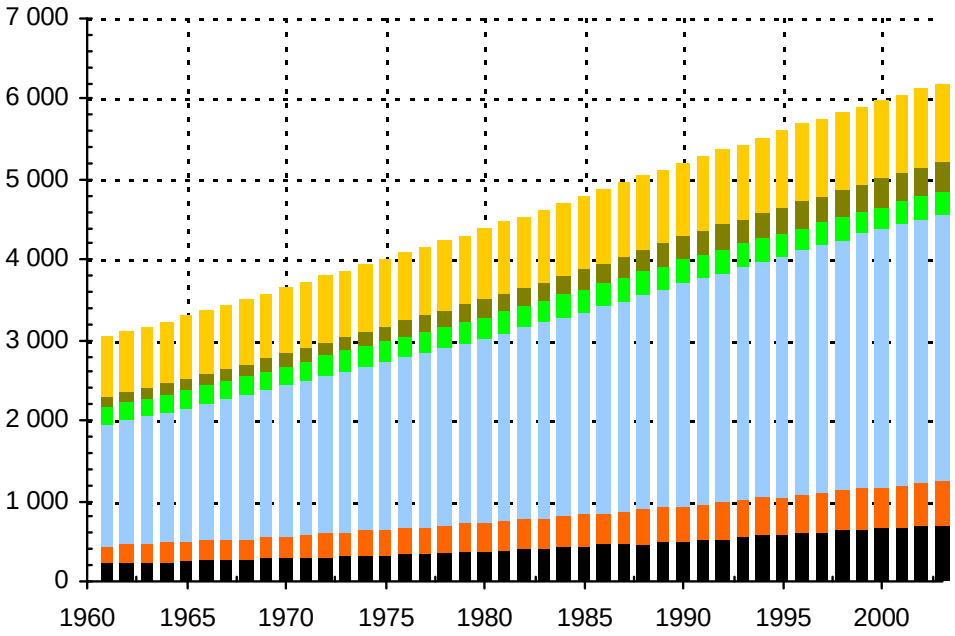


The 6 MEA regions

- OECD = Oecd-1990
- MENA = Middle East & North Africa
- FSU = Former USSR
- ASIA = Asia
- LAM = Latin America & the Caribbean
- SSA = Sub-Saharan Africa

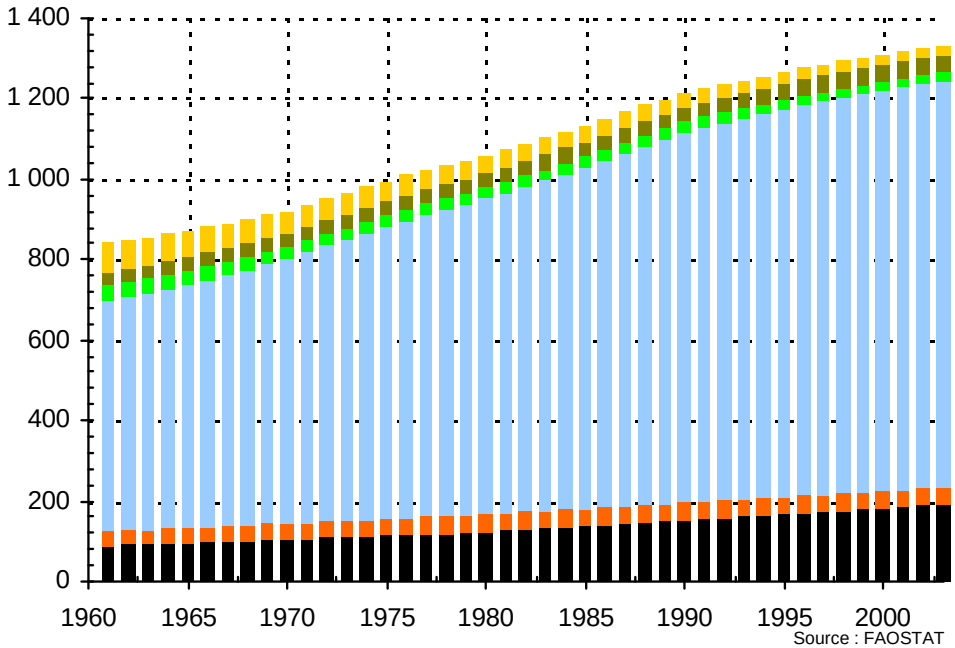
Human populations

Inhabitants (million)



Farmers : highly and increasingly concentrated in Asia and Africa

Active agricultural workers (million)

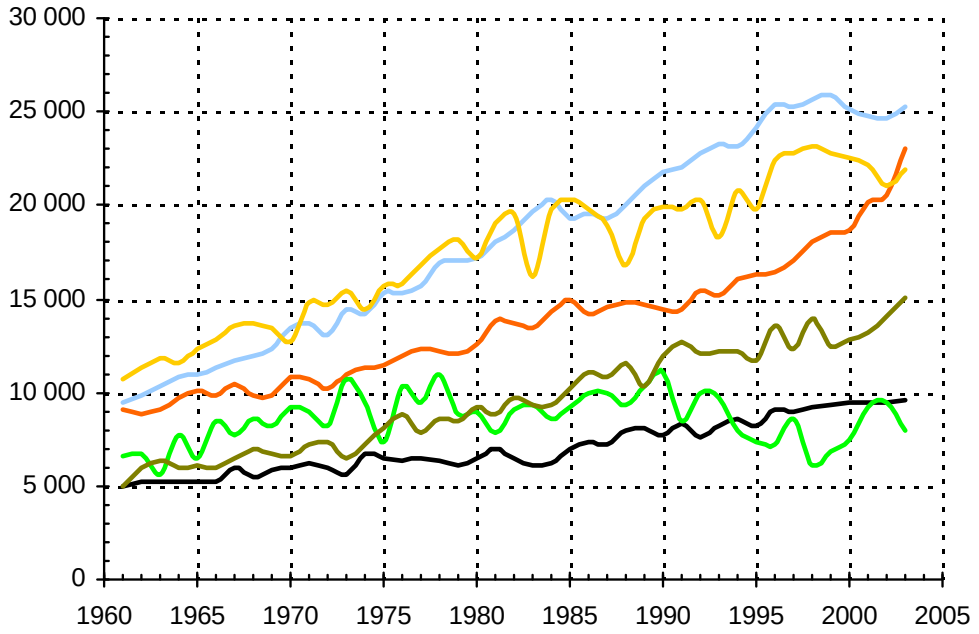


Source : FAOSTAT

Highest land productivity in ASIA

Note : 10 000 kcal =
~ 2.4 kg of soybean
~ 2.8 kg of rice milled
~ 2.9 kg of pea
~ 3.0 kg of wheat
~ 15.0 kg of potato
~ 58.8 kg of tomato

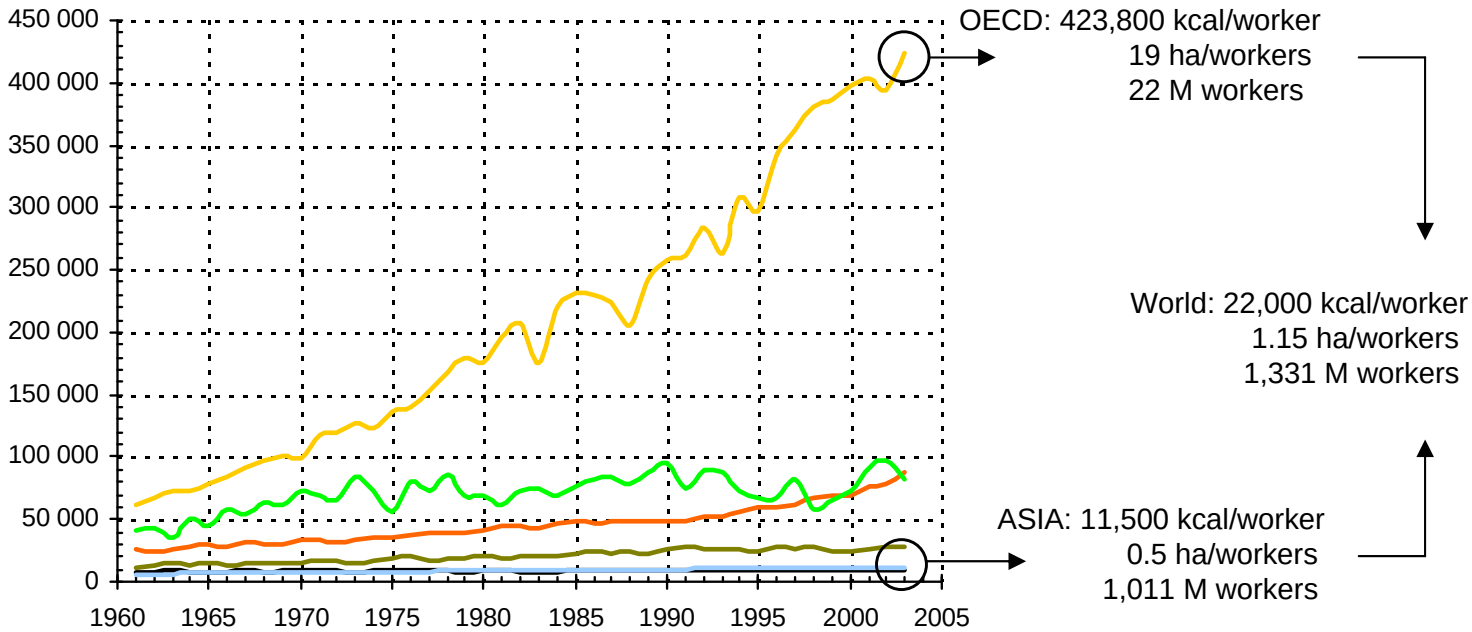
Vegetal kcal / day / cultivated hectare



Source : B. Dorin, out of FAO data

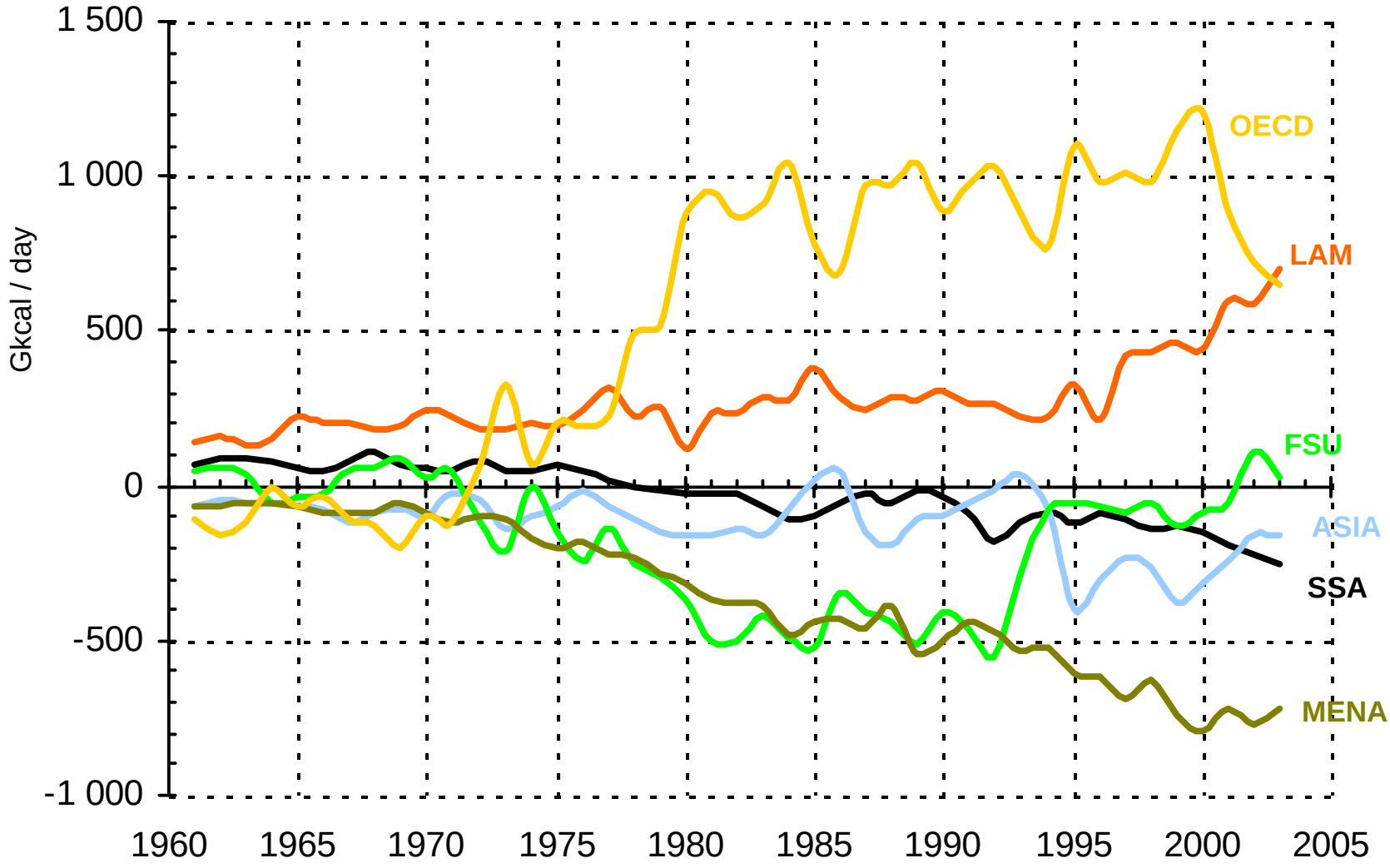
A labour productivity boom in OECD

Vegetal kcal / day / agricultural worker



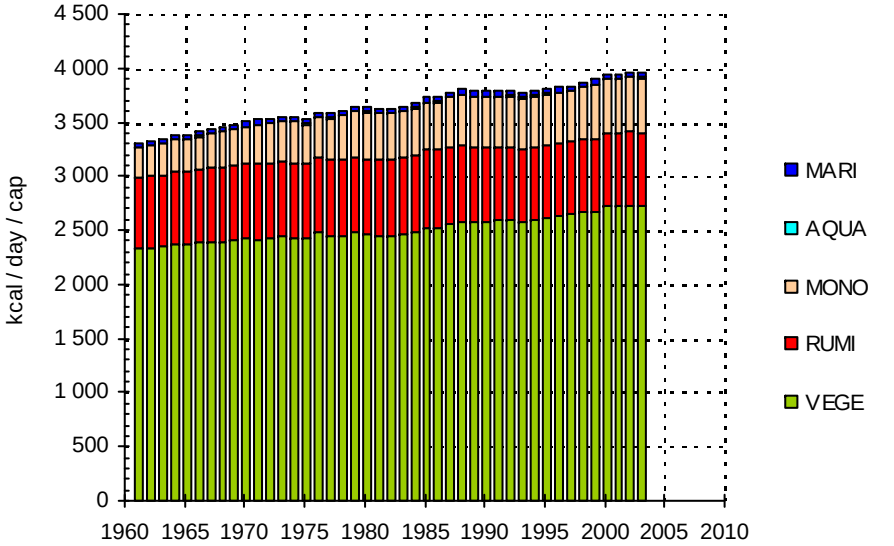
A boom of food trade to clear surpluses and fill in deficits

Net balance of vegetal food trade
(Exports – Imports)



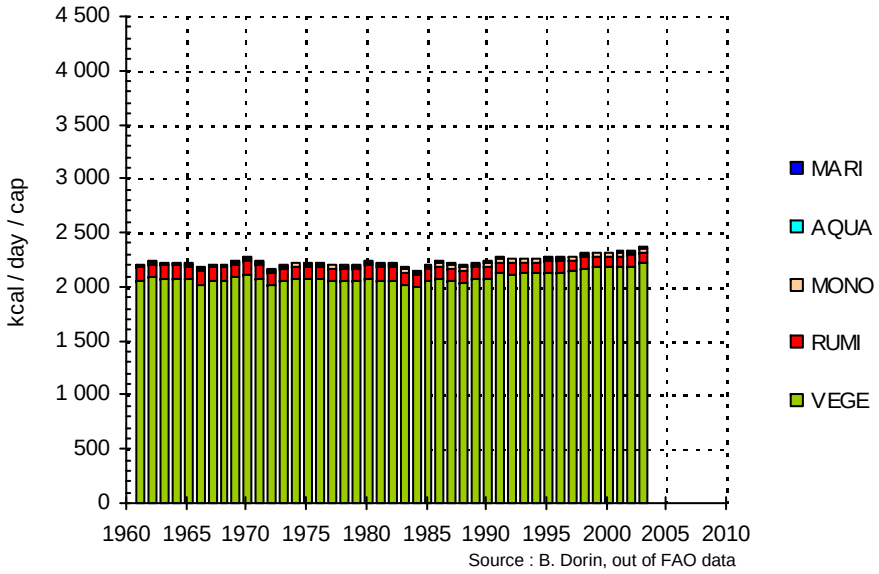
Source : B. Dorin, out of FAO data

But still very large disparities in per-capita food availabilities



OECD

- Animal proteins :
  71 g / day on 125 (60%)
- Animal fats :
  89 g / day on 165 (55%)



Source : B. Dorin, out of FAO data

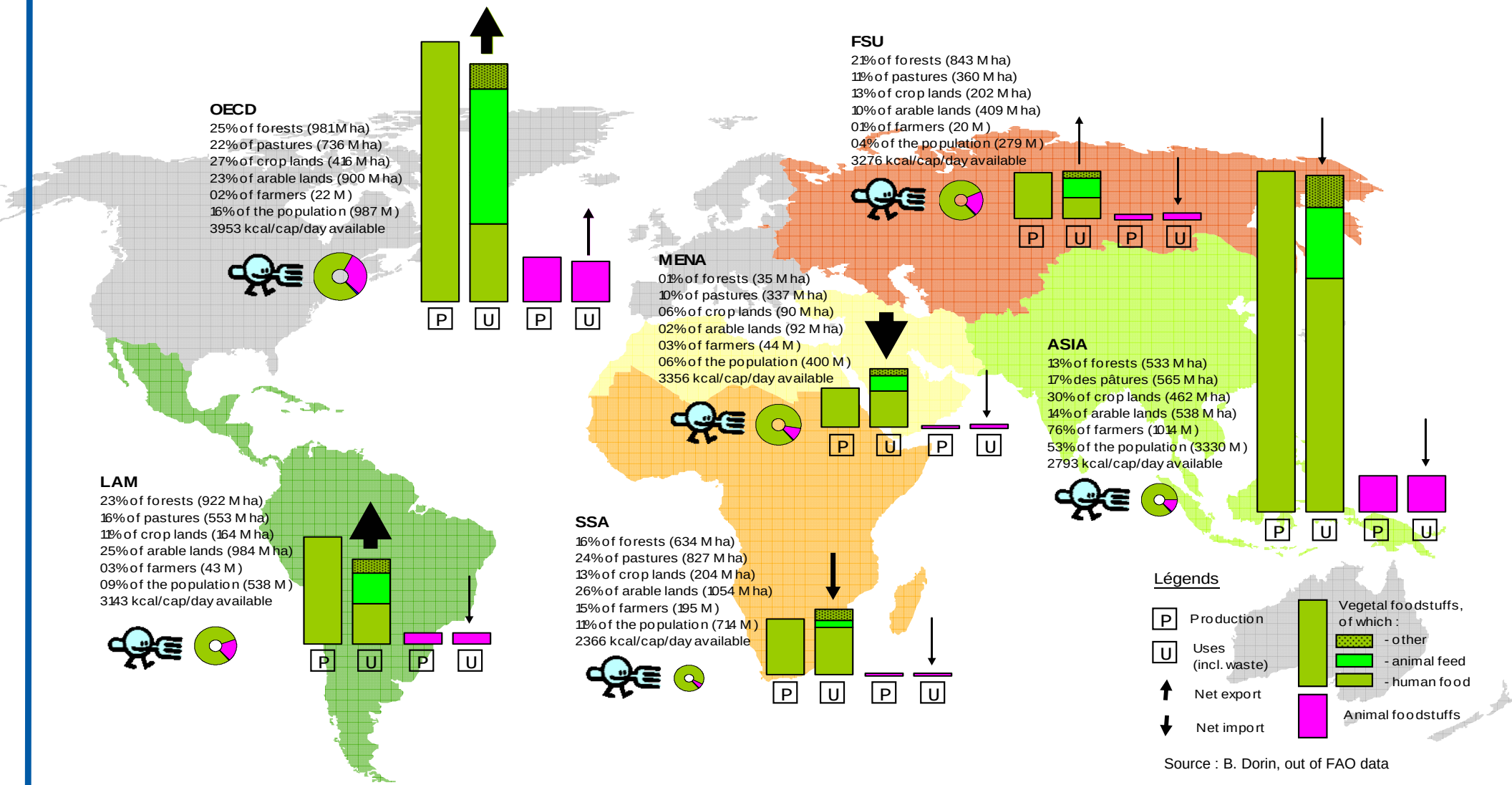
Sub-Saharan Africa

- Animal proteins :
  12 on 60 g / day (20%)
- Animal fats :
  10 on 48 g / jour (20%)

❸ *Towards which new «equilibrium» in 2050 ?*

Resources, productions, trade and uses of food biomasses (2003)

http://www.cirad.fr/upload/en/communique/Cirad-Inra-Agrimonde-GB.pdf



Source : B. Dorin, out of FAO data

Scenarios, hypotheses, collective debates… (2050)

Agribiom simulations

Part III

Scenarios and challenges for feeding the world in 2050

Two first explorations by Agrimonde : the "AGO" and "AG1" worlds

❶ Towards which new «equilibrium» in 2050 with…

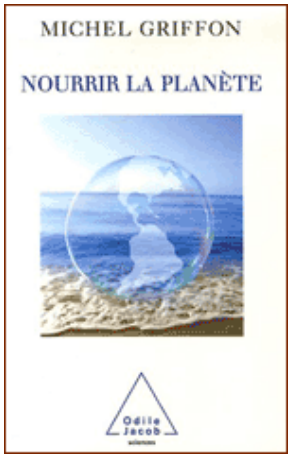
- +/- population growth (7-11 billions inhabitants in 2050) ?
- +/- incomes, incomes distribution and population migrations (regional opportunities of decent incomes, self-subsistence…) ?
- +/- change in food diets (vegetal/animal, macro/micro nutrients…) ?
- +/- demand in non-food products (bio-energies, bio-materials...) ?
- +/- economic liberalization and trust in international trade ("sovereignty" in cereals / other basic vegetal foodstuffs / feed for animal productions / animal foodstuffs…) ?
- +/- environmental regulations (forests, greenhouse gases, biodiversity…) ?
- +/- important crisis on present yield boosts (fossil fuels, water, pesticides, phosphates…) ?
- +/- climate change
- …/…

❷ *The "AGO" and "AG1" worlds*

Two scenarios "reprocessed"

The *Doubly Green Revolution* scenario

Source: Griffon M., 2006. Nourrir la planète. Pour une Révolution doublement verte, Odile Jacob, Paris



The Green Revolution, which was introduced on a world scale after World War II, made it easy to ignore the threat of hunger. But the Green Revolution also encouraged overpopulation; it ravaged the environment in many places; it created inequalities in the sharing of the planet's wealth, and these inequalities have made the threats we must face in the coming decades even greater than those the world had to confront in the early twentieth century.

Agrimonde platform

The "Agrimonde 1" scenario (AG1)

The "Agrimonde GO" scenario (AGO)

The *Millennium Ecosystem Assessment* scenarios

Source: MEA, 2005. Ecosystems and Human Well-being: Scenarios, The Millennium Ecosystem Assessment, Washington DC.

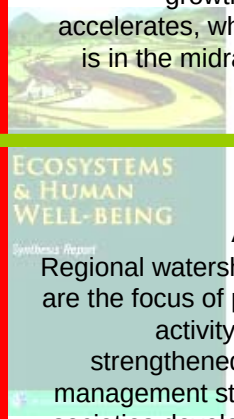
Global Orchestration
A globally connected society that focuses on global trade and economic liberalization and takes a reactive approach to ecosystem problems but that also takes strong steps to reduce poverty and inequality and to invest in public goods such as infrastructure and education. Economic growth in this scenario is the highest of the four scenarios, while it is assumed to have the lowest population in 2050.

Globalization

Techno-Garden
A globally connected world relying strongly on environmentally sound technology, using highly managed, often engineered, ecosystems to deliver ecosystem services, and taking a proactive approach to the management of ecosystems in an effort to avoid problems. Economic growth is relatively high and accelerates, while population in 2050 is in the midrange of the scenarios.

Reactivity

Proactivity



Order from Strength
A regionalized and fragmented world, concerned with security and protection, emphasizing primarily regional markets, paying little attention to public goods, and taking a reactive approach to ecosystem problems. Economic growth rates are the lowest of the scenarios (particularly low in developing countries) and decrease with time, while population growth is the highest.

Adapting Mosaic
Regional watershed-scale ecosystems are the focus of political and economic activity. Local institutions are strengthened and local ecosystem management strategies are common; societies develop a strongly proactive approach to the management of ecosystems. Economic growth rates are somewhat low initially but increase with time, and population in 2050 is nearly as high as in Order from Strength.

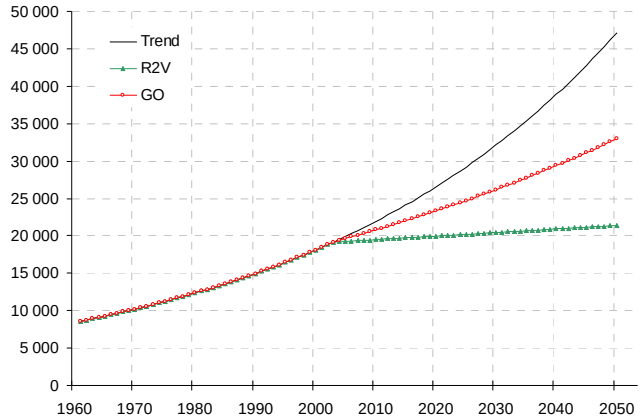
Regionalization

Main quantitative assumptions

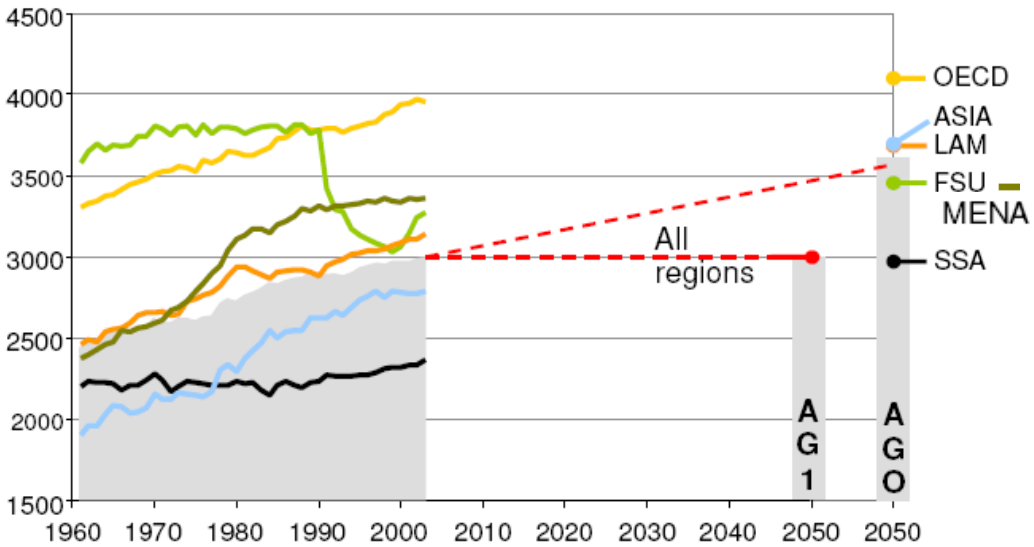
		2003	2050 - AG1	2050 - AGO
Uses	Population	6.2 Gcap	8.8 (+42%)	8.8 (+42%)
	Human food	3,000 kcal/day/cap 17% Non-Veg	**3,000** **17%** Non-Veg	**3,590** (+19%) **23%** Non-Veg
	Other uses	~14,440 Gkcal/day	Feed (Agribiom) + seed (3%) + waste (max 4%) + other (max 5%)	Feed (Agribiom) + seed (3%) + waste (max 4%) + other (max 5%)
Ressources	Food yields	~19,190 kcal/day/ha	~20,030 (**+4%**)	~32,940 (**+75%**)
	Crop land - for N-Food	~1,530 Mha neg.	~2,105 (**+38%**) 224 Mha	~1,860 (**+21%**) 217 Mha
	Pastures	~3,330 Mha	~2,845 (**–14%**)	~3,585 (**+8%**)
	Forest	~3,905 Mha	no change	+14% (?)

Trade : trade of plant food only (i.e. no trade of animal foodstuffs or by-products)
(hypothesis/variant n°1 written “h01”)

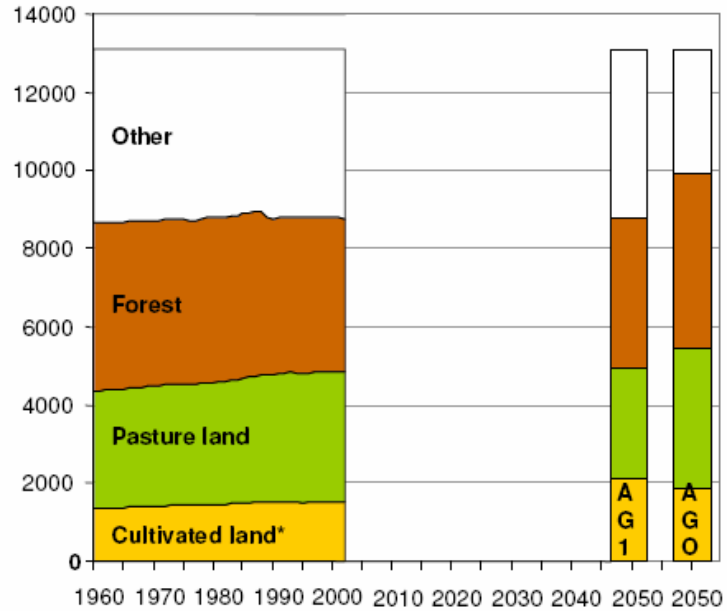
kcal/day/ha



kcal/day/cap

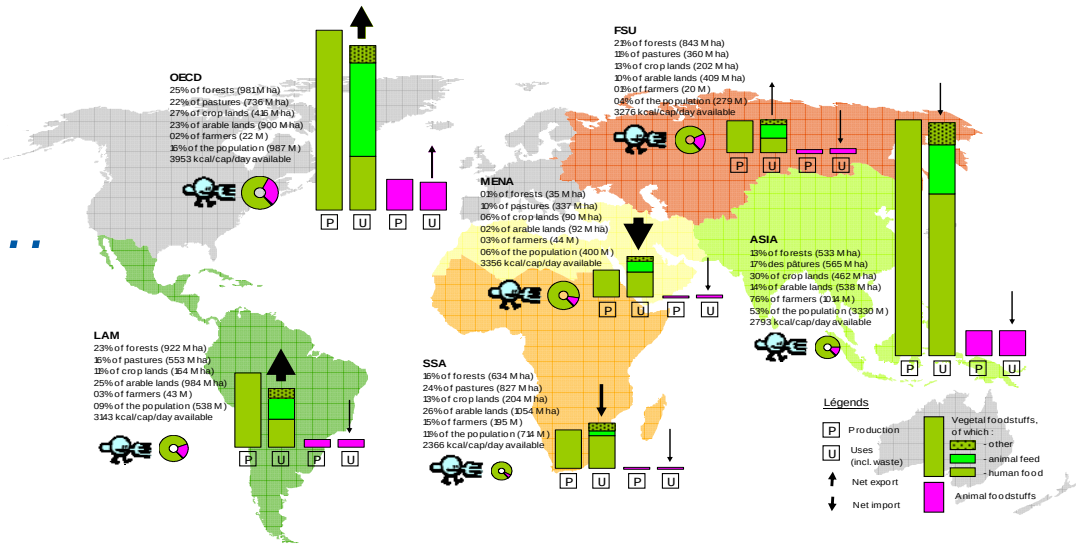


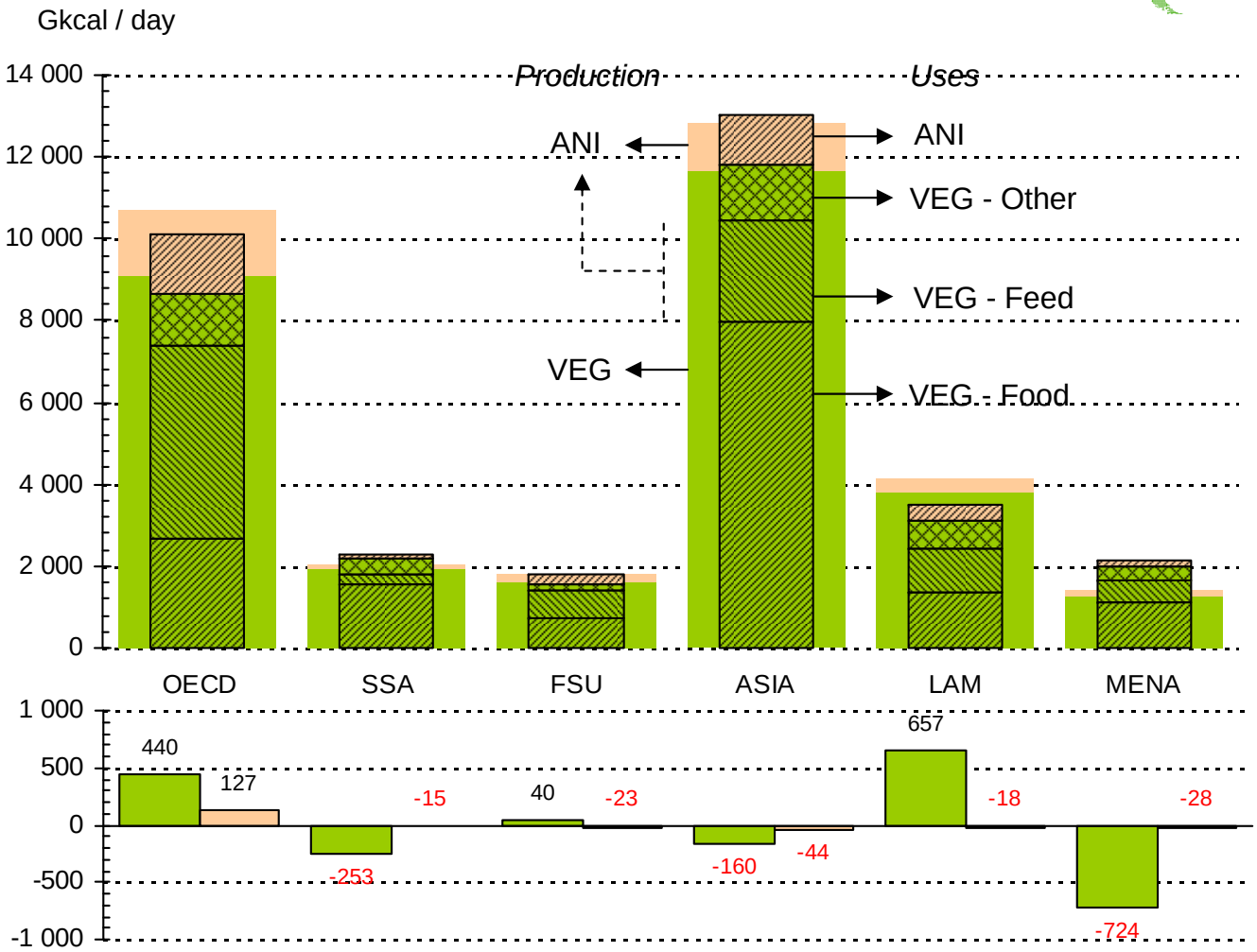
Mha

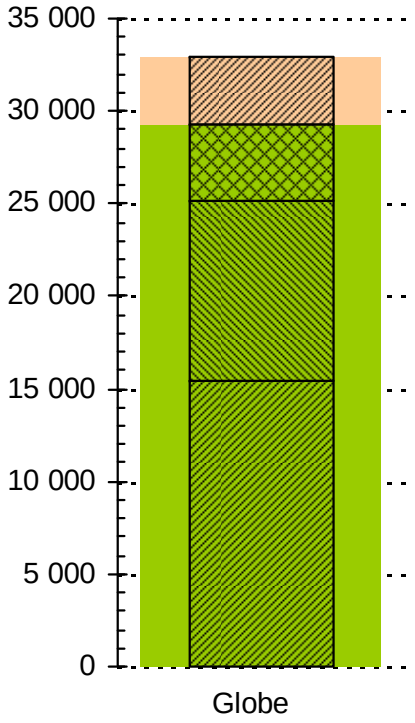


❸ *Two new hypothetical equilibriums for 2050…*

- Base 2003

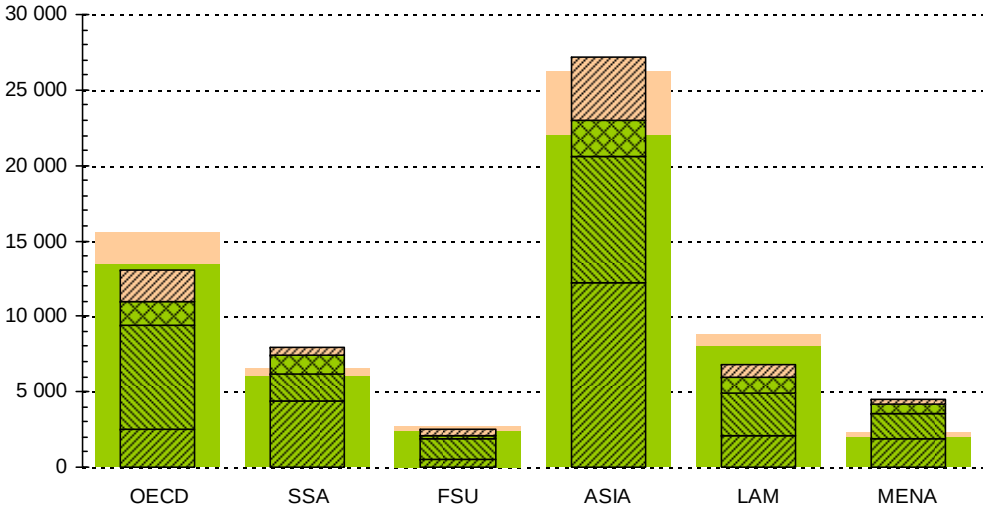


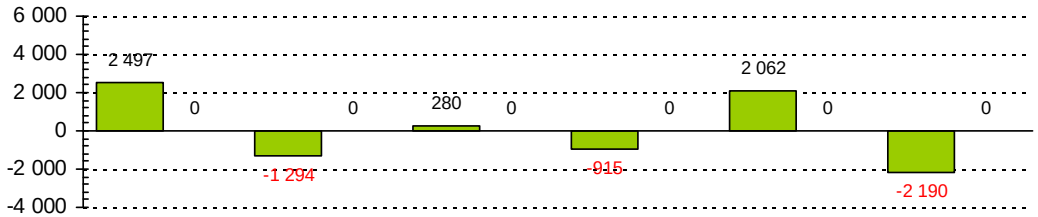


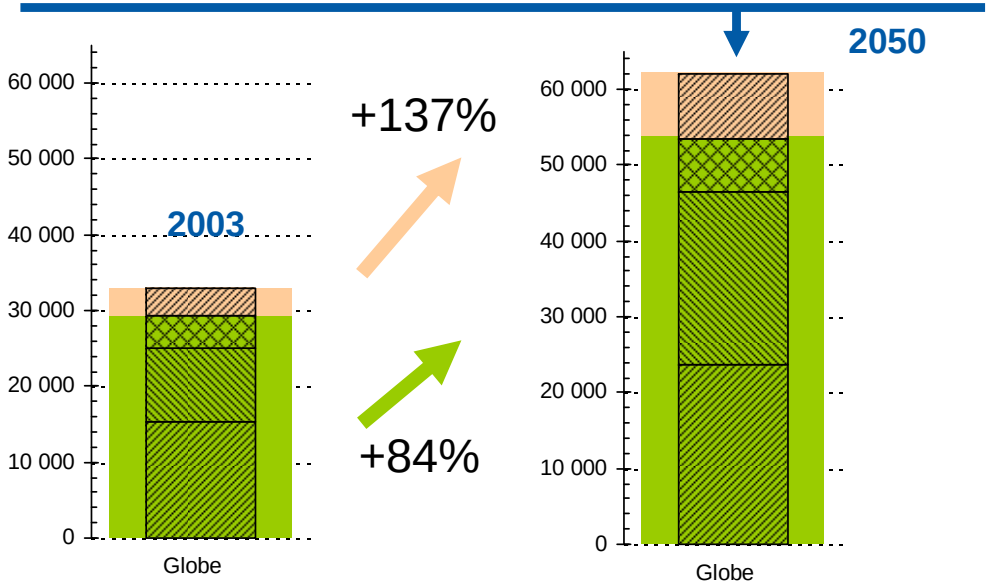


Scenario 2050 - AGO

AGO.h01

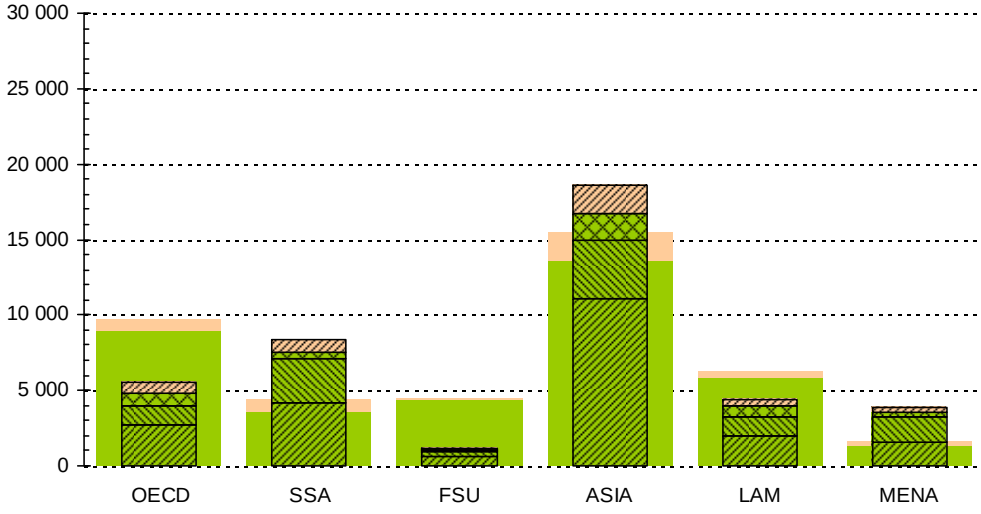


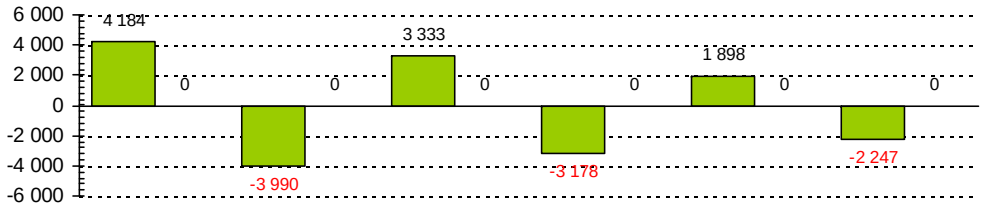


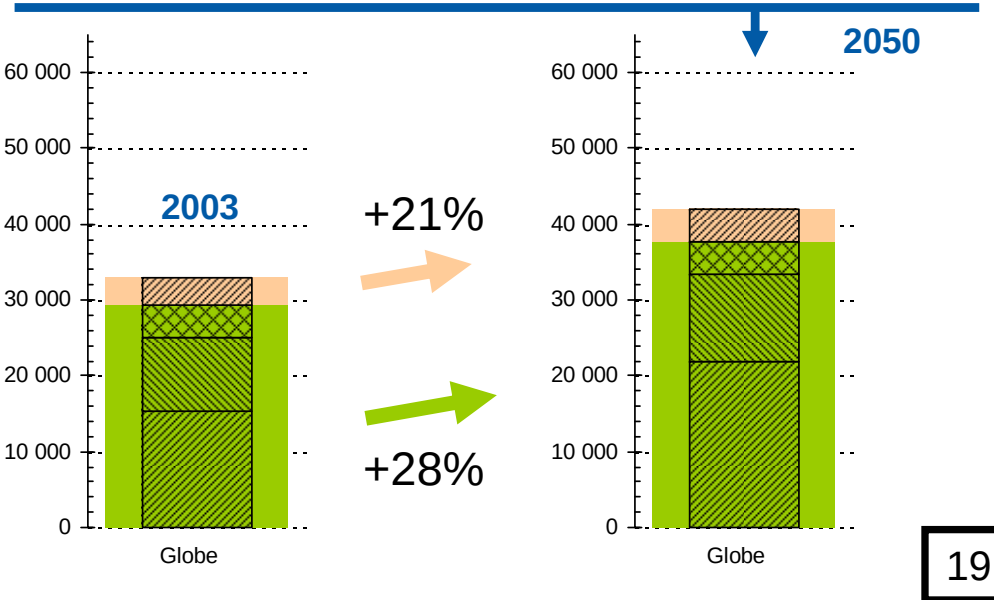


Scenario 2050 - AG1

AG1.h01







❹ *Amongst conclusions…*

The planet can feed properly 9 billions people in 2050 but…

- What is in our plates (total calories, %Veg/Ani, macro/micro-nutrients…) is a key driver for:
  - preserving some ecosystem services (carbon sequestration, soil, water, pollination…) and/or saving the use of some agricultural inputs (water, fertilizers, pesticides…)
  - reducing some important human health problems (from under-nutrition to obesity)
  - opening larger opportunities for non-food productions (bio-energies, biomaterials…) and reducing substantially post-harvest losses and food wastes
  - maintaining a diversity of production systems, landscapes and environments

- Food trade can secure some regional food needs and avoid huge migrations, provided the net-deficit regions/populations can:
  - pay for their food imports (local opportunities of incomes?)
  - rely on a fair and transparent international trade regulation system

  ...also aware of poor farmers incomes

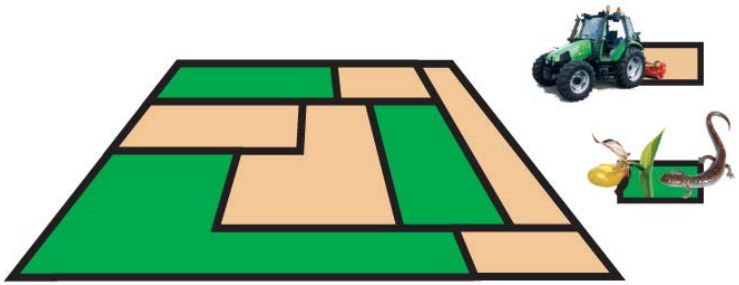
- Preserving or improving agricultural yields calls for breakthroughs:

(a) Need for much less polluting & less dangerous techniques (for workers, flora, fauna…)
founded on: - much better exploitation of ecosystem services (pollination, IP…)
- new technologies (ITC, genetics, monitoring…)
- mobilizing jointly scientific & local knowledge (social learning processes)

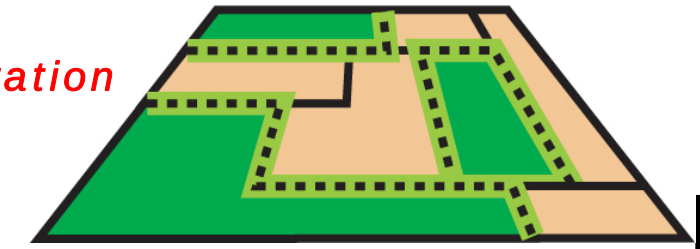
(b) "Ecological intensification" might emerge as an interesting option
for sustainable biomass production and food security of poor farming families,
provided we don't stay locked-in a 50 year-old model of agricultural intensification

(c) The yield/area dilemma might be an opportunity to overcome
usual boundaries between cities, wider countryside & natural areas:
- urban & peri-urban agriculture…
- agro-forestry, agro-ecology…
- stewardship of wet areas (…and not only draining them)
- complementarities between differentiated areas (…and not setting land aside)

Dilemma production/conservation



Segregation vs Integration



To follow up…

- Need to involve a large set of actors, stakeholders …and academic disciplines into food production, food security, food safety and food quality issues!

- Need to debate food and agriculture scenarios at various regional levels (…with various stakeholders)

- Need to better simulate (with Agribiom and other quantitative tool)
  - induced consumptions of fossil fuel and water
  - GHG emissions/sinks (C, CO_2, CH_4, N_2O…)
  - regional employments / incomes / migrations
  - …/…

thanks you for your attention!