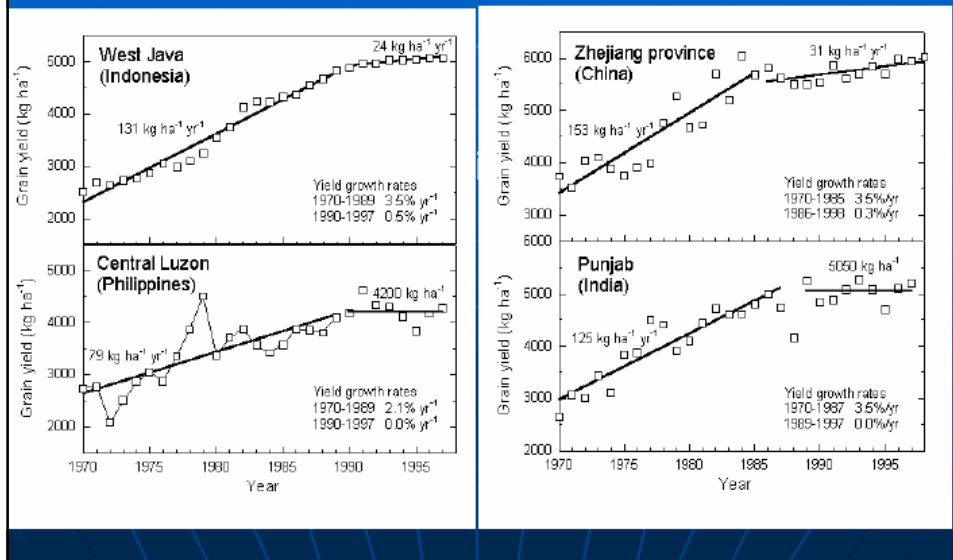


The need for long term scenarios in agriculture identified at the international scale, since 2006

- ⌘ After the Green revolution
  - ⊗ Yields are stagnating ?
  - ⊗ Environmental consequences, water scarcity, climate change
  - ⊗ Problems with fossile energies (cost, GHG)
  
- ⌘ Demographic growth
  
- ⌘ Changes in diets
  - ⊗ Total calories
  - ⊗ Share of animal products

## Yield Trends – not increasing

(from Cassman, 1999)

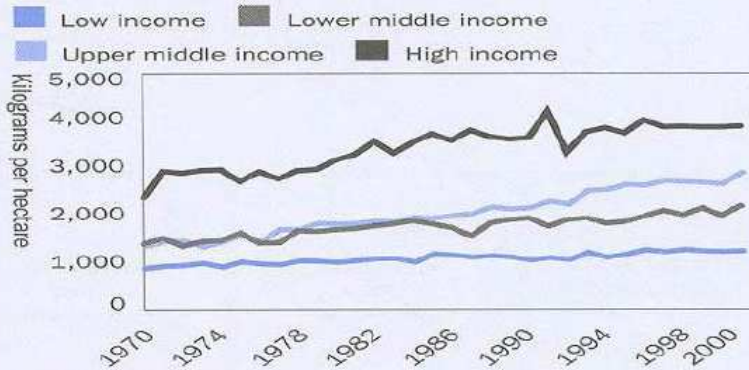


Food security :  
a question at (at least) two different scales

- ⌘ Will the planet be able to produce enough at the global scale for global demand ?
- ⌘ Will agricultural production ensure enough development and income in developing countries and rural areas so that poor rural and urban population will be able to access available food ?

**Farmers in the world's poorest countries are still untouched by yield increases**

Cereal yields by income level, 1970–2000



Source: World Bank and FAO.

5

What limits of the croppable area ?  
What further intensification ?

A specific framing of the question

- ⌘ Where are the reserves for increasing agricultural production ?
  - ☒ Area available with cropping potential ?
  - ☒ Potential for increasing yields ?
- ☒ Different intensification strategies (area/yield), different technological trajectories
- ☒ How can we compare them ?
- ⌘ Imagine sustainable development pathways
  - ☒ Social and environmental impact of agricultural development
- ⌘ Forecasts ? Scenarios ? Narratives ? Projects ?

6

## FAO Outlook 2015-30 and now 2030-50

### ⌘ Trend projections to the mid term

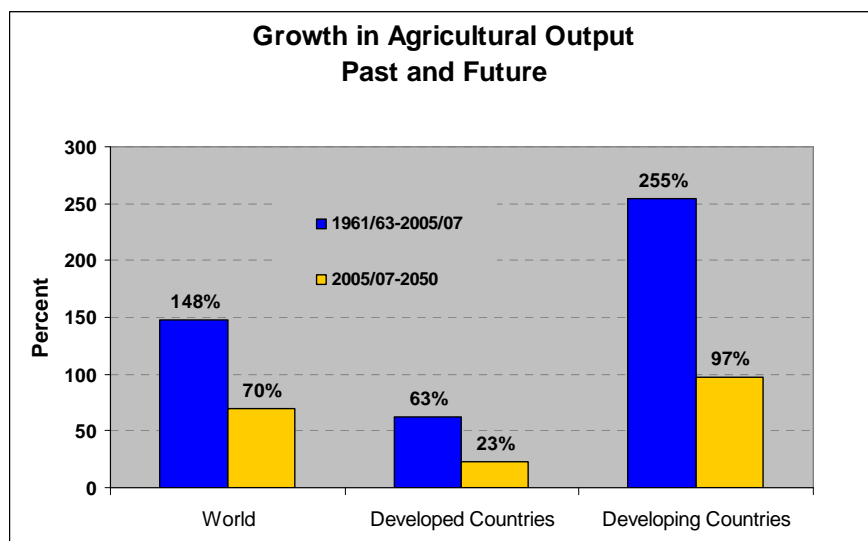
- On productions, consumptions, resources

- ☒ Analysis of past series
- ☒ Extrapolation
- ☒ Expert estimates

### ⌘ Extension of the approach to 2050, with one central scenario

7

## FAO Outlook 2015-30 and now 2030-50



8

## IAASTD : what scenarios ?

Important messages about the long term future

1. Business as usual is not an option
2. Organic / ecological / resilient agriculture can feed the world

But quantitative scenarios not designed in order to sustain these messages

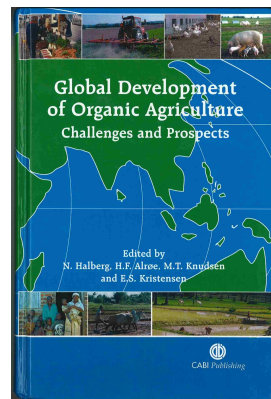
9

## Organic agriculture and food security : an open controversy

### ⌘ Modelling food projections to 2020 relative to baseline scenario, IMPACT model

#### Conclusions in brief:

1. Possible to convert 50% of Europe and North America to OA without significant effects on food security in Sub-Saharan Africa
2. Converting 50% of Sub-Saharan Africa to OA may reduce needs for food import and improve local food access

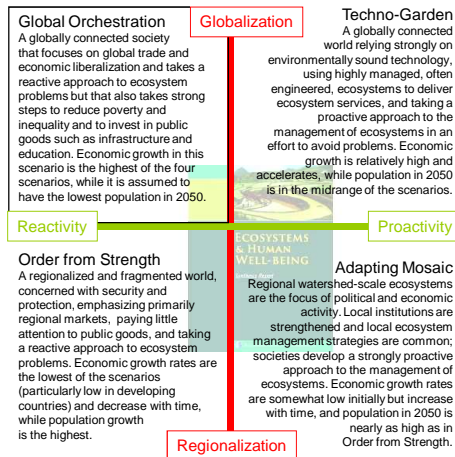


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## Other existing scenarios : Millennium Ecosystem Assessment

### The Millennium Ecosystem Assessment scenarios

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

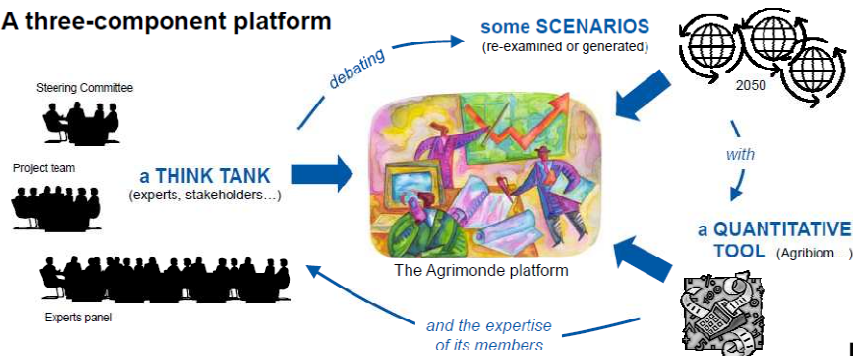


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## The foresight exercise Agrimonde

- A joint INRA-CIRAD project** (2006-2008 = 1<sup>st</sup> phase)
  - French National Institute for Agricultural Research ([www.inra.fr](http://www.inra.fr))
  - French Agricultural Research Centre for International Development ([www.cirad.fr](http://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



## A quantitative module : Agribiom (B.Dorin, T. Le Cotty)

- **Two main objectives**
  - 1) Representation of aggregated past trends
  - 2) Uses / Resources balances simulation
- **One unit of account** : food calories
  - **Five product categories considered** :
    - Plants
    - Grazing animals / Non grazing animals
    - Freshwater / Marine products
- **Animal production functions**
  - Not reusing standard conversion coefficients from vegetal to animal
  - Represent the diversity of feed source between regions

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## A 1<sup>st</sup> set of robust models

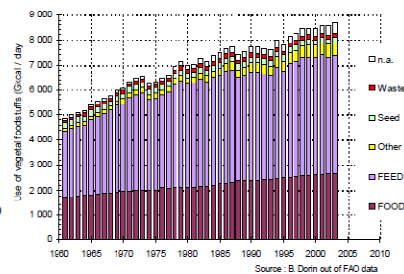
Cross-country animal production functions  
(B. Dorin + T. Le Cotty)

- A model with 2 interdependent functions
  - $Prod\_Rumi (Gkcal) = f(x1, x2, x3, \dots, Prod\_Mono)$
  - $Prod\_Mono (Gkcal) = f(x1, x2, x3, \dots, Prod\_Rumi)$

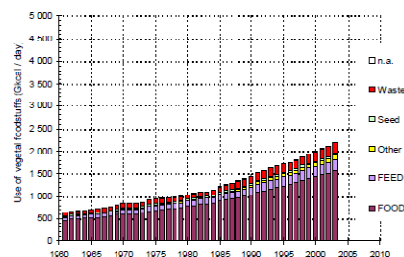
- Key explaining factors (x1, x2, x3...):
  - Feed of vegetal origin (Gkcal)
  - Feed of animal origin (Gkcal)
  - Pasture area (1 000 ha)
  - Agricultural active population (1,000 cap)
  - Tractors (units)
  - .../...

- 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 )



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

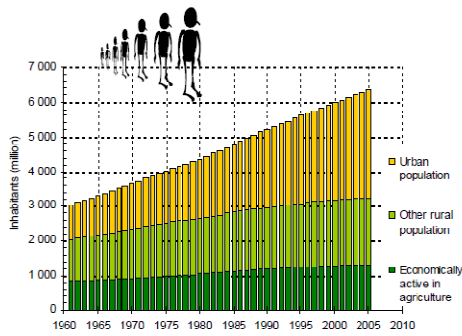


# From past trends to scenarios

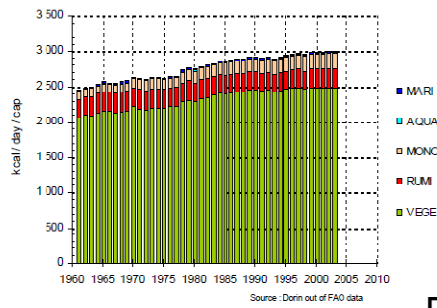
A 1961-2003 brief overview of the world food economy through Agribiom eyes...

## 1 From average world increases...

The population doubled



The per-capita food availability increased too...



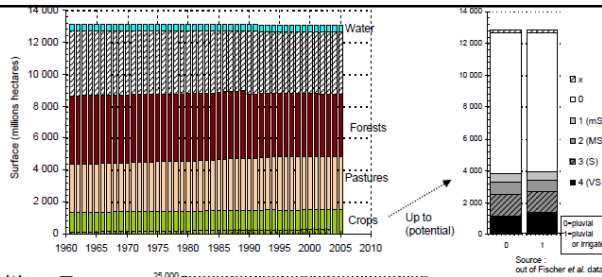
Source : Donn out of FAO data

1

On the resources side:

Agricultural area ↗

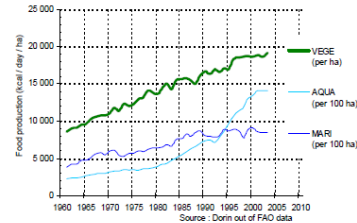
- Pastures : + 11%
- Crops : + 13%



Source : out of Fischer et al. data

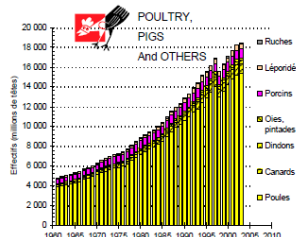
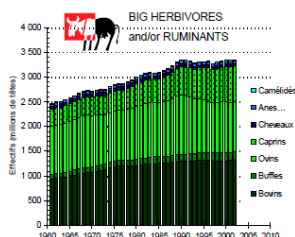
Land and labour productivities ↗

- Veg calories / cultivated ha : + 123%
- Veg calories / farmer : + 53%



Source : Donn out of FAO data

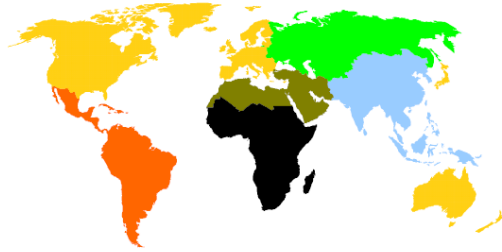
Livestock ↗



1



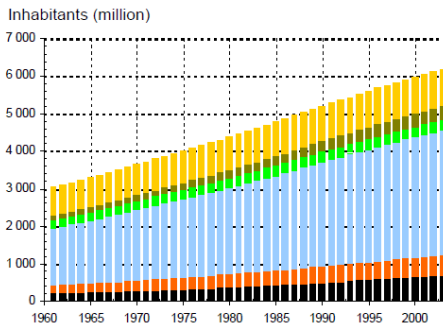
## 2 ...to regional disparities



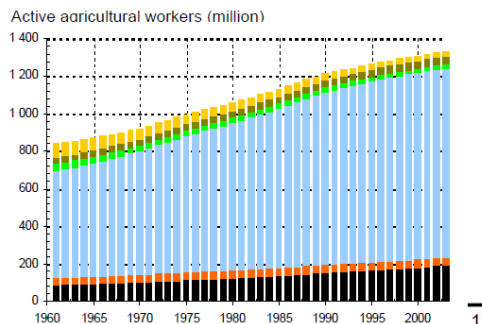
The 6 MEA regions

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

### Human populations



### Farmers : highly and increasingly concentrated in Asia and Africa

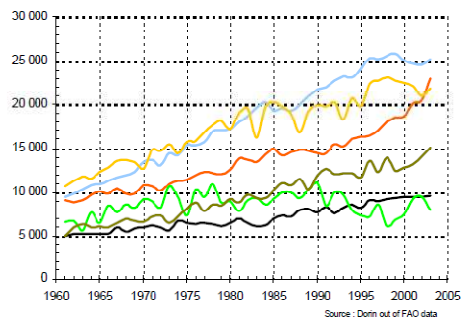


### Highest land productivity in ASIA

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

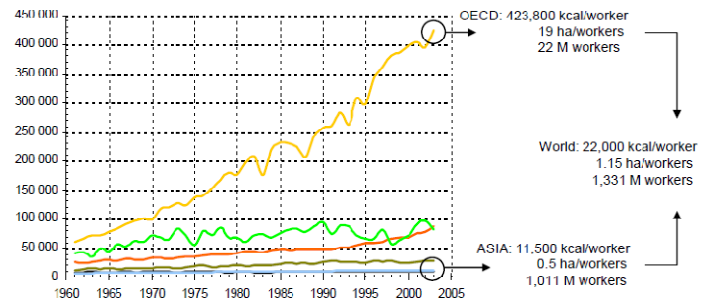
- SSA
- LAM
- ASIA
- FSU
- MENA
- (OECD)

Vegetal kcal / day / cultivated hectare



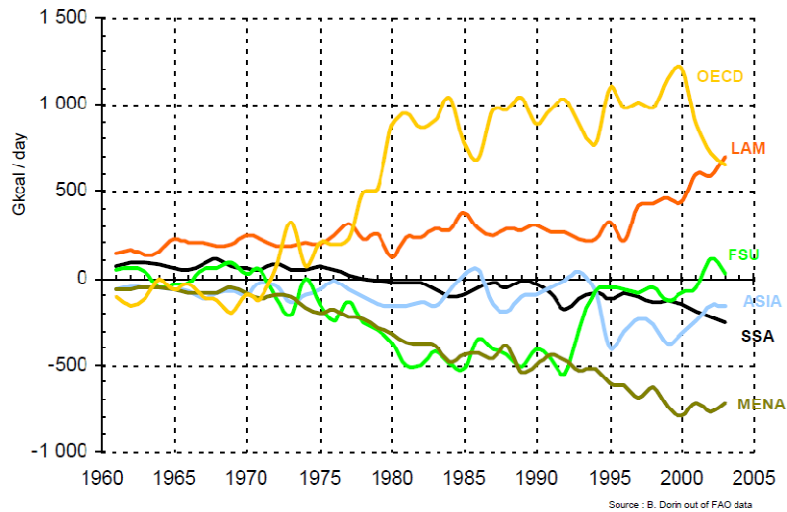
### A labour productivity boom in OECD

Vegetal kcal / day / agricultural worker



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

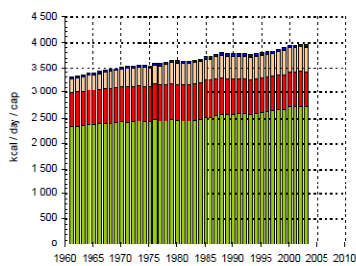
Net balance of vegetal food trade  
(Exports – Imports)



Source : B. Dorin out of FAO data

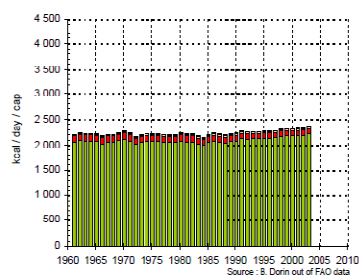
14

■ 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%)

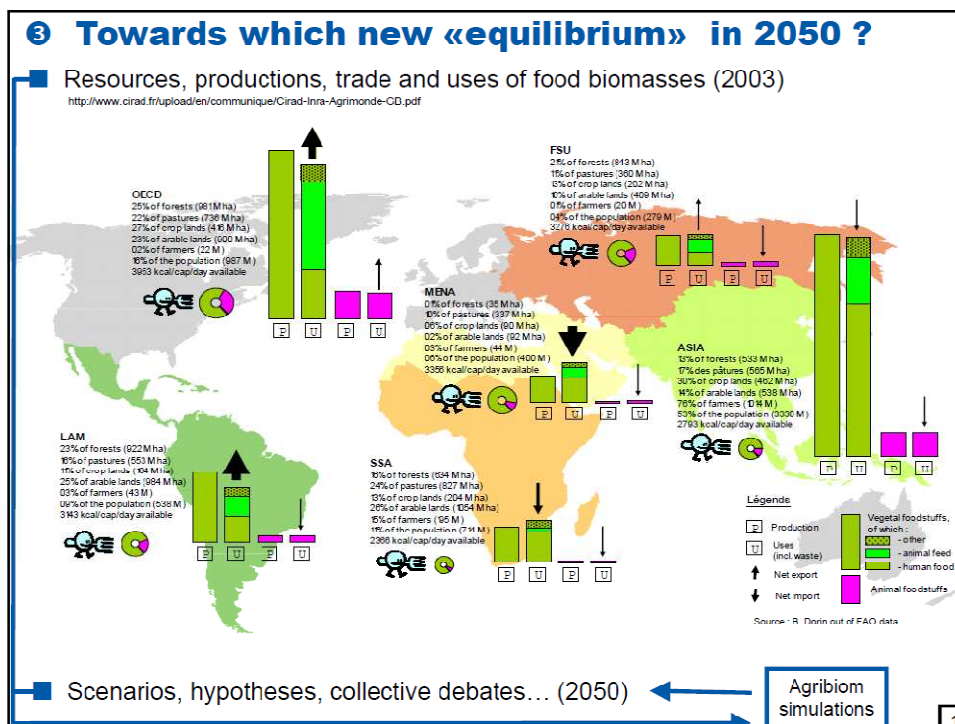


Sub-Saharan Africa

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

Source : B. Dorin out of FAO data

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## Scenarios and challenges for feeding the world in 2050

First explorations by Agrimonde : the "AGO" and "AG1" worlds...

### ① 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**
- .../...


# 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

**MICHEL GRIFFON**  
NOURRIR LA PLANÈTE



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.

**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.

**Regionalization**

**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.

**Reactivity**

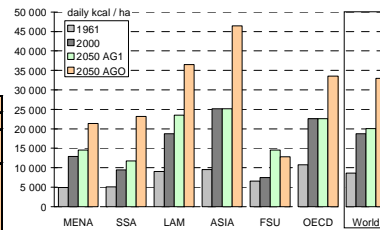
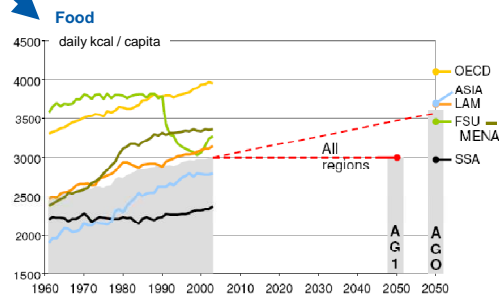
**Ecosystems & Human Well-being**

23

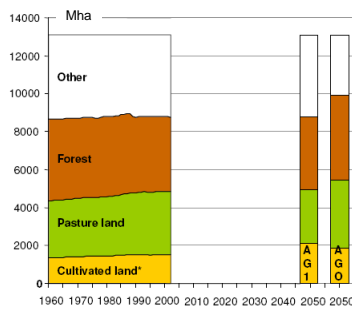
## Main quantitative assumptions

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

Trade : h01 : trade of plant food only (i.e. no trade of animal foodstuffs or by-products)  
h02 : import of animal foodstuffs instead of import of plant feed



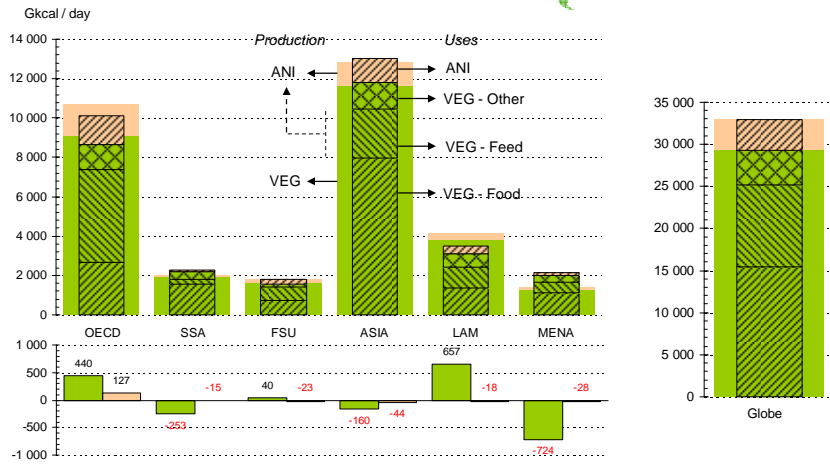
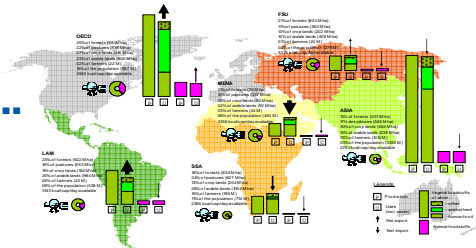
**Yield**  
**Land**



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## Two new hypothetical equilibriums for 2050...

■ Reference year 2003



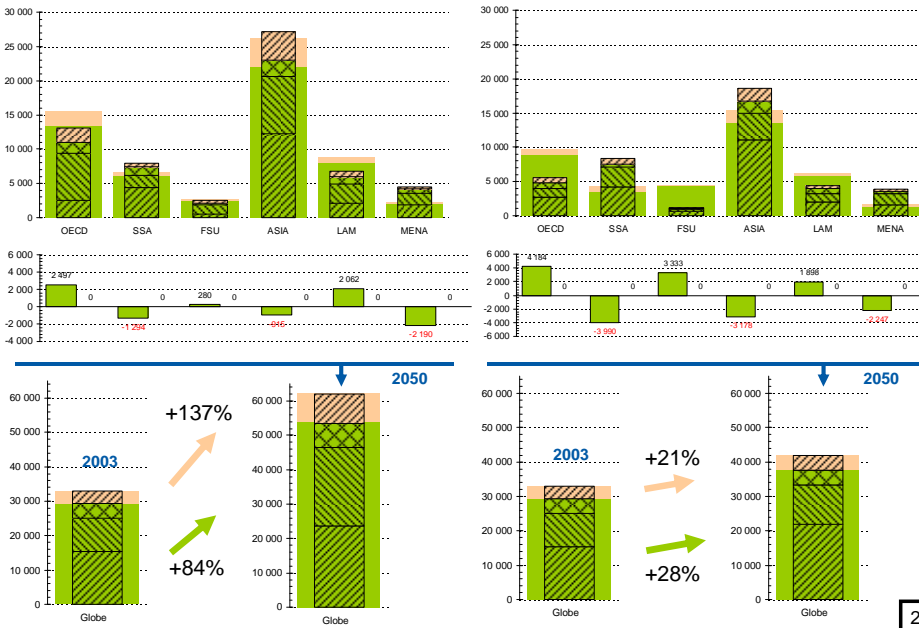
25

■ Scenario 2050 - AGO

AGO.h01

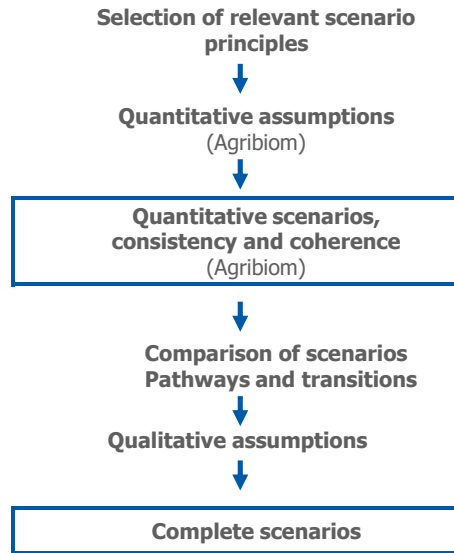
■ Scenario 2050 - AG1

AG1.h01



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## Possible narratives for each scenario



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	<b>Agrimonde GO</b> <i>Global economic growth to ensure food security</i>	<b>Agrimonde 1</b> <i>Feeding the planet and/by preserving the ecosystems</i>
	Economic growth in LDC based on agricultural development	
<b>Growth, develop &amp; migrations</b>	High level of global growth Acceleration of urbanization	Global growth based on deving countries Stabilization of urbanization
	Massive north south transfers	
<b>Regulations and governance</b>	Trade liberalisation	UNOFS : price distortions, volatility, temporary exceptions, envt protection Multi-fonctionnality
	Massive public and private investment	
<b>AKST-D</b>	Continuing the same technological pathway	Scientific innovation for ecological intensification : ▪ specific / generic ▪ interactive, mutualization
	Massive investments	
<b>Energy</b>	Rapid growth of energy demand Energy efficiency Biofuels	Demand management Energy efficiency, renewable energies Decentralized production Farm autonomy

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## What lessons from the 2 scenarios ?

### 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

*There is no necessary convergence of world diets towards today's OECD mean diet.*
- 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 and environmental externalities

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- 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
    - new technologies (ITC, genetics, monitoring...)
    - mobilizing jointly scientific & local knowledge (social learning processes)
  - and need for organizational breakthroughs (markets, regions, food chain, diversification of food systems...)
  - (b) Need to reframe the usual yield / area dilemma and production / protection divide :
    - urban & peri-urban agriculture...
    - agro-forestry, agro-ecology...
    - complementarities between differentiated areas (...and not setting land aside)
  - (c) "Ecological intensification" might emerge as an interesting option for sustainable biomass production and for food security of poor farming families, provided institutional and technological lock-in situations can be overcome

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■ Growth and development pathways in agriculture and rural areas

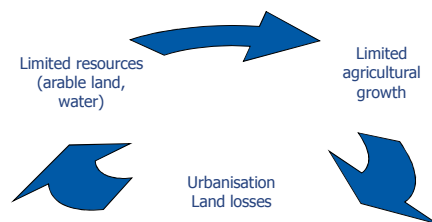
*Sub saharan Africa*

Some yield improvements seem very easy to gain through classical intensification :

- Are they really accessible ?
- What resilience to climate change of such a development pathway ?
- Will it be possible to change for another pathway ?

Ecological intensification as a development pathway : high yield growth and resilience to climate change are needed !

*MENA, Asia*



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**To follow up...**

- Need to debate food and agriculture scenarios at various regional levels (...with various stakeholders)
- 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 better simulate and compare devt pathways
  - induced consumptions of fossil fuel and water
  - GHG emissions/sinks (C, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O...)
  - regional employments / incomes / migrations
  - .../... and biodiversity ?
- Some other themes for further scenarios/research:
  - think outside conventional boundaries (urban/peri-urban agriculture, agroforestry, agroecology...)
  - the importance of livestock systems & their diversity
  - the importance of transformation and retail industry strategies at various scales

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## Contacts

**Sébastien Treyer, Iddri**

[sebastien.treyer@iddri.org](mailto:sebastien.treyer@iddri.org)

**Sandrine Paillard, Unité Prospective, INRA**

[sandrine.paillard@paris.inra.fr](mailto:sandrine.paillard@paris.inra.fr)

**Bruno Dorin, Cirad**

[bruno.dorin@cirad.fr](mailto:bruno.dorin@cirad.fr)

**Synthesis of the report :**

[http://www.gip-ifrai.fr/gip\\_ifrai/activites\\_programmes\\_de\\_l\\_ifrai/prospective\\_agrimonde](http://www.gip-ifrai.fr/gip_ifrai/activites_programmes_de_l_ifrai/prospective_agrimonde)

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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

### 1 The ambition for Agrimonde

Having a quantitative tool for :

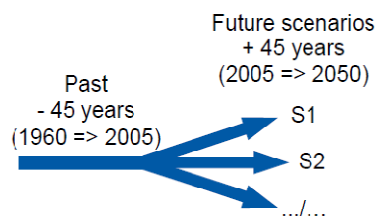
(1) revisiting the past, better understand it (with new estimates, new models...)

(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)

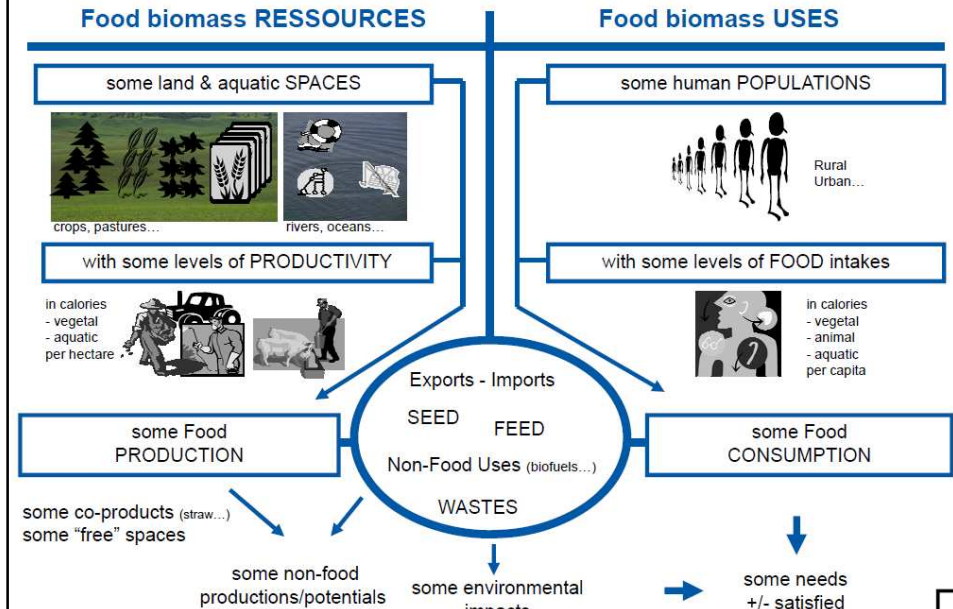
Implications ? (international trade, energy & water consumptions...)



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

## The basic 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»)



## The items

### ■ 5 « compartments » of food biomasses (only...)

### ■ Other productions (non-food...)

Fibres, Tobacco, Rubber... Fodders... Wood



#### 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...*

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

## 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<sup>3</sup>) of DM

- Fibres, rubber...
- Crop residues...
- Fodders...
- Wood (fuel or industrial wood)

