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**
  - a THINK TANK (experts, stakeholders…)
  - a QUANTITATIVE TOOL (Agrimonde…)
  - some SCENARIOS (re-examined or generated)
  - The Agrimonde platform
  - and the expertise of its members
  - debating
Aims & architecture of AgriBiom

Part I

Future scenarios
+ 45 years
(2005 => 2050)

Past
- 45 years
(1960 => 2005)

Future scenarios
+ 45 years
(2005 => 2050)

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

0 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

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

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

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

Future scenarios
+ 45 years
(2005 => 2050)

S1
S2
.../

S1
S2
.../

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

with some levels of PRODUCTIVITY

in calories
- vegetal
- aquatic
per hectare

some Food PRODUCTION

some co-products
some “free” spaces

Exports - Imports
SEED
FEED
Non-Food Uses (biofuels...)
WASTES

some Food CONSUMPTION

some need e/- satisfied

Food biomass USES

some human POPULATIONS

Rural
Urban...

with some levels of FOOD intakes

in calories
- vegetal
- animal
- aquatic
per capita

Non-Food Uses

some co-products
some “free” spaces
The items

- 5 « compartments » of food biomasses (only)
- Other productions (non-food)

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

The unit of account

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

\[
\text{Total Calories} = \text{Carbohydrates} \times 4 + \text{Proteins} \times 4 + \text{Fat} \times 9
\]

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

A convergence on an interactive interface

- Synthesizing, Connecting, Visualizing millions of historical data
- Feeding / Enriching computable general equilibrium models
- New models (e.g. animal/vegetal production functions...)
- Collective debate with live simulations (researchers, decision makers...)
- Imports, transformations (S/U balances in kcal, proteins...)
- and connection of millions historical data (1960-2005)
  relating to national productions, consumptions and trade of biomasses :
  - Populations (human, animal)
  - Consumptions (human, animal)
  - Land use (crops, pastures, forests...)
  - Production factors (labor, tractors, fertilizers...)
  - Productions (human, animal, aquatic...)
  - Trade (Imports / Exports)
  - Environmental externalities
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)
  - …/…

- 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…)

From past trends to scenarios
A 1961-2003 brief overview of the world food economy through Agribiom eyes...

From average world increases...

- The population doubled
  - [Graph showing population growth from 1960 to 2010]

- The per-capita food availability increased too...
  - [Graph showing per-capita food availability from 1960 to 2010]
On the resources side:

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

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

- **Livestock**

...to regional disparities

- **Human populations**
  - Inhabitants (million)

- **Farmers**: highly and increasingly concentrated in Asia and Africa

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

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 alfalfa
- 15.0 kg of potato
- 58.8 kg of tomato

**A labour productivity boom in OECD**

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**Crop yields (kcal/d/ha) / Labor productivity (ha/worker) (1961 – 2003). Source: B. Dorin**
A boom of food trade
to clear surpluses and fill in deficits

Net balance of vegetal food trade
(Exports – Imports)

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
Towards which new «equilibrium» in 2050?

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

Scenarios, hypotheses, collective debates… (2050)

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

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 released the environment from many places; it increased the use of chemical fertilizers and pesticides; 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 now face in the coming decades even greater than those the world had to confront in the early twentieth century.

The Millennium Ecosystem Assessment scenarios

Global Orchestration

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. The population in 2050 is in the midrange of the scenario.

Techno-Garden

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 invest in public goods such as infrastructure and education. Economic growth in this scenario is the highest of the four scenarios, which is assumed to have the lowest population in 2050.

Order from Strength

A regionalized and fragmented world, concerned with security and protection, emphasizing regional, 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 in an effort to avoid problems. 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

Globalization

Techno-Garden

Adapting Mosaic

Order from Strength

Regionalization

Main quantitative assumptions

- **Population**: 6.2 Gcap in 2003 and 8.8 Gcap in 2050.
- **Human food**: 3,000 kcal/day/cap in 2003 and 3,590 kcal/day/cap in 2050.
- **Other uses**: -14,440 Gkcal/day in 2003 and +5,000 Gkcal/day in 2050.
- **Food yields**: 19,190 kcal/day/ha in 2003 and 20,030 kcal/day/ha in 2050.
- **Crop land**: ~1,530 Mha in 2003 and ~2,105 Mha in 2050.
- **Pastures**: ~3,330 Mha in 2003 and ~2,845 Mha in 2050.
- **Forest**: ~3,905 Mha in 2003 and no change in 2050.

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

- **Population**: 6.2 Gcap in 2003 and 8.8 Gcap in 2050.
- **Human food**: 3,000 kcal/day/cap in 2003 and 3,590 kcal/day/cap in 2050.
- **Other uses**: -14,440 Gkcal/day in 2003 and +5,000 Gkcal/day in 2050.
- **Food yields**: 19,190 kcal/day/ha in 2003 and 20,030 kcal/day/ha in 2050.
- **Crop land**: ~1,530 Mha in 2003 and ~2,105 Mha in 2050.
- **Pastures**: ~3,330 Mha in 2003 and ~2,845 Mha in 2050.
- **Forest**: ~3,905 Mha in 2003 and no change in 2050.
Two new hypothetical equilibriums for 2050...

**Base 2003**

- Forests: 25% of 981 million hectares (M ha)
- Pastures: 22% of 736 million hectares
- Crop lands: 27% of 416 million hectares
- Arable lands: 23% of 900 million hectares
- Farmers: 0.2% of 22 million
- Population: 1.6% of 987 million
- Calorie availability: 3953 kcal/cap/day available

**SSA**

- Forests: 16% of 634 million hectares
- Pastures: 24% of 827 million hectares
- Crop lands: 13% of 204 million hectares
- Arable lands: 26% of 1054 million hectares
- Farmers: 1.5% of 195 million
- Population: 1.1% of 714 million
- Calorie availability: 2366 kcal/cap/day available

**ASIA**

- Forests: 13% of 533 million hectares
- Pastures: 17% of 565 million hectares
- Crop lands: 30% of 462 million hectares
- Arable lands: 14% of 538 million hectares
- Farmers: 76% of 1014 million
- Population: 53% of 3330 million
- Calorie availability: 2793 kcal/cap/day available

**LAM**

- Forests: 23% of 922 million hectares
- Pastures: 16% of 553 million hectares
- Crop lands: 11% of 164 million hectares
- Arable lands: 25% of 984 million hectares
- Farmers: 0.3% of 43 million
- Population: 0.9% of 538 million
- Calorie availability: 3143 kcal/cap/day available

**MENA**

- Forests: 0.1% of 35 million hectares
- Pastures: 1.0% of 337 million hectares
- Crop lands: 0.6% of 90 million hectares
- Arable lands: 0.2% of 92 million hectares
- Farmers: 0.3% of 44 million
- Population: 0.6% of 400 million
- Calorie availability: 3356 kcal/cap/day available

**FSU**

- Forests: 21% of 843 million hectares
- Pastures: 11% of 360 million hectares
- Crop lands: 13% of 202 million hectares
- Arable lands: 10% of 409 million hectares
- Farmers: 0.1% of 20 million
- Population: 0.4% of 279 million
- Calorie availability: 3276 kcal/cap/day available

**Scenario 2050 - AGO**

- Production
- Uses (incl. waste)
- Net export
- Net import

**Scenario 2050 - AG1**

- Production
- Uses (incl. waste)
- Net export
- Net import

**Scenario 2050 - AG0**

- Production
- Uses (incl. waste)
- Net export
- Net import
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
If Recommendations ...
(1) Food policies able to:

- promote diets based on a consumption of various foodstuffs (cereals, oilseeds, pulses, roots and tubers, fruits and vegetables… eggs, milk, meats… fishes) both in a sufficient and reasonable way, as well as adapted to local food cultural preferences, so that important and growing human health problems can be tackled, from under-nutrition to obesity or cardiovascular diseases
- limiting as far as possible the present huge post-harvest and/or post-purchasing wastages of food

If recommendations ...
(2) Agricultural policies able to:

- encourage in the long run Low-Input High-Diversity systems of agricultural productions, in order to enhance (i) less polluting and less dangerous agricultural techniques (for workers, flora, fauna, soils, water…) (ii) the resilience of agriculture to economic, energetic or climatic crises, (iii) the annual biomass production per hectare through judicious local combinations of various vegetal and animal species (iv) employment and food security in rural areas
- boost in the short run the access of small farmers in developing countries (especially in Africa) to national and international markets (roads, internet…) as well as to cheap credit and to traditional agricultural inputs (irrigation, fertilizers, seeds…)
- if “productivity” (yields) relates to technology (i.e. research inputs among others) and farmers’ know-how, “production” relates to policy decisions regarding land tenure, producers’ organizations, farmers’ capacity building, access to credit, property rights, etc.
If recommendations ...
(3) Trade and competition policies able to:

- encourage the formation in the world of several large regional free-trade and sovereign areas for food
- safeguard day-to-day imports and export of basic foodstuffs between these areas especially in case of crises
- fight efficiently against market powers which erode farmers incomes because of high prices upstream (inputs bought from an oligopsony of multinationals) and low prices downstream (outputs sold to an oligopoly of traders, processors or distributors).

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$_2$O…)
  - regional employments / incomes / migrations
  - …/…
thanks you for your attention!