The complexity of innovation system and transition processes

Challenges and potential ways to address them

Philippe Baret
Université de Louvain

Innovations for transition

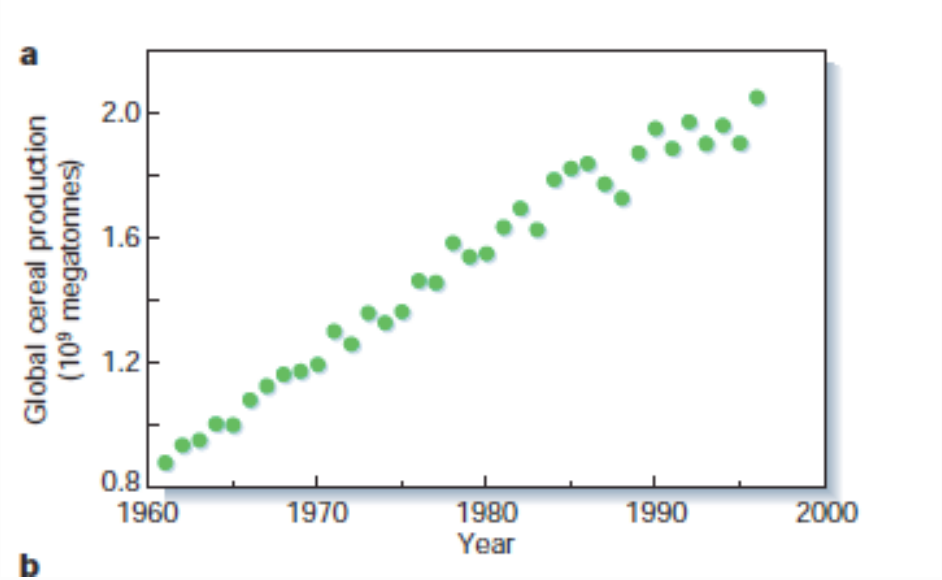
- **Agricultural systems face new challenges**
- **Innovation is a key element for transition**
- **All innovations are not equivalent**
- **Relevance of innovation is a priority for transition**

Theory of transition

Geneva airport
Advertisement for a bank

1. Agriculture faces new challenges

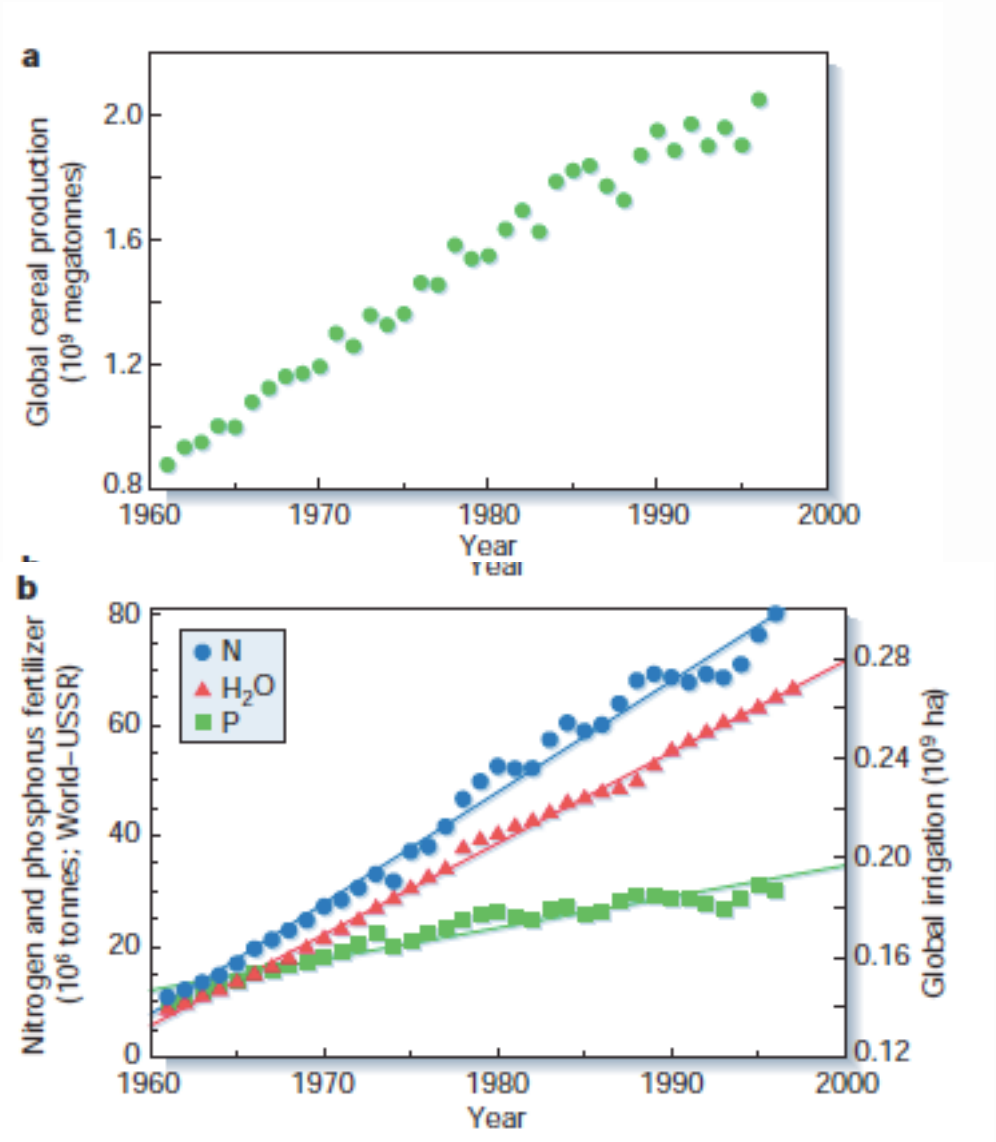
Agriculture faces new challenges



- **The main outcome of XXst century agriculture was increase of global food production**

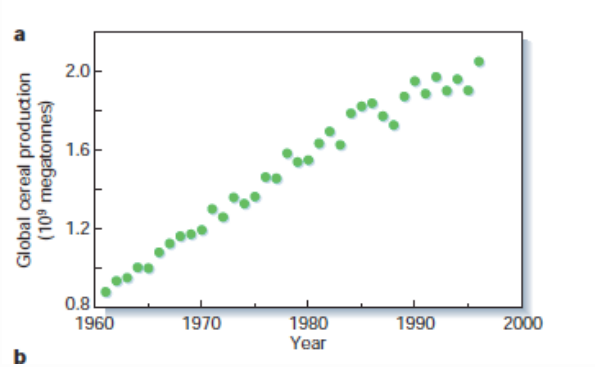
Tilman et al., 2002

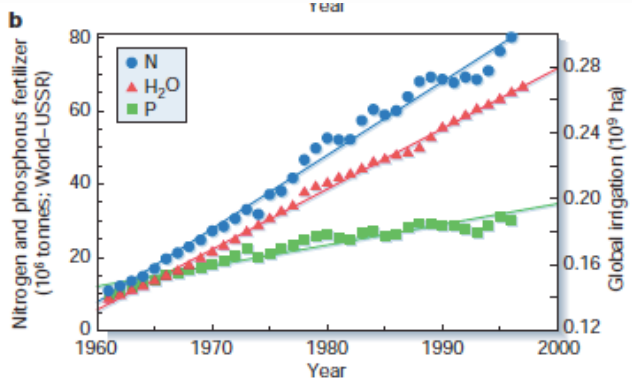
Agriculture faces new challenges

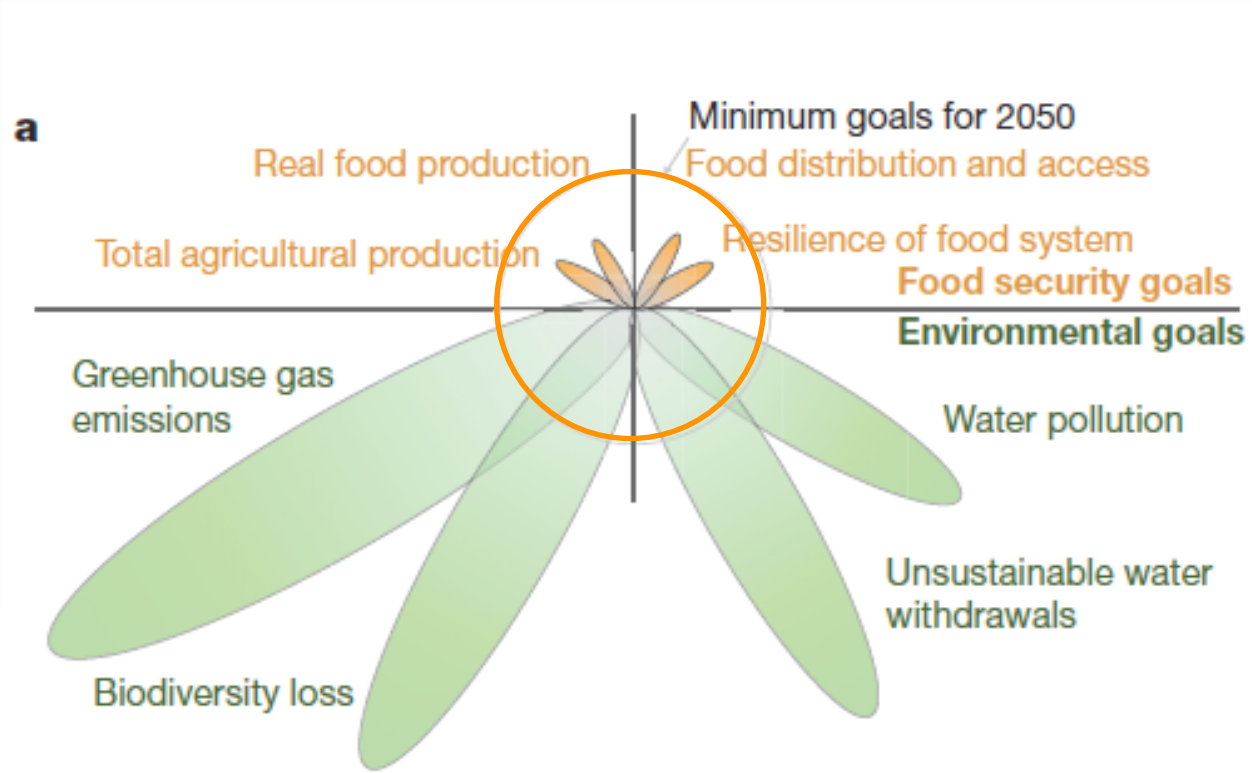


- **The main outcome of XXst century agriculture was an increase of global food production**
- **Agriculture of the XXIst century has to meet new challenges**
  - **food production**
  - **ecosystemic services**
  - **climate change mitigation**

Agriculture faces new challenges

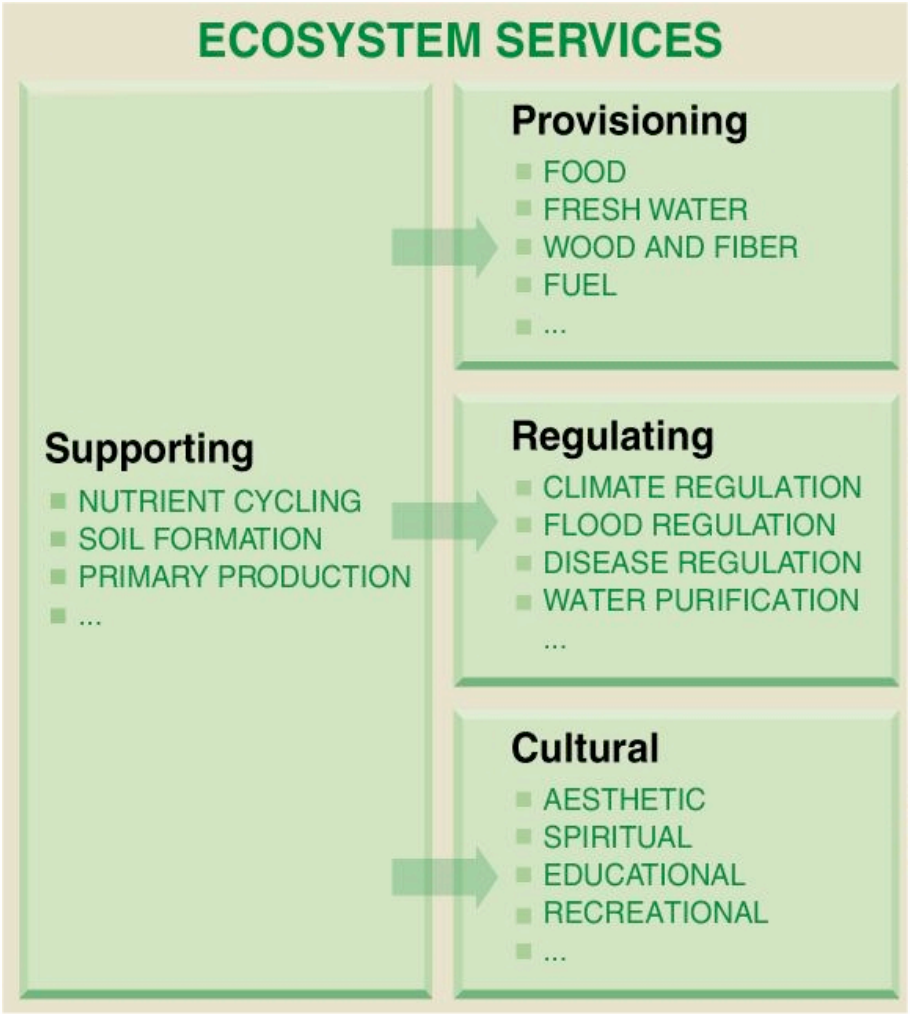






Foley et al., 2011

The positive side of the coin : the emergence of ecosystemic services



- **Ecosystemic services acknowledge the multifunctionality of agriculture**
- **Their valuation may be tricky**
- **How to think the link between ecosystemic services and innovation ?**

The New Green Revolution:
How Twenty-First-Century Science Can Feed the World

by Olivier De Schutter and Gaëtan Vanloqueren

A farmer gathers wheat in Bamiyan, Afghanistan.

De Schutter and Vanloqueren, 2012

"Our strategy today must recognize the connection between climate change and food security. It must leverage the potential of the new sustainable agriculture paradigm (...)

It must not only preserve land and other agricultural resources for future generations; it must actively restore lands and resources that have been degraded."

2. The way to transition

Are the agricultural systems changing ?

- Not sure
  - a lot of words but what about indicators ?
- The change is probably not fast enough
- Are the today innovations preparing the right pathway for the future ?

Why is the transition so slow ?

- **Two hypotheses**
  - Alternatives to the mainstream system do not exist
  - Alternatives exist but are not implemented
- **A third option : solutions will emerge when required**

Alternatives are available

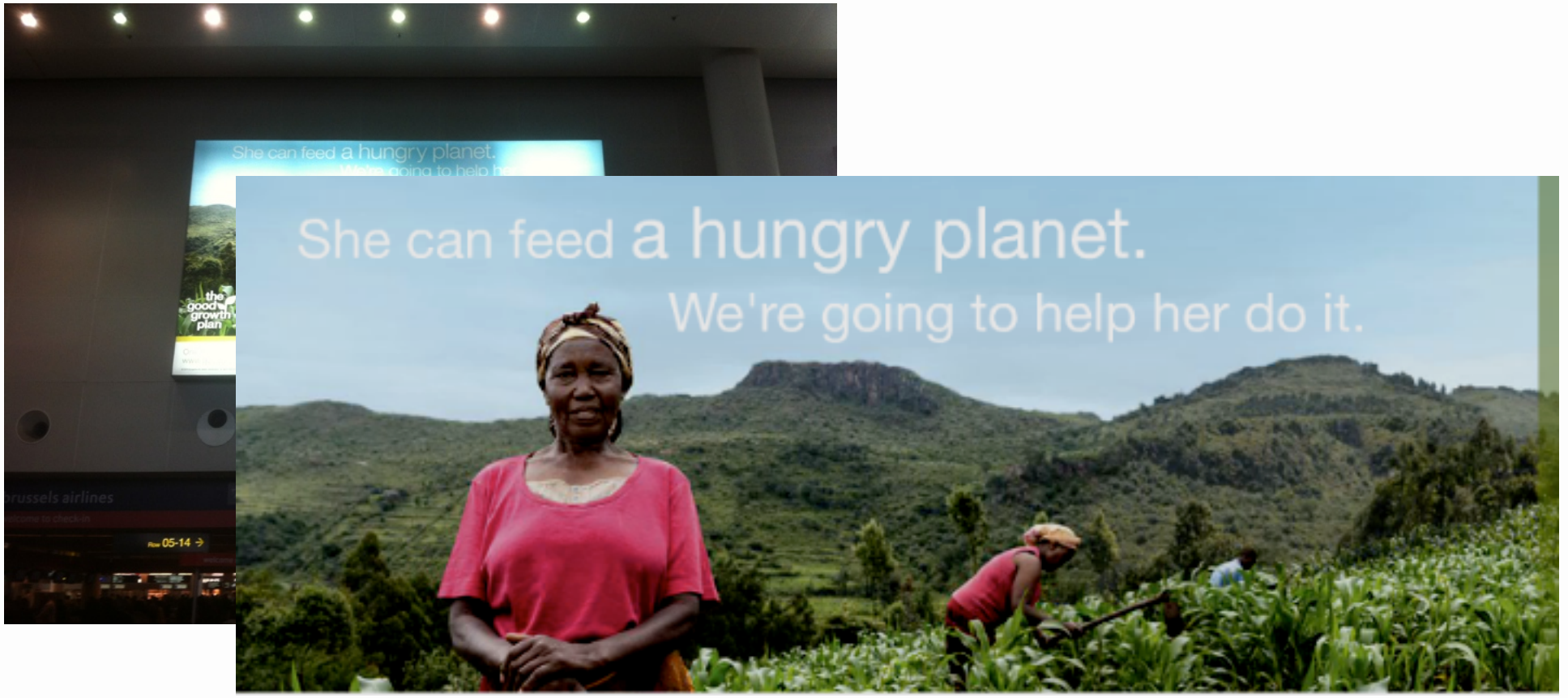
- **What are the alternatives ?**
  - ecological intensification
  - agroecology
- **A question of capacity building**
  - research requires long term investment
  - Matthew effect
- **The objective is not full substitution but a reasonable and balanced exploration of all relevant pathways**

3. Case study

A solution to preserve biodiversity

A solution to preserve biodiversity ?

- **A more productive agriculture to preserve land for conservation**



A solution to preserve biodiversity ?

- **A more productive agriculture to preserve land for conservation**

We're helping smallholder farmers
to raise yields while conserving water,
soil and ecosystems.

The Economist : More growth, not less ..

Biodiversity

Hang on

More growth, not less, is the best hope for averting a sixth great extinction

HAINAN gibbons sing to each other every morning; but these days they do not have much to sing about. The species (pictured) is endemic to a Chinese island that is not just a fruitful producer of rice and rubber but also a golfer's paradise. Most of its forests have been destroyed to accommodate these activities, and the gibbon population is down to a couple of dozen. If the species disappears, it will be the first ape to go extinct since the beginning of the Holocene era 12,000 years ago.

The Hainan gibbon is only one of 4,224 species listed as critically endangered by the International Union for the Conservation of Nature. Attention tends to focus on mammals and birds, but amphibia, such as frogs, are even more at risk.

Over the past few centuries mankind's economic growth has caused many of the problems that other species face. But as our special report this week argues, greater human prosperity now offers other species their best chance of hanging on.

What did for the dinosaurs

There have been five great extinctions in the history of Earth. One killed off the dinosaurs; another wiped out up to 96% of

yields rise, allowing more food to be produced on less land. Population growth rates fall: in East Asia, fertility has dropped from 5.3 children per woman in the 1960s to 1.6 now.

One consequence is that in rich countries conditions for other species are, by and large, improving, and endangered creatures are moving away from the edge of the cliff. America's bald eagle, for instance, was down to 412 breeding pairs in the 1960s. There are now 7,066. Whale populations are mostly recovering thanks to a moratorium on commercial whaling. More broadly, the Living Planet Index, a compilation of a wide range of indicators of biodiversity produced by the Zoological Society of London and WWF, has risen over the past 40 years in temperate (generally rich) countries and fallen in tropical (generally poor) ones. This is not just because rich countries export their growth to emerging markets. Look, for instance, at the fate of the forests on the Korean peninsula: in South Korea, one of the world's fastest-growing countries in recent decades, forest cover is stable, whereas North Korea has lost a third of its forests in the past 20 years. Nobody exported their growth to North Korea.

In emerging markets some indicators are improving as people press governments to look after the environment better. Deforestation in the Brazilian Amazon, for instance, has fallen from 28,000 sq km in 2004 to 5,000 sq km last year. From a

A solution to preserve biodiversity ?

- **A more productive agriculture to preserve land for conservation**
- **Is it relevant ?**
  - **Is the yield/productivity the issue ?**
  - **Which impact on disease and weeds ?**
  - **Which impact on climate change ?**
  - **Which long term equilibrium ?**
  - **No other options ?**

x Agricultures
x Ecological conditions

Complexity of innovation

Issues	Levels
Is the yield/productivity the issue ?	Endpoints
Who will benefit from the strategy ?	Actors
Which impact on disease and weeds ?	Scale
Which impact on climate change ?	Systemic
Which long term equilibrium ?	Prospective
No other options ?	Atlernatives

Complexity of innovation

Levels	
Endpoints	Data, Methods (multicriteria, …), Indicators, Interpretation
Actors	Diversity of actors, Lobbies, Agency of actors, Diversity within actor's categories
Scale	Plant, plot, farm, landscape, Emerging properties, Diversity of agricultures
Systemic	Interactions, Trade offs
Prospective	Long term outlook
Alternatives	Land sharing as an other option


Photo : Ph Baret

4. The imbalance between alternatives

Alternatives	Land sharing as an other option

Relevancy implies a problem driven systemic approach

Research Policy 38 (2009) 971–983

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations

Gaëtan Vanloqueren*, Philippe V. Baret

Earth and Life Institute, Université catholique de Louvain, Belgium

ARTICLE INFO

Article history:
Received 22 December 2006
Received in revised form 8 October 2008
Accepted 25 February 2009
Available online 5 April 2009

Keywords:
Technological trajectories
Evolutionary economics
Transgenic plants

ABSTRACT

Agricultural science and technology (S&T) is under great scrutiny. Reorientation towards more holistic approaches, including agroecology, has recently been backed by a global international assessment of agriculture S&T for development (IAASTD). Understanding the past and current trends of agricultural S&T is crucial if such recommendations are to be implemented. This paper shows how the concepts of technological paradigms and trajectories can help analyse the agricultural S&T landscape and dynamics. Genetic engineering and agroecology can be usefully analysed as two different technological paradigms, even though they have not been equally successful in influencing agricultural research. We used a Systems of Innovation (SI) approach to identify the determinants of innovation (the factors that influence research choices) within agricultural research systems. The influence of each determinant is systematically described (e.g. funding priorities, scientists' cognitive and cultural routines etc.). As a result of their interactions, these determinants construct a technological regime and a lock-in situation that hinders the development of agroecological engineering. Issues linked to breaking out of this lock-in situation are finally discussed.

Vanloqueren and Baret, 2009

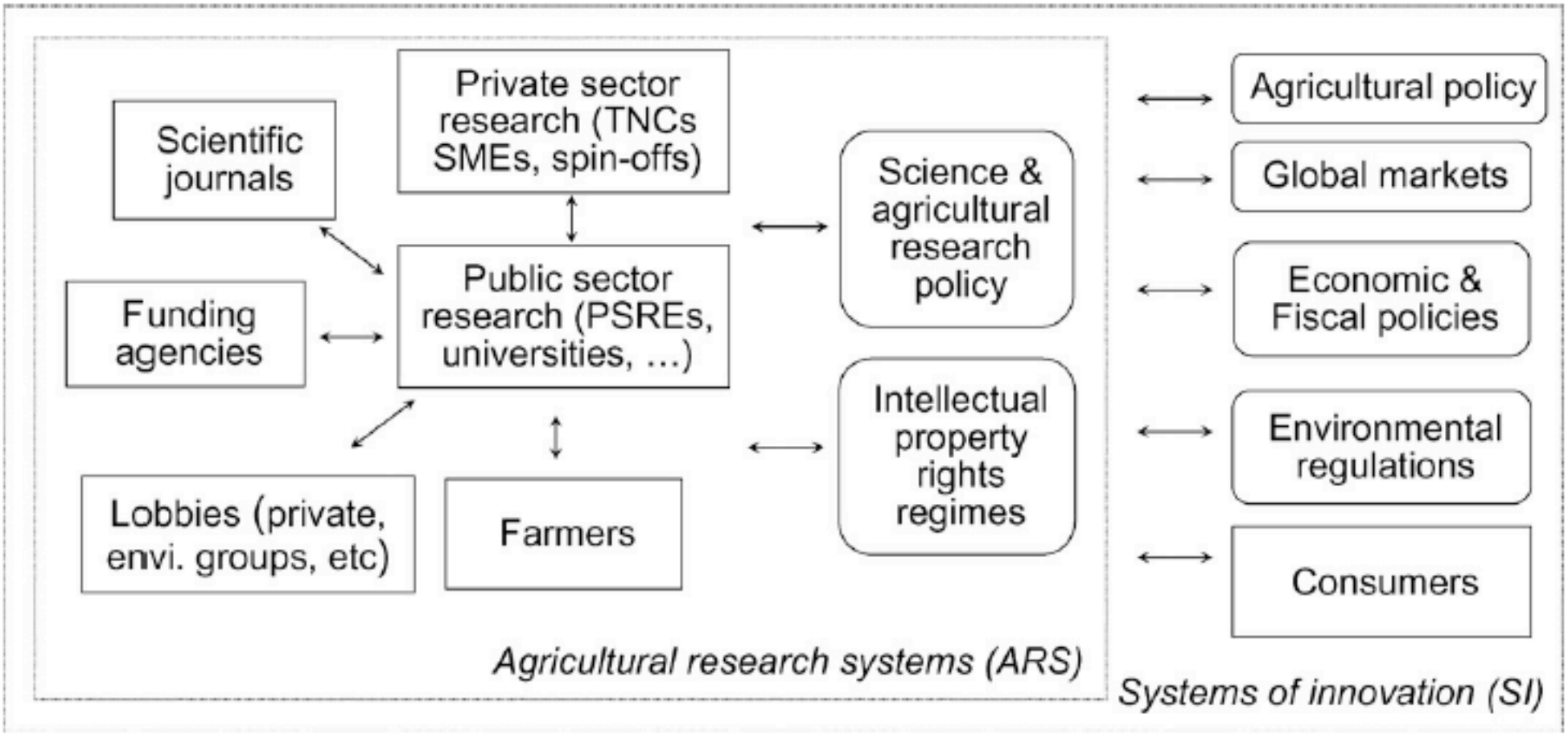
Comparison of alternatives at the macro level

- **The aim**
  - **To understand why the current agricultural S&T landscape has not sufficiently supported holistic and agroecological approaches, while other agricultural innovations, such as transgenic crops, were able to flourish.**
- **The method**
  - **Compare two paradigms of innovation**
    - **Genetic engineering vs. Agroecology**

Agroecology vs ecological intensification

- **The question**
  - **Is this differential only due to the intrinsic superiority of genetic engineering compared with agroecology, or can it be methodologically explained by other factors? If so, which ones?**

System of innovation



The causes of imbalance (1)

- **Agricultural science policies**
  - Research orientations
    - Focus on growth, competitiveness and biotechnologies
  - Relationships between public & private sectors
  - Imbalance in the power of lobbies
  - Media
- **Private sector**
  - Research orientations
    - Focus on biotechnologies
    - Importance of patents

The causes of imbalance (2)

- **Public sector**
  - Cultural and cognitive routines
    - Values and world views of scientist, Conception of progress
- **View of complexity**
  - Methodological reductionism
  - Genome, plant or plot as entry points
- **Organization within research systems**
  - Rules of the game
  - Career constraints

Conclusion

- **Genetic engineering is not a “wrong” pathway of innovation.**
- **But “de facto” it impedes the development of alternative solutions based on agroecological engineering.**
- **The process of innovation is not “problem driven” but it mainly driven by competition between paradigms.**

5. The lock-in issue


Photo : Arthus Bertrand

Why is the transition so slow ?

- **Two hypotheses**
  - **Alternatives to the mainstream system do not exist**
  - **Alternatives exist but are not implemented**
- **A third option : solutions will emerge when required**

The lock-in issue and the keyboard paradox

- **The QWERTY keyboard : an innovation in a context**

  Is it still relevant ?

  If not, why is it surviving ?

David, 1985

Exemple of path dependency and lock-ins

- **In technology**
  - **QWERTY keyboard**
  - **Video recording : Betamax vs. VHS**
- **In agriculture**
  - **Substitution of chemicals by IPM - Cowan et Gunby, 1996**
  - **Fungicide in wheat – Vanloqueren and Baret 2008**
  - **Genetic engineering - Vanloqueren et Baret, 2009**
  - **Conversion to organic farming – Lamine 2011**
  - **Diversification of cultures – Meynard et al. 2013**
  - **Belgian Blue Cattle - Stassart and Jamar, 2008**

IPM implementation in the United States

- Integrated Pest Management
- Factors militating against a general switch to IPM.
  - IPM is an immature technology.
    - it will involve a period of low payoffs,
    - uncertainties
      - farmers are uncertain about whether they can make the technology work
      - farmers are uncertain about how good it really is.
      - difficulty in educating bank managers and insurance agents about the feasibility and reliability of IPM.47
  - Problem of coordination.
    - It would be difficult for any individual in a region to be the only person adopting it. Thus no one is willing to start the ball rolling.
  - Small policy adjustments will not suffice to shift farmers from one

IPM implementation in the United States (2)

- **Consequences**
  - **Small policy adjustments will not suffice to shift farmers from one technology to another.**
  - **The problems of knowledge can only be dealt with by generating more of it.**

IPM implementation in the United States (2)

Conclusion

- More generally, the analysis of pest control technologies suggests that it is difficult to envisage a relatively fast, natural, incremental process that would entail a general shift to IPM.
- Only a crisis in the chemical technology seems to provoke such a shift, and even then, not every time !
- The existence of path dependence in the economy raises the possibility that economic processes may be subject to considerable inertia.

Organic conversion in France

Conditions of success

- **The progressiveness of transitions and the presence of antecedents in farmers' trajectories.**
- **Collective dynamics among farmers at local level where they can meet and share their difficulties, solutions and doubts, especially in the case of IPM where, unlike organic farming, institutionalized or militant professional networks are scarce.**
- **The inclusion of food distribution and consumption practices and, more generally, the interactions with the non-agricultural sphere.**

The legitimation of organic farming in civil society in environmental and health terms is one of the reasons for the recent increase in organic consumption, while the lack of legitimation in the institutional and professional world is probably a reason for the slow development of organic production in France. It is even worse for IPM which is neither legitimated nor codified by laws and regulations.

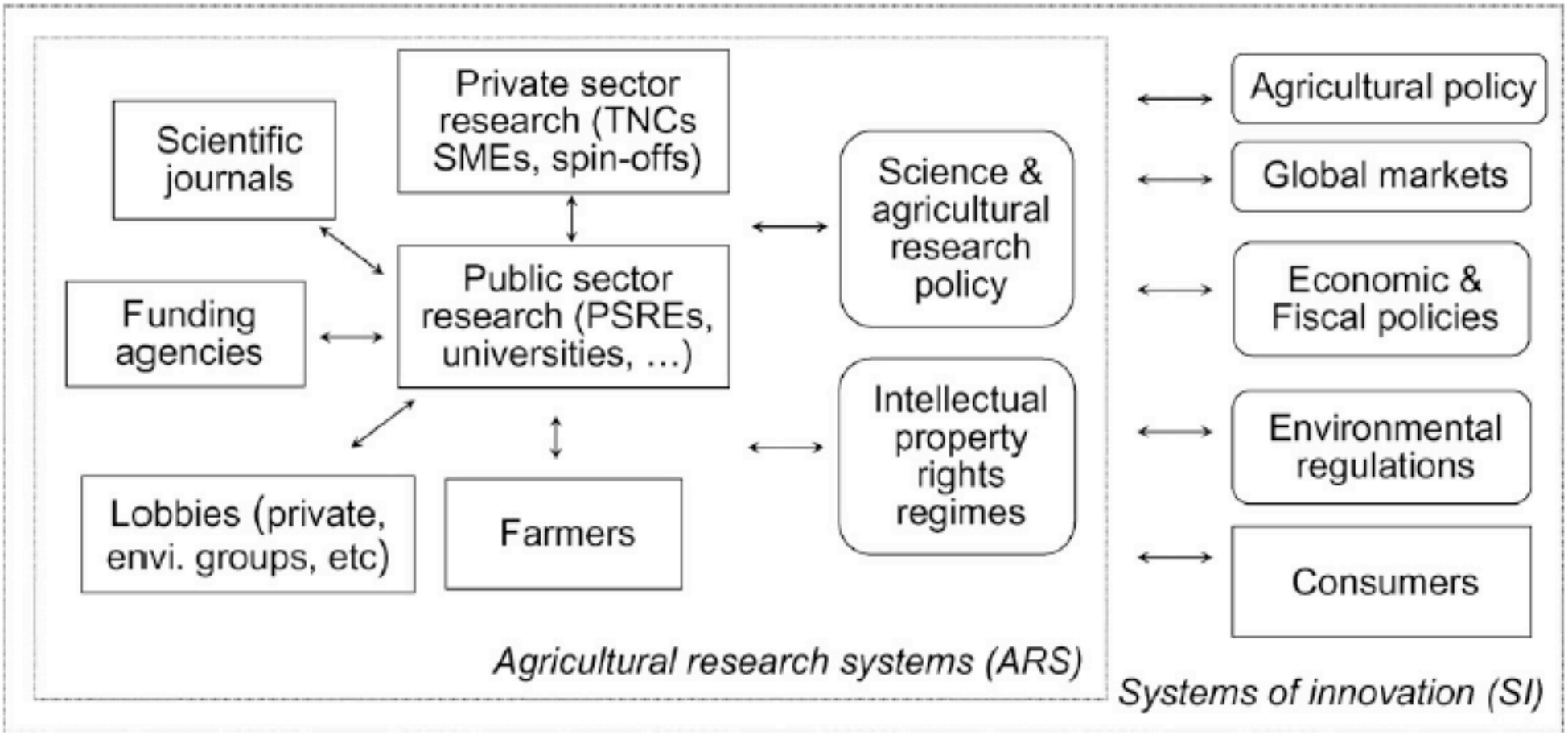
An integrative vision of agriculture

- **One of the obstacles in our thinking about both the problems and solutions concerning unsustainable food lies with the failure to really appreciate agriculture as an interdependent and integrated component in complex human, cultural and ecological systems.**
- **For too long, and in the advanced world especially, we have, both in policy and academic terms, tended to treat agriculture as a separate and independent sector**

Food systems

Marsden, 2012

System of innovation



Relevance of innovation is a key issue

- Due to imbalance between paradigms
- Due to lock-ins
- Considering the changes of context for agriculture
- Considering the shortage of funding

- It is important to favour the best innovations in terms of relevance and scientific quality

6. How to assess the relevance of innovation ?

Propositions

- **Adoption of a broader perspective on innovation**
  - consider the whole system of innovation
  - combine technological and social innovation
  - comprehensive assessment of the real present situation
- **Appreciation of relevance per se**
  - The development of methodological tools for relevance assesment
  - A two tier evaluation to single out relevance
  - Projects have to be both relevant and scientifically sound
- **Learn from other sectors**
  - transition in the energy sector

Propositions (2)

- **Acknowledgment of path dependency, lock-in, Matthew effect**
  - They are the diseases of the innovation systems
- **Be radical and take risk**
  - Research is a place for creativity, not for reproductibility
  - Business as usual is an impossible pathway
  - Agroecology is an utopy
  - Is a mid-way option the right one ? It has to be proven
- **Be together**
  - We need exploring new avenues in collaboration with the end-users

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Acknowledgments





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