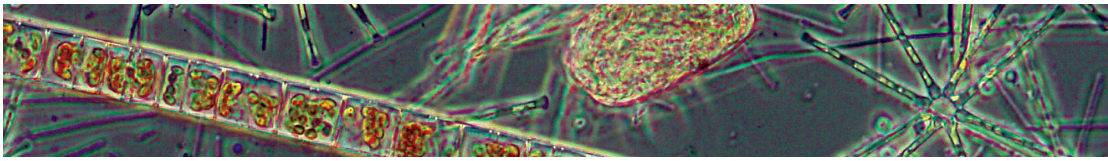

Self-assessment report 2009

FOOD & NUTRITION
AGRICULTURE
ENVIRONMENT

INRA

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General introduction

In 2009, INRA will be assessed by the AERES, and inspected by the French Court of Auditors *(Cour des Comptes)*. For INRA, such appraisals provide an opportunity to look from different angles at the major strategic issues addressed by the Institute:

- the first viewpoint, that of INRA itself, is described in **this document** and refers to the strategy identified by the Institute as being necessary to accomplish its statutory missions, from its definition to its operational implementation and results;
- the second viewpoint, explained in the **letter from the President**, places the assessment in a prospective context, rooted in the concept of mission-oriented research.

The present report thus presents a self-assessment of INRA. For this reason, the document first of all examines **the missions of INRA, its strategy** with respect to these missions and in its operational context. A second section considers the **mobilisation of resources and partnerships**, and operational implementation of the action plan. A third chapter contains different sections devoted to **examining the results** that benefit different groups of actors concerned by INRA's mission-oriented research. The final section of the document describes **assessment** procedures and how they are applied.

The core of the report concerns **ongoing achievements or changes**, relevant to the duration of the recent Contract of Agreed Objectives. However, the strategy of an organisation such as INRA develops and is deployed over the medium term. Thus, depending on the subjects concerned, it involves retrospective elements, current policy changes or perspectives, when these can inform the strategy. The section relative to the impact of innovations, particularly on socioeconomic actors, sometimes refers to relatively long-standing research projects, the results of which have now become relevant.

A unique system in the environmental and life sciences

As a public scientific and technological establishment, INRA is under the dual supervision of the French Ministries for Research and Agriculture.

INRA was set up in 1946 in response to pressing demands from society to "feed France". Today, its research focuses on **three areas that cannot now be dissociated: food and nutrition, agriculture and the environment.** Indeed, INRA's challenge is to contribute to solving global problems: world agriculture that is both competitive, respectful of the environment and of territories and natural resources, which is the best adapted to human nutritional needs and to new uses of agricultural products.

In terms of size, INRA is the **leading agricultural research institution in Europe**. In terms of its published results, it ranks second in the world in the fields of agricultural, plant and animal sciences.
As a mission-oriented research institution, INRA considers that it has a **dual task: to advance knowledge and to respond to questions raised by society**. If it is to react to the major issues concerning policy, society and the economy, INRA needs to develop its activities in the context of structural **partnerships** with all the actors affected by its results (academic and industrial partners, government authorities and citizens). Scientific partnerships enable the development of new approaches, the pooling of resources and a more informed grasp of the world dimensions of the issues addressed. Government authorities, farmers and industry, and associations of citizens or consumers also play a crucial role in the orientation, monitoring and exploitation of INRA research.
INRA is characterised by its **strong regional roots**. With 74% of its staff working in the provinces, the Institute is present in almost all French regions, including overseas. **Twenty regional centres** working on 21 high-priority themes reflect the commitment of INRA to regional dynamics as well as to the European Research Area and international activities.

Research is carried out by **14 scientific divisions** comprising a total of 381 units: 218 research units, 50 experimental units, 76 research support units and 10 service units.
One of the originalities of INRA is that it employs a high proportion of technical staff providing support for research activities. Thus in 2007, 1828 researchers were working in the fields of life sciences, materials sciences, human and social sciences, alongside 2427 engineers and assistant engineers and 4249 technicians and technical assistants. In addition, 1600 doctoral students, 1000 foreign researchers and 1900 trainees are hosted each year by INRA laboratories.
The annual **budget** reaches €746 million, 72% of which is dedicated to staffing costs (primary budget, 2008). Approximately 2500 **publications** each year are referenced internationally (ISI), more than 30% of them written with partners in other countries. INRA participated in 166 **projects** under the 6th Framework Programme (FP6). A **portfolio** of 350 licences and 450 varieties, and the filing of some twenty new patents and as many software programs or databases each year complete the production of the Institute.

Missions and the development of strategy

1. INRA's strategy

1.1 INRA's missions and how they are changing

French Decree No. 84-1120 dated December 14 1984, laid down the **generic missions** of INRA:

- the status of a mission-oriented research institution, combining the excellence of its disciplines and the need to take account of the purpose (relevance) of its research,
- the mission to generate scientific knowledge and innovations, and then to disseminate them,
- the mission to contribute to training in, and through, research, to the spread of scientific culture and to the science/society debate,
- the duty to contribute, through its expertise, to informing decision-making by public authorities and actors in society.

The missions thus defined for INRA also included a definition of the scope of its investigations. Restricted originally to "agriculture and its related industries", they have gradually broadened in line with changes to different issues affecting society, and since 2001 they have explicitly concerned "agriculture, food and nutrition and the environment". INRA's status as a mission-oriented research institution focused on these three areas, often referred to as "the tripod", was once again confirmed by its supervisory ministries in 2005.

The portfolio of disciplinary skills thus constituted focuses not only on the life sciences, but also on food sciences, economic and social sciences, applied mathematics and environmental sciences. The scope of these competences draws strength from the pertinence of these three clusters, but particularly from the interactions that exist between them. If account is to be taken of this complexity, it is necessary to adopt an integrated approach to research questions, which is why INRA actively encourages the study of inter-disciplinary and transdisciplinary issues [1].

1.2 Management bodies

INRA's **Board of Directors** decides upon the strategy that determines the Institute's activities, while at the same time monitoring their implementation. It constitutes the single decision-making body where the needs of economic and social actors, supervisory ministries, scientists and staff are all taken into account.

These decisions can be informed by the **Scientific Advisory Board** which appraises the quality of assessment procedures within INRA and produces thematic analyses on its own initiative or at the request of central management.

The **Common Advisory Committee for Ethics in Agricultural Research** is able to throw light on the complex ethical questions that underlie recent evolutions in agriculture, ecology, society and biology.

Comprising the President, two Deputy Directors General and five Scientific Directors, the **Management Board** debates any subject of a scientific, organisational or administrative nature. It discusses and proposes strategies for INRA, as well as taking collective decisions that will ensure the day-to-day operation of the Institute. Quarterly meetings, discussions and regular exchanges between the Management Board, division heads and the presidents of research centres guarantee the coherence and shared objectives of INRA's policies.

The **Joint Technical Committee (CTP)** provides a forum for debate between staff and managers concerning the strategic orientations and day-to-day operation of the Institute. It comprises ten representatives from management and ten from staff, the latter being appointed by the unions present within INRA and representing all staff members.

[1] Transdisciplinary issues mean that researchers interact not only amongst themselves but also with socioeconomic and political stakeholders.

1.3 Four-year orientation plans for INRA and relations with the government

The development of INRA's strategy, in collaboration with government authorities and its other partners, is ensured in three stages. Medium-term strategic orientations are mainly defined as a result of in-house discussions at INRA and contributions from stakeholders; they are formalised in an **orientation document** which is debated and then adopted by the Board of Directors. Regarding its implementation, the Institute discusses with the three ministries for Research, Agriculture and the Budget the principal objectives that it must attain during the next four years, which are then laid down in the **Contract of Agreed Objectives** between the Institute and the Government. This document is also adopted by the Board of Directors. Annual **budget discussions** make it possible to align policies on resources with these policies on objectives, through adoption by the Board of Directors of the primary budget for the Institute. In addition, execution of the Contract of Agreed Objectives is the subject of an annual progress report presented by central management to the Board of Directors, which thus supervises its implementation.

a. The Strategic Orientation Document for 2006-2009:

As in its previous version (2002-2005), the current Strategic Orientation Document identifies six areas of scientific research. It defines the changes required in each of these areas (in terms of resources and scientific production). These are then broken down into 49 thematic fields by the divisions. This two-tier structure of activities serves both to manage the allocation of human and financial resources to the divisions, and to analyse the results obtained by the Institute, because they are all referenced in the document.

Six scientific areas

The six scientific areas defined by the Strategic Orientation Document, and also included in the Contract of Agreed Objectives for 2006-2009, signed with the supervisory ministries, are:

A: Sustainably manage and improve the environment, control the impacts of global change and productive activities

B: Improve human food and nutrition, preserve consumer health and understand consumer behaviour

C: Diversify products and their uses, increase their competitiveness

D: Develop research and generate generic data to obtain further knowledge of living organisms

E: Adapt species, practices and agricultural production systems

F: Understand and improve the organisation of actors and their strategies, analyse the challenge of public policies, contribute to their design and assessment, and anticipate change.

b. The Contract of Agreed Objectives for 2006-2009

The Contract of Agreed Objectives describes the contractual arrangements with supervisory ministries concerning the Institute's strategic orientations. It is binding on both parties and provides a stable and explicit framework for the objectives to be targeted by the Institute over a four-year period. Ten principal objectives, broken down into some fifty projects and accompanied by indicators for their completion, have thus been determined. These objectives concern in particular:

- greater openness towards Europe and the world, either through the hosting of researchers or through the management of European projects;
- maintenance of a capacity for scientific orientation and management at the service of the French community while providing support for a reorganisation of the national research and higher education landscape and the increasing importance of the ANR [2];
- the diversification of partnerships with industry and society as a whole in order to include the new dimensions of INRA's mission. Thus renewed emphasis should be laid on developing dialogue between science and society;

the adaptation of human resources policies, assessment procedures, and the management and administration of research, to these new priorities.

Execution of the Contract of Agreed Objectives is the subject of an annual progress report to the Board of Directors.

[2] ANR: National Research Agency.

c. Partnerships with French public establishments

Because of its scope of intervention, INRA mainly receives requests for support at a national level from the **French Ministries for Agriculture and the Environment, and from public establishments supervised by these ministries**.

Framework contracts are agreed between INRA and these different **ministries**, which provide for regular meetings to exchange views on subjects of common interest and to identify new projects. It is thus that collective expert reports, studies or even research projects are developed and initiated.
As for **public establishments**, INRA collaborates mainly with the AFSSA [3] by means of a framework agreement on health issues, but also with INERIS [4] with respect to pesticides, ONF [5] concerning the sustainable management of forestry, AFFSET [6] on environmental risks and ONEMA [7] concerning water and aquatic environments.

In addition, INRA is often asked by public actors to mobilise its scientists to provide individual support in the development or assessment of public policies, or in the context of foresight studies [8].

Relationships between INRA and regional actors are described in Chapter 6.

INRA's contribution to debates on the political agenda

During the period of the current Contract of Agreed Objectives, agricultural, food and environmental issues have again been at the forefront of French political debate. INRA has contributed to informing its supervisory ministries on debates that concern the scope of its missions: the Common Agricultural Policy, the Environment Round Table *(Grenelle de l'Environnement)*, questions concerning food safety, biofuels, the abrupt rise in agricultural prices, reducing pollution due to pesticides, the importance of consuming fruits and vegetables in a context of expensive foodstuffs.
INRA has also participated actively in national debate on reform of the French research system.

1.4 Organisation

INRA's scientific policy is defined in a single strategic context shared by central management, the five Scientific Directors and the **fourteen scientific divisions**.

The Presidents of the **20 regional research centres** [9] represent the President of INRA; in the strategic plans for their centres, which describe the scientific strategy of INRA in regional terms, they assure contacts with local partners and the optimum implementation of nationally-defined scientific policies. In this context, they are responsible for links with universities, regional government bodies and socioeconomic and academic partners. In addition, these research centres constitute the local level for management and administration of the Institute, and thus house Research Support Services (SDAR) grouping all functions that provide support for research units.

14 Scientific Divisions

- Nutrition, Chemical Food Safety and Consumer Behaviour (ALIMH)
- Plant Biology (BV)
- Science and Process Engineering of Agricultural Products (CEPIA)
- Forest, Grassland and Freshwater Ecology (EFPA)
- Environment and Agronomy (EA)
- Animal Genetics (GA)
- Plant Breeding and Genetics (GAP)
- Applied Mathematics and Informatics (MIA)
- Microbiology and the Food Chain (MICA)
- Animal Physiology and Livestock Systems (PHASE)
- Animal Health (SA)
- Plant Health and Environment (SPE)
- Science for Action and Sustainable Development (SAD)
- Social Sciences, Agriculture and Food, Rural Development and Environment (SAE2)

[3] AFSSA: French Agency for Food Safety.

[4] INERIS: National Institute for the Industrial Environment and Risks.

[5] ONF: National Forestry Commission.

[6] AFSSET: French Agency for Environmental and Occupational Health and Safety.

[7] ONEMA: French Agency for Water and Aquatic Environments.

[8] For example, participation in the work of operational committees for the Environment Round Table (Grenelle de l'Environnement), in the "France 2025" foresight study, or in hearings of the Parliamentary Office for Scientific and Technological Choices on subjects such as biofuels or animal welfare.

[9] A map of the regional research centres is shown on page 69.

2. The major challenges posed by changes to the external context

The purpose of the first section of this chapter is show how INRA's strategy, in the very broad context of agriculture, food and nutrition and the environment, has strived to develop coherent plans with respect to current geopolitical and scientific challenges. The second section presents the upheavals created by new techniques for the production of knowledge. The third section describes the challenges related to recent changes to the institutional landscape of public research in France. The main implications of these changes in terms of strategic challenges for INRA are summarised at the end of the chapter.

2.1 Agriculture at the crossroads of world food and environmental challenges

INRA was set up in 1946 in response to pressing demands from society to "feed France". In the 1960s, French farming, with the support of agricultural research, was able to take up the challenge of satisfying the quantitative food needs of the country's citizens. During the 1980s, European policies, as well as research and innovation, contributed to development of the French agrifood industry, which has since become a major contributor to national exports.

During the past ten years, the return of agricultural, food and environmental crises to the political agenda has revealed that the future of French agriculture, which is closely dependent on global dynamics, can no longer be analysed at the national or even European level alone. In a context of world trade and concerns relative to global change, agriculture in both France and the rest of the world is now confronted by three major questions:

the question of global food safety, under the combined effects of demographic growth, global warming and the increasing rarity of natural resources, notably land, fossil energy and water;

the question of food quality and the effects of diet on health, problems that are exacerbated by the ageing of populations and the paradoxical co-existence of 923 million undernourished people and nearly one billion obese individuals;

the question of the sustainable management of territories and natural resources, and preservation of the environment, in a context of growing urban populations, which since 2008 are now in the majority.

INRA's adaptations to these new challenges

To take up the challenges of an agricultural system that must produce more but in a different way, INRA has had to review all its research and innovation objectives and integrate a wider variety of scientific disciplines, while at the same time developing new partnerships.

These adaptations have resulted in an active restructuring of its scientific resources:

- reorganisation of the Management Board, with the appointment of a Scientific Director for the Environment, Cultivated and Natural Ecosystems,
- the creation of new research divisions (notably "Forest, Grassland and Freshwater Ecology" and "Nutrition, Chemical Food Safety and Consumer Behaviour") and the removal of more specialised divisions,
- the organisation of research clusters dedicated to the biotechnologies (Versailles, Jouy-en-Josas, Bordeaux, Montpellier), the environment (Rennes, Grignon, Nancy, Guyane, Dijon, Avignon), food and human nutrition (Dijon, Clermont-Ferrand, Paris, Jouy-en-Josas, Toulouse), food sciences (Nantes), regional dynamics (Dijon, Grignon) and public policies (Rennes, Paris, Toulouse).

■ The need to move beyond disciplinary approaches

The societal questions with which agricultural research are confronted are complex and cannot be resolved by simply adding together the views of specialists from different disciplines (**multidisciplinary approaches**). Nor is it sufficient to cross these views under an **interdisciplinary** approach, where each modifies his project in line with the ideas of other specialists. An approach in which researchers interact with socioeconomic and political stakeholders is now preferred, as only this can enable all parties to appropriate all the innovations generated by research (**transdisciplinary approach**).

The promotion of transdisciplinary approaches

To respond to the complexity of issues, INRA organises research partnerships with stakeholders in the context of "transdisciplinary programmes", for example in genomics (notably Génoplante and Génanimal). Identifying the issues to be addressed by research concerning changes to the world economy and the expectations of society can also be achieved through collective expert studies (e.g. in the plant health field) and foresight studies on the challenges we face (e.g. the Agrimonde, New Ruralities and CAP 2013 Foresight Studies).

2.2 High throughput is invading the generation of knowledge

The dynamics of knowledge production in the life sciences evolved considerably during the 1990s. With the development of high throughput technologies, it was necessary to review the organisation of biology by developing ultra-modern technology clusters and enhancing exploration capabilities using informatics, bioinformatics and modelling. All other disciplines were subsequently affected by the opportunities offered by high-throughput technologies, which resulted in major changes to the approaches adopted in all scientific fields.

INRA participated in these changes by setting up advanced technology clusters and developing its potential for formalisation through the use of applied mathematics. In addition, INRA tried to provide support for this policy by actively organising the conservation and analysis of its genetic resources, and by basing its experiments in a constantly updated and major network of experimental farms.

■ Biotechnologies

During the 1990s, agricultural research was revolutionised by the advances achieved not only in biology (notably genomics) but also in ecology, environmental sciences and food sciences.

These developments required the reorganisation of research groups and the resources attached to them, and also gave rise to some major ethical questions concerning, in particular, the patentability of living organisms, the acute nature of which was reinforced by the important economic interests underlying this research.

The essential need for public sector research compatible with the stakes involved

Faced with these challenges, INRA decided it was necessary to enhance its performance, rendering it more visible on the global stage and generating results accessible to all.

Thus, **in line with national policies**, discussed and shared with CNRS, INSERM and the universities, decisions were taken as to the initiation of technology platforms, centres for biological resources, centres for research in human nutrition, environmental observatories and training and education.

At the same time, INRA continued to develop the informatics tools essential to the handling and processing of data arising from different analyses. It also modernised its centres for genetic resources in order to preserve the future, storing genetic material obtained from samples collected throughout the world during the Institute's sixty years of existence.

At an international level, INRA has played, and continues to play, a pioneering role in several major biotechnological advances: participation in the sequencing of grapevine, wheat (chromosome 3B), tomato, poplar, model plants such as barrel medic (*Medicago truncatula)*, pig, cattle, trout, and numerous micro-organisms (pathogenic, symbiotic or used by the agri-food industry). Furthermore, INRA is leading the major programme for the metagenomic analysis of human intestinal flora. Finally, INRA was one of the instigators of the functional analysis of genomes, such as the full bank of *Arabidopsis thaliana* insertion mutants, or the CATMA chip (*Complete Arabidopsis Transcriptome MicroArray*), which enables study of the *Arabidopsis* transcriptome.

2.3 Institutional changes to the public research system

Recent legislation has given rise to profound policy changes that have exerted significant effects on INRA's activities and notably in the field of higher education and research. Thus the following important laws have recently been promulgated:

- in the **public funding** area: the Organic Finance Law (LOLF), implemented in 2006;
- in the **research** sector: the Research Programming Law of April 2006, which in particular set up the National Research Agency (ANR) and the Agency for the Evaluation of Research and Higher Education (AERES), followed by the "University Freedom and Responsibility Law" (LRU) of August 10, 2007;
- in the **agricultural** sector: the 2006 Agriculture Orientation Law, and successive reforms to the Common Agricultural Policy (CAP).

Faced with these changes, INRA's policies have been based on three principles:

- French research must be organised in regional sites with close University links;
- Agricultural research must be managed at a national level that will ensure the coherence and excellence of agricultural activities at regional sites, and openness to other disciplinary approaches;
- Agricultural research must strengthen its links with agricultural training so that its results will become knowledge and know-how and the issues its addresses will inform public policies, economic activities and, in return, research itself, in a sustainable manner.

a. A new architecture

■ Independence of universities:

The profound reorganisation of higher education and research in France has notably resulted in greater powers for universities, the reform of doctoral studies and implementation of the LMD (Bachelor's-Master's-Doctorate) degree system in agricultural higher education establishments, as in other sectors.

b. New instruments

Deployment of the ANR and the increasing importance of European funding have resulted in the spread of project-based management.
Insofar as research units are now assessed by external bodies, this single, centralised system may increase the risks of preferring academic production (because of its universal utilisation) to the detriment of innovation or expertise, the impact of which is more difficult to establish.

INRA is contributing to these changes:

- by mobilising its efforts to highlight the challenges targeted by the Institute in calls for projects;
- by encouraging INRA researchers to take responsibilities in the design and management of ANR or European projects;
- by taking the initiative to federate other mission-oriented research agencies in order to define a more exhaustive assessment method that respects all the missions of research units, in close cooperation with the AERES.

2.4 Consequences in terms of INRA's strategic challenges

These ongoing changes are creating challenges for INRA at many levels. Indeed, the **global dimension of the issues addressed** by INRA is undeniable. Today, all the subjects studied by the institution have connotations and implications in Southern and Mediterranean countries, as well as in all major emerging countries. In other words, without having a specific mission to deal with research issues affecting Southern countries, INRA must work more frequently in collaboration in order to draw optimum benefit from issues targeted by CIRAD [10], and in return ensure that the latter will benefit from INRA's assets. At the same time, INRA must respond **to the needs of local agriculture**, which is itself confronted by the globalisation of agricultural and food issues, thus increasing the number of challenges it faces.

Because of global change, INRA research must give particular priority to **agro-ecology**. INRA has developed experimentation and assessment in a broad range of ecological and economic situations, and production methods that improve yields and reduce the harmful impacts of farming on the environment. Research must be pursued in order to develop methods, concepts, practices and innovations that will integrate agronomy and animal husbandry, in order to generate **coherent solutions**. And this research must also integrate the innovations developed and implemented by the actors themselves.

INRA will not be able to take up this challenge without increasing its efforts regarding **systemic approaches**, despite the problems in valorising these approaches from an academic point of view. This challenge will form the basis for essential changes to investigative methods, partnerships and the assessment of both research and researchers.

In response to these long-term demands, INRA must improve its ability to draw on **young talents** by increasing its social and scientific attractiveness while offering such young teams the best possible working conditions.

Without seeking to impose its views, INRA must act as an efficient vector to inform French society, **opinion-formers**, public decision-makers and citizens on the challenges and their answers in terms of agriculture, the environment and the agri-food sector. These ambitions must be accompanied by a reorganisation and diversification of INRA's partnership system. The Institute must increase its dialogue with environmental protection and consumer associations, while maintaining strong links with unions and agricultural development organisations. This revival needs to be successful at all levels of the institution, from central management down to each of the research teams.

The development of **project or programme-based funding** by external agencies, means that INRA is faced with major challenges of reactivity and strategic consistency. Indeed, because a project emanates directly from a team, this guarantees greater reactivity and good mastery of the subject. On the other hand, the growing number of projects, and the increasing importance of this type of target-based funding, are not necessarily consistent with the Institute's scientific strategy, thus raising the question whether INRA can continue to manage its activities. For this reason, particular attention must be paid to the national coherence of actions and their monitoring by all scientific managers in the Institute, so that the missions entrusted to INRA continue to be carried out in the context of a more open, and more competitive, national research system.

10 French Agricultural Research Centre for International Development.

3. The development and implementation of strategy

INRA's strategy requires systems that will first of all guarantee the scientific relevance of its work, without which it is not possible to achieve any high quality innovations that will benefit the political and socioeconomic worlds. Watch systems on different scientific areas, and foresight studies to inform long-term decision-making, are thus presented in the first two sections of this chapter. Taking account of the requirements of stakeholders is an essential stage when determining the socioeconomic relevance of a strategy; this is covered in the third part of the chapter. The final section looks at the different methods employed to construct scientific strategy.

3.1 Watch systems on different scientific areas

Scientific Directors and the scientific divisions ensure a daily scientific watch on the subjects that concern them.
Formal structures also exist alongside these analyses. One approach is to adopt the views of the **Scientific Advisory Board** on emerging subjects. Thus several reports have recently been published by this Board on integrative biology, microbiology or animal health.
Foresight workshops (FW), funded by the National Research Agency (ANR) constitute a second method: these workshops are primarily designed to produce a "state of the art" view on a research theme that is the subject of exploration at the national level, and which will, if relevant, provide a basis for future calls for proposals from the Agency. INRA plays an active role in scientific foresight on areas relevant to its missions, and notably regarding programmes where the Institute is delegated responsibility by the ANR.
INRA thus coordinates the VégA FWI on the energy and chemical uses of biomass, and the ADAGE FW on adapting agriculture and man-made ecosystems to climate change.

INRA coordinates the VégA Foresight Workshop on "Plants for biomass in the future"

The VégA Foresight Workshop (FW) is a project that received funding in 2008 from the National Research Agency (ANR) for a two-year period. The purpose of the VégA FW is to identify sustainable plant species and production systems in response to the need for the renewable plant biomass that is necessary to develop new energy production systems, green chemistry and biomaterials.
Because of the wide-ranging consultation its work involves, the FW can provide the foundations for a **national strategy on this subject**. The Ministry for Higher Education and Research has thus decided to compile a national reference document on biomass. This approach also provides a **structure for INRA**, in an area of considerable importance to its work: foresight data, the strengthening of skills, visibility (notably in Europe) and the identification of major projects. To prevent any national "navel-gazing", INRA is paying particular attention to complementary links with projects in the same area at **the European scale** (e.g. EPOBIO).
In addition to CIRAD and the French Petroleum Institute (IFP) and 17 other establishments that are signatories of the project, the VégA FW has also welcomed the spontaneous adherence of 31 other partners. The network is thus very widespread, and open to: public research organisations, higher education establishments, agricultural and forestry technical centres, biomass producers, companies active in the sectors of agriculture, chemistry and energy or using bioproducts, and environmental protection associations. More than 200 experts are thus involved and cover a vast range of disciplines (chemistry, process engineering, plant biology, microbiology, agronomy, ecology, green and white biotechnologies, economics).

3.2 Foresight studies to inform long-term challenges

INRA's use of a foresight approach, as early as 1993, has been central to its work as a mission-oriented public research institution. The aim is to identify responses to the major challenges to which agricultural research must contribute, based on the construction of scenarios for the medium and long-term future, while at the same time clarifying the principal factors for change. By involving a wide variety of actors in open discussions on the project, it also provides foundations for new research partnerships, based on a shared analysis of the challenges ahead.
Three **sectoral foresight studies** have recently been carried out to inform strategic thinking on the future of fish farming, poultry farming or crop protection. During the period covered by the current Contract of Agreed Objectives, INRA also initiated three foresight studies on the **challenges facing society**, which throw new and valuable light on the future of agriculture at different scales: in France (New Ruralities), Europe (Agriculture 2013), or in the context of global change (Agrimonde).

Foresight studies on the challenges facing society

New Ruralities: possible futures for French rural populations at the horizon of 2030. Because of the increased mobility of people, goods and information, and changes to lifestyle, rural areas are experiencing profound change. This has resulted in demographic growth which is relatively well distributed throughout the country, as well as urban dynamics linked to the spread of major towns and cities. Drawing on the skills of a wide variety of actors and disciplines, the New Ruralities foresight study, completed in July 2008, developed thinking on possible evolutions that could affect rural areas between now and 2030. Its approach combined a macroscopic method based on quantified indices, and a regionalised approach reasoned in terms of living experiences. This study's results, which are currently the subject of numerous presentations, notably to national and regional economic and social councils, invite researchers and public decision-makers to reflect on the diversity of regions, conflicts of use and new complementarities between towns and the countryside. In terms of research orientations, this foresight study has led to the initiation at INRA of research that is both geographical (in the context of the RURAGRI Era-NET) and thematic, concerning the development of peri-urban structures.
Agriculture 2013: carried out in partnership with Crédit Agricole and Groupama, the aim of this study was to anticipate the strategic determinants of agricultural, food and environmental policies for Europe at the horizon of 2013. Completed in October 2007, its conclusions were the subject of more than 100 presentations at the request of government bodies and different partners in the world of farming.
Agrimonde: The foresight study on "World Food and Agricultural Systems in 2050" was carried out in the context of the INRA-CIRAD (French Agricultural Research Centre for International Development) partnership. Its initial results, presented in June 2008, explored the different levers that could be activated to meet the major challenge of feeding humanity while preserving planetary resources. They emphasised the determining role played by diet, technological options, spatial organisation and agricultural trade in reducing poverty and protecting ecosystems. From a scientific point of view, the foresight study challenged INRA to integrate databases of different types (demographic, agronomic, energy, transport) and develop its skills in modelling and scenario design.

Sectoral foresight studies

The future of French fish-farming at the horizon of 2030: partners in this study included INRA, IFREMER, CIRAD, representatives from the CIPA (the French Association for Fish-farming Products) and other companies. Other foresight studies currently under way are focusing on the **poultry sector** or **crop protection techniques** in Europe.

3.3 Taking account of stakeholder needs to ensure greater relevance

If it is to respond to major political, social and economic challenges, agricultural research must draw strength from **dialogue with all the actors concerned** (academic and industrial partners, government authorities and citizens) in order to analyse data on the problems encountered so that an appropriate scientific strategy, and its resulting pathways for innovation, can be developed. Indeed, because of the rapid changes ongoing in all contexts, taking account of the divergent needs of all partners can be a complex process. A consultation method that explains points of controversy and allows debate on the differences in viewpoints expressed by these partners is therefore important to discussions on the responses that research may be able to provide.
Some of the methods implemented by INRA are described in the box below. The CAP-Environment project, which was designed to test a method for actor-research consultation, is presented in the section on INRA's contribution to interactions between science and society.

A variety of partnership methods to enable orientation

Sometimes formalized (notably with public sector actors) but often in the context of local mechanisms (particularly with industrial actors), consultation and agreement must be ensured at all times:
Framework agreements with the Ministries for Agriculture and the Environment provide for account to be taken by INRA of the needs for research or expertise in the development of public policies.
Partnerships with actors in farming may be organised at all levels of INRA: from central management to the divisions and even at the level of numerous research units. Some specific consultation arrangements exist, such as sector groups in the plant or animal fields, or national framework agreements with different actors in agriculture.
Orientation partnerships at regional level have taken on particular importance thanks to implementation during the past ten years of incentive programmes "for and on regional development" (PSDR) which involve researchers and agricultural and non-agricultural partners, the aim being to focus on regional development issues.

While remaining aware of the views of its partners, **INRA must also be prepared to take risks** to enable innovations in response to changes that may not yet have been taken into account by economic actors. Two examples concern breeding

objectives in the field of animal genetics, and the development of sustainable agroecology, in response to the dual challenge of intensive but ecologically-friendly agriculture.

An illustration of INRA's capacity for anticipation

The development of a full range of varieties for low-input farming: the winter soft wheat variety KORELI, registered in the French catalogue in July 2006, which combines a high yield under low input management and good baking quality, is a good illustration of INRA's positioning in major sectors of sustainable agriculture, in that it can propose varieties that could not be developed by private sector breeders.

In the field of animal genetics, breeding objectives have often been in advance of economic constraints. For example, although the formula used to calculate cow's milk prices still places extra value on fat content, levels of useful matter (proteins) have been targeted explicitly by selection for more than 25 years.

3.4 Methods employed to develop scientific strategy

Since 1998, INRA's strategy has been determined by its Management Board, which takes collective decisions after wide-ranging consultations and appropriate discussions with divisions and centres. It then organises their implementation by the Institute in strategic plans for each division and research centre.

a. Research divisions at the centre of contractual arrangements

Each of the 14 **scientific divisions** that form a national network of scientific skills organised on a long-term basis around high-priority scientific areas, proposes a **4-year strategic plan** after consultation with its research units. Validation of this plan by the Management Board is confirmed by a mission statement from the latter. For each area of activity, this document fixes production or organisational targets, with milestones to mark progress towards their accomplishment. Implementation of each strategic plan is the subject of an **annual meeting** between the Management Board and each division, during the management session, the agenda of which is based on specifications drawn up by central management that each year requires examination of a particular transversal issue. Thus, in 2008, each division presented its policy in response to the challenges raised by the "*Grenelle de l'Environment*" round table. During these meetings, a report on achievements, including tracking indicators, is also presented by the division, and is then debated with the Management Board. A report on all the decisions taken during the annual meeting is sent to each division head for action. In return for this contractual commitment, and so that policies can be implemented in a stable context, the divisions are assured that they will be able to recruit a minimum number of researchers and engineers during the four years covered by this strategic plan. **The divisions are subsequently assessed on implementation of their strategic plan before negotiating the next stage**, which intervenes after signature of the Contract of Agreed Objectives with the French Government, so as to guarantee the strategic alignment of all entities within the Institute with the policy line.

Orientations are then given by division heads to the **unit directors**; these are also laid down in the form of a mission statement that defines the targets fixed for a unit and the developments required to fulfil the division's strategic plan. Achievement of these objectives serves as a framework for the annual allocation of human and financial resources to units by division heads, as a function of the budget it has been attributed by central management, but also depending on the specific mechanisms implemented by the division to encourage performance.

Centre presidents also draw up a **centre plan** that determines the regional specificities of the Institute's scientific strategy, favouring the pooling of resources and the links that will be necessary with local partners.

Through regular monitoring, the **division heads** ensure the coherence of the orientations followed by the divisions in the context of the objectives fixed by the Institute, setting up networks to accomplish their tasks whenever necessary.

INRA's strategy and objectives at different levels are thus laid down in three types of document:
- Divisional strategic plans, and annual reports on their execution;
- Mission statements to unit directors;
- Plans for each centre.

Operational implementation of the Institute's policies is thus mainly ensured by the divisions, which have globally described them in the form of 49 thematic areas. This type of organisation favours the coherence of activities and the management planning of jobs and skills. It also constitutes a governance system that can resolve any clashes that occur between the resources dedicated to achieving scientific excellence and producing innovations, and those allocated to the transfer of knowledge. However, in view of the rapid evolution of different issues, a special unit set up in 2009 is now exploring the hypothesis of a new organisational system that would place more emphasis on project-based management.

Policies concerning shared scientific facilities and tools at INRA have accompanied these changes by encouraging consolidation of the Institute's scientific network (based on its strategy) in research and experimental units of sufficient size to benefit from research and experimentation facilities and technical platforms that will optimise INRA's response to the challenges it faces. They also include guidelines on the **property portfolio** which aim to reduce the total number of buildings owned by the Institute, in order to ensure better maintenance of the facilities that remain.
Indeed, in order to ensure a more dynamic and visible regional policy, several **centres** have been, or will be, merged: this was the case for Nantes and Angers in 2008 and should apply to Sophia-Antipolis and Avignon in 2010.

b. Allocation of resources as a function of strategic choices

Based on the contractual arrangements established between the divisions and central management, 82% of INRA's operating budget is delegated to the divisions at the beginning of each year.
In the context of the annual recruitment policy decided on in the Institute's primary budget, 70% of the new posts available are allocated contractually by central management to the divisions, to enable implementation of their strategic plans. The remaining 30% is allocated by the Management Board to emerging projects, in order to encourage the decompartmentalisation of approaches and the reactivity of INRA. The definition of recruitment profiles for these emerging projects then results from collective discussions concerning the major priorities determined by the Board of Directors in the context of executing the Contract of Agreed Objectives. In order to ensure the sufficient deployment of skills to emerging priorities, each year central management reserves certain researcher and engineer posts, a policy that is rendered possible by the currently high rate of retirements, and a desire not to saturate the employment ceiling allocated to the Institute.

Emerging priorities in recent years

Green chemistry: the challenge is to provide the chemicals industry with compounds comparable to those obtained from the petrochemical industry, but produced using lipids, starch, sucrose and cellulose. If it is to replace petrochemicals, green chemistry still needs to demonstrate its industrial, economic and environmental efficiency. Some twenty INRA research units are working in this area, and they were recently allocated some fifteen additional posts (2007-2008).
Biofuels: INRA has mobilised fifteen posts for the design of production systems. The biotechnical, economic and social aspects of these systems are under study. In addition, a polyvalent industrial pilot plant has been designed in partnership with agricultural and industrial partners (FUTUROL).
Climate change and water resources: INRA has allocated fifteen posts to work on the control of greenhouse gas emissions and adapting agriculture to climate change, in addition to activities already under way on the impact of global change.
Innovative farming systems: twelve researcher posts have recently been allocated to this area in order to reinforce the development of innovations and production systems that take account of environmental protection, product quality and economic viability.

Mobilisation of resources and partnerships

for implementation of the action plan

4. Human resources management aligned with strategic objectives

For a research institution, the **long-term management** of skills in areas affected by major scientific challenges is an essential dimension of its strategic planning.

Satisfactory operation of the Institute requires the commitment of each one of its researchers, engineers and technicians, whose professional skills give a daily meaning to INRA's missions. This commitment supposes that all agents are **personally motivated** to carry out their professional activities, prepare their career development and thus better contribute to the success of the Institute.

In addition, at both the national and international levels, there is now real competition between research organisations to attract and retain the most skilled personnel. The **attractiveness** of INRA is thus crucial to its strategy, so that it can implement the objectives it has fixed itself.

The challenges faced in terms of human resource management, and to which INRA strives to respond, include the assurance of better career mobility, the encouragement of highly motivating career paths by increasing qualification through **training**, ensuring **assessment of the results achieved** while clearly acknowledging the contribution of each staff member, and to encourage and recognise those who **take on responsibilities** and managerial functions.

Finally, 70% of the Institute's budget is devoted to human resources, so that its policies in this field are also a determining factor in terms of their **financial importance** to the economic equilibrium of INRA.

4.1 A framework and resources that enhance attractiveness

One of INRA's challenges is to attract young, high-quality scientists, whether they come from France or other countries. For this reason, one of the priorities of the Institute's Contract of Objectives concerns a major increase in the proportion of foreign researchers recruited each year, particularly from European countries. This input of valuable skills will also contribute to enhancing the international status of the Institute.

Policies to enhance **INRA's attractiveness** are thus based on greater international openness. At the European level, INRA needs to advertise its needs for skills and the opportunities that are available for hosting and recruitment. This can be achieved by adapting the hosting arrangements for foreign scientists. Their presence in research units will reinforce the intellectual assets of the Institute, notably rendering it more attractive to young researchers. These policies will also enable better recognition of individual contributions to development.

■ Policies in favour of young researchers

Developing attractiveness also requires particular attention to the training of **young researchers**. INRA was one of the first French research agencies to implement deliberate policies regarding the hosting, management and monitoring of doctoral scientists. In 2007, these policies resulted in the adoption of a **Charter for Doctoral Students** and young post-doctoral fellows at INRA; this describes the undertakings (and also the expectations) of the Institute with respect to these young scientists.
Thus as soon as they join the Institute, **young researchers** and research support staff are welcomed during day-long meetings that inform them on the challenges and demands of their jobs and the career paths that are open to them.
In addition, **specific incentive arrangements** have been set up. The special status of an Associate Scientist on Contract has been reoriented so that it will attract young people interested in exploring areas at the interface of two disciplines. The creation of Young Scientist Contracts, which over five years combine a period as a doctoral student and a post-doctoral attachment in another country, offers a professional career path that is both stimulating to young researchers and beneficial to the Institute.
As well as INRA's focus on young researchers, their contractual status at the start of their professional careers can place them in a precarious and unpredictable position. For this reason, INRA prefers to recruit its full-tenure junior researchers at an early stage, and then continues to monitor the professional outcomes of contracted employees after their time at the Institute.

A charter on the hosting of doctoral students and post-doctoral fellows

To strengthen INRA's policies of openness and attractiveness by improving the conditions for the entry of young researchers into its laboratories, a draft charter on the hosting and management of doctoral students and post-doctoral fellows was drawn up in 2007, and was then discussed within the Institute.
Compilation of this charter provided an opportunity to strengthen the links between INRA and associations of doctoral students and post-doctoral fellows, which are very active and sensitive to improvements to the conditions affecting the professional careers of young scientists working for research institutions.
This charter has now been circulated to all INRA research units. In addition, a specific document for broader circulation is currently being drawn up.

4.2 Promoting the necessary diversity of scientific skills

INRA's activities form part of a framework that is limited on the one hand by the demand for internationally-recognised scientific production, and on the other by the need to create innovation and know-how, to generate expertise and make a significant contribution to training.
Clearly, a satisfactory balance cannot always be found in the activities of all individuals. But it must be taken into account at the **collective** level, in terms of the activities of research units and divisions. Similarly, the variety of activities that contribute to fulfilling the Institute's missions is essential to the career dynamic of researchers, whose motivations may evolve over time.

Beyond constant and shared efforts to attain excellence, the **diversity of professional approaches** that results from this variety is mainly managed, over time, by means of the three collective skills present within INRA: (i) its ability to develop research objectives at the interface of several disciplines, such as biology and human and social sciences, in association with non-academic partners; (ii) the mobilisation of recognised skills around individual and collective expertise at the service of economic development, and (iii) translation of the signals received from society into opportunities for pertinent research actions and targets.

INRA must thus ensure **maintenance of this global skills equilibrium** by involving the largest possible number of its researchers in the systemic analysis of agricultural issues and the exploration of new fields concerning the environment and food and nutrition.
In order to translate and enrich this **diversity of skills** into a recruitment policy, each year INRA's central management sets aside a certain number of posts in its budget that can be made available to specific scientific projects arising from the Institute's decision-making. In this way, new researcher profiles are opened for recruitment as a function of the scientific challenges relevant to emerging issues.

In addition, central management itself organises the competitive recruitment of **Research Directors**, so as to select the best candidates who comply with the missions expected of an INRA researcher. Furthermore, through promotions to Research Directors or rewards for the most brilliant scientists (the annual INRA Awards: *Les Lauréats de l'INRA*), it ensures that this acknowledgement of quality confirms the necessary diversity and complementarity of its missions.

Finally, INRA, together with CEMAGREF, is one of the few Public Scientific and Technology Establishments to have organised the **individual assessment of engineers** during the past five years; these staff members welcome the recognition and advice that result from this process. In return, INRA is able to gain a very clear picture of their activities, which are essential to accomplishing its missions.

The promotion of professional gender equality at INRA

INRA has adopted a deliberate policy of equality for men and women in the Institute, both in terms of recruitment procedures (composition of panels) and appointments to collective bodies or management posts.
Thus in all national commissions or committees, women now account for more than 40% of appointed or elected members. Between 2006 and 2008, the number of women in management posts rose by nearly 70%. For example, the percentage of women appointed as Directors of Research Units rose from 15% to 21.5%, while there are now more than 25% of female Deputy Directors.
The increase in the number of female researchers since the end of the 1990s has now led to a good balance within this group. 2008 was indeed an historic year for INRA, because for the first time, a majority of women (57%) were recruited as Research Directors as a result of the competitive procedure for that year.

4.3 The recruitment policy and its results

During the past ten years, INRA's recruitment policy has gradually been **aligned with its policy objectives**, resulting today in a correlative increase in, and evolution of, the numbers of **scientific publications in different strategic areas** covered by the Institute. In addition, significant efforts have been made to develop skills appropriate to scientific priorities, through the recruitment of bioinformatics or ecology specialists, while the number of technology experts has declined.

In order to improve the skills available in certain areas of competence, INRA has also initiated important hosting policies, involving the development of **"packages"** (contracts with attractive salaries, specific allocations of doctoral students and young post-doctoral fellows, operating credits) for senior researchers from countries with which the Institute wishes to establish closer collaborative ties. In 2008, ten "packages" were thus initiated and will help to strengthen links with the UK, China, Sweden, Hungary, etc.

Encouraging INRA's European openness with respect to recruitment

In order to attract the best candidates, a targeted communication campaign was started in 2006 for the recruitment of ITA [11] and researchers; this was further enhanced in 2007 and then repeated in 2008. To advertise the jobs available in the Institute, this campaign targeted both France and the major European countries, the aim being to cover all the communication tools that could be consulted by appropriate candidates: websites, journals, forums, circulation lists, etc..
For the recruitment of ITA, greater importance was given to advertising in national and regional newspapers and magazines, and on radio stations. In addition, more INRA stands were organised during recruitment fairs. For example, for the first time in 2008, INRA participated in the French Public Sector Employment Fair.
The results achieved following the 2007 competitive process for junior scientists in terms of the applications received revealed a doubling in numbers when compared with previous years, with a marked increase in the number of European candidates.
In 2008, more than 80 websites contained information on INRA recruitment opportunities, and Cooperation and Cultural Departments in French Embassies were also asked to advertise these posts (China, India, Netherlands, Hungary, Hong-Kong, Sweden, Italy). Finally, INRA asked its representatives in Brazil and India to increase their communication campaigns.

Number of candidates per post	2000-2006	2007	2008
CR2	5.1	10	9.2
CR1	3.6	4.2	3.4
ITA	34.8	36.04	20.26

The success observed in 2007 was followed by a slight downturn in 2008: 10 candidates per post for the 2nd class junior scientist (CR2) competitive procedure in 2007 versus 9.2 in 2008; 4.2 for the 1st class junior scientist (CR1) procedure in 2007 versus 3.4 in 2008. Nevertheless, these efforts should be pursued so that the trend initiated in 2006 can continue, principally with respect to CR2 and CR1 candidates who are more susceptible to the effects of these campaigns than ITA, whose applications are more likely to reflect the national economic context.

[11] ITA: engineers, technicians and administrative staff.

4.4 Career support through in-house training

The dynamics of the changes affecting research support functions are concomitant with those of the scientific professions. The aim is to adapt the skills available to **the modernisation and collective efficiency** of the Institute's daily operation, in order to offer an optimum working environment to INRA's scientists.

Support for these changes is provided by means of **active policies on continuing training**. In addition to **ensuring support for scientific policies**, a priority in recent years has been the development of "professional" skills that will encourage specialisation and improve the mastery of **new management tools**. The Institute has thus set up specific training courses intended for its **future managers** (practical courses in the management of agricultural research), i.e. unit directors and managers.

Furthermore, particular attention is paid to several fields that are seeing considerable change at present: i) **scientific and technical information (IST)**, based on a approach that allies the management planning of skills and organisational forecasting; ii) **management and secretarial skills**, through the organisation of specific training courses; iii) **computer skills**, through the organisation and implementation of CATI (Automated Centres for Information Processing, or *Centres Automatisés de Traitement de l'Information*) within the Institute.

Thus the principal challenge of the **FuturIST project**, initiated in 2006, is to define the future of the IST function within INRA and identify the skills profiles required for the future when compared with those available at present. The aim of this approach is to develop a system that can manage the gap that is opening because of changes to skills in the context of appropriate training or conversions to other support functions, in addition to the number of staff currently retiring. A more specific project is to be initiated in 2009 to enhance the career prospects for **secretarial staff** and ensure a clear separation in units from the budget and accounts officer.

Dynamic institutional training policies

Faced with changes to its context and scientific challenges, in 2006 INRA developed a truly institutional policy for continuing training that was consistent with the scientific orientations of the Institute and ensured support for human resources policies. At all organisational levels, from units to centres or divisions, agents can thus perceive and better understand their environment, the purpose of their professional activities and the opportunities available to improve them.
Four strategic areas with respect to training were thus identified:

- support for **scientific policies and their priorities** ("researcher schools", the training of doctoral students and post-doctoral fellows in the profession of researcher, the development of federative programmes, construction of the European Research Area, the changes to techniques and concepts, the emergence of new methods for the organisation and operation of research, the development of links between science and society, etc.);
- dynamic leadership and **collective management** (support for those who take on responsibilities to the benefit of the community, the development of a project-led culture, changes to research support functions, the deployment and appropriation of information and management systems, policies to restructure INRA's research units);
- support for the **development of skills** and career paths (in particular, evolving and emerging professions, the individual development of a professional career path, training for individuals hosted by the Institute);
- the promotion of **individual rights** (leave for professional training, qualifying training at the initiative of an agent, personalized training).

It is the responsibility of division heads, unit directors and all agents (both full-tenure and contractual) to make use of the training opportunities available, in order to sustain and develop individual and collective skills.
A few figures on training: a budget of €3.8 million per year; 2.72% of the HR budget devoted to training each year; 7000 trainees each year; 34 hours of training/person/year; 58.6% of full-tenure staff received training, while 18.2% of staff did not follow a training course.

5. Strengthening academic partnerships

The Institute's partnership strategy is based first of all on its **ambition to participate actively in constructing the European Research Area**; INRA is convinced that a research institution of its type will only have a long-term future if it is positioned at the centre of this Research Area, while pursuing its ambitions at a global scale.
The academic partnerships enjoyed by INRA lie at the heart of its scientific strategy and focus on two dimensions: the first is specific to its mission as a research institution, which is to offer its teams an opportunity to work in an optimum academic environment, while the second aims to mobilise outside teams around its own challenges but in a context of shared interests, so that researchers will benefit from skills that complement their own, particularly with the objective of developing clusters of European importance.

5.1 Alliance strategy

INRA's alliance strategy is based on **four scientific convictions**: the synergy of research programmes carried out in temperate and tropical regions, the promotion of sites that integrate the training-research-development continuum, a broadening of disciplinary fields in partnership with universities, and a strengthening of links with agricultural training institutions.

- The globalisation of issues means that research must seek a synergy between the approaches adopted and results acquired in temperate regions and those obtained in tropical or Mediterranean regions, thanks to the revival of comparative agronomy; this synergy will also improve the visibility of the French agricultural research system, which hitherto has not risen to global challenges;

- Reorganisation of the French research system, giving greater importance to universities, is an essential development that has already taken place in most countries. Furthermore, investigative approaches centred around costly technology platforms requiring specific skills will accelerate this process. However, these necessary changes cannot be achieved using the same methods in different fields. A distinction must thus be made between mission-oriented research and other more academic sectors, not only because of the specific purpose and organisational requirements of the former, but also because higher education is less closely involved in this research. As far as INRA is concerned, a large proportion of its research resources are based in rural areas far away from universities, so that adaptation to this new system can only fully be achieved through the emergence of integrated centres for research, training and development, dedicated to the agricultural, veterinary and food and nutrition fields;

- Broadening of the disciplinary scope of INRA's agricultural research to new objectives requires the mobilisation of skills from other research institutions (CNRS, INSERM, INRIA), as well as universities, as is seen in all other developed countries;

- Agricultural research generates concepts, techniques, practices and challenges that require stronger links with training. While maintaining its essential links with universities, particular attention must therefore be paid to collaboration and coordination with agricultural and veterinary training institutions.

In the context of this analysis, INRA focuses its academic partnership strategy on four main needs:

- **closer institutional links** with establishments specialised in identical fields at the national, European and international levels.
- more **strategic dialogue with partner institutions**, in order to establish pertinent and long-term relationships around shared and well-defined scientific projects concerning research or training activities.
- the development of broader **links between disciplinary fields** that will allow INRA to mobilise all the skills it requires to conduct its research within the scope of its missions.
- the search for **global coherence** between the regional organisation of INRA, its partnership arrangements and the national importance of its missions. The Institute's aim is to develop thematic clusters that are competitive at an international level and which reconcile the excellence and relevance of their research with the economic and political challenges of their fields of competence.

These objectives can be addressed in different ways at the European, national and international scales.

5.2 Europe

International relations at INRA are based on contacts and exchanges sustained by its teams with numerous research and training institutions throughout the world.
INRA researchers produce a large number of joint publications with foreign partners, and this situation is monitored attentively. Such collaborations with groups in European countries have seen sustained growth, from 19.8% of publications in 2001 to 22.6% in 2006.

■ Bilateral cooperation with European research organisations

Within **Europe**, agricultural research is reliant on both initiatives taken by the Commission and the efforts of similar institutions to establish bilateral or trilateral collaborative research projects around major challenges. This forms the basis for the links forged by INRA at an institutional level.

Thus INRA is involved in institutional, bilateral cooperative work with its three main European counterparts, i.e. Wageningen University and Research Centre (WUR) in the Netherlands, the Biotechnology and Biological Sciences Research Council (BBSRC) in the UK and the Leibnitz Institute (WGL) in Germany.
Joint calls for tender with the BBSRC in the field of plant production, with the WUR in aquaculture and with the WGL on the genetic diversity of wheat, have opened the way to stronger links. Indeed, INRA and its counterpart agencies hope to develop a nucleus for European cooperation that will encourage and anticipate developments at a European level and then prepare appropriate structuring projects.
Bilateral collaborations complementing those already established in the context of dedicated programmes, have been established with other partner countries such as Sweden, Hungary or Poland.

■ Multilateral cooperation at a European level

In the context of the Sixth Framework Programme, INRA **teams** participated in 166 projects funded by the European Commission (out of approximately 400 submissions), 43 of which were coordinated by the Institute.

As for the European Research Area, INRA's **institutional** strategy is to become involved in managing major, structuring projects within Europe. Major efforts have been made to ensure long-term support for multilateral projects in Europe, and particularly those carried out in the context of important Framework programmes [12]. On themes of strategic importance to INRA, the aim is to encourage researchers to take on the coordination of European projects, but to relieve them of the administrative complications related to their assembly and management. Since this support system was set up, several INRA researchers have taken the initiative to coordinate ambitious European projects, such as: ENDURE, the European Network for the Durable Exploitation of Crop Protection Strategies, EADGENE, the European Animal Disease Genomics Network of Excellence, EVOLTREE, a Network of Excellence on the Evolution of Trees as Drivers of Terrestrial Biodiversity, or MetaHIT, on the Metagenomics of the Human Intestinal Tract.
A box showing the growth of INRA successes under the Framework Programme is shown in Chapter 8.

Metagenomics of the human digestive tract, a research project led by INRA

As early as 2005, INRA researchers started to encourage the collaboration of global actors in this discipline and to initiate an international dynamic. At the same time, the European Affairs Department at INRA (DARESE), together with researchers, were trying to make the European Commission aware of the importance of this theme to enabling a clearer understanding of the links between nutrition and health. A project was granted funds of €12 million under the first call for FP7. The project retained, MetaHIT, is being coordinated by the INRA Research Centre in Jouy-en-Josas and is thus the first internationally-funded project to catalyse research efforts in this field. INRA's ability to mobilise external partners has been considerably enhanced by this success, and to date more than €100 million have been allocated to this challenge.

5.3 Academic partnerships in France

A policy of **association at the level of research units** is one of the instruments preferred by INRA in its institutional partnerships, and it can be achieved in two ways: by means of Joint Research Units (UMR) and Contract-Based Research Units (USC). A Joint Research Unit (UMR) is a structure that is common to all the partners involved. Based on a joint strategy and scientific project, the partners are committed for a period of four years. Contract-Based Research Units (USC) are designed to formalise more targeted research collaborations, which may be limited to a team within a unit from a research institution other than INRA.
INRA is developing its partnership policy in line with changes to the national research landscape.

[12] FPRD: Framework Programme on Research and Development (European Union).

The specific challenges that lie at the heart of INRA's mission, and its increased needs for engineering skills, mean that three types of academic partnership may be organised.

a. A consortium project to strengthen alliances with agricultural and veterinary schools

This recent initiative arose from the need to sustain teaching in **disciplines that are not covered by universities**, such as agronomy, animal husbandry, veterinary sciences or quantitative genetics.

A second reason underlying this project is the importance to INRA of **systemic approaches**, which are well integrated in the curricula of engineering schools.
The transformation of knowledge acquired in laboratories into **know-how**, and then its dissemination to those not attending courses for training in research, can also be anticipated from this alliance.
Furthermore, this project should facilitate the **transfer of innovations** through an improved interface with partners in agricultural development.
Finally, the consortium allows the French system to propose **full and competitive training at an international level**.

An historic and structural partnership undergoing change

Collaboration between INRA and advanced agricultural and veterinary training schools takes the form of 85 joint research units, which involve 1500 INRA researchers and engineers, and 430 teacher-researchers from these schools.
So as to better federate these links at a local level, INRA is directly involved in the structuring of seven **skills clusters** focused on sciences and technologies in the life sciences and the environment, which were initiated in 2004 by the Minister for Agriculture.

Current changes
The seven sites (Ile-de-France, Montpellier, western France, Rhône-Alpes and Massif-Central, Dijon, Lorraine and Toulouse) are thus gradually organising specialised higher education courses in new EPSCP (Public Scientific, Cultural and Professional Establishments). These are coordinated locally with universities and research agencies in the skills clusters in which INRA participates.
To guarantee national coherence for this system and prevent any overlaps, to promote the exhaustiveness of research and to optimise synergies, a **consortium** is currently under discussion. This Public Establishment for Scientific Cooperation (EPCS) could group INRA, CIRAD and the EPSCP (as they are gradually set up). The consortium has been given three targets: to improve the performance of the national system for research and agricultural training, to enhance its visibility and capacity for international action, and to mobilise new scientific skills in these fields.

b. Targeted and strategic links with universities

INRA has reviewed its **alliances with universities** based on a strategic analysis performed by senior managers from these establishments **and the shared interests** it highlighted. This led to a joint agreement to discontinue, maintain or strengthen - depending on the circumstances - previously established collaborations. Collaboration now takes the form of a contract that binds the partners while respecting the independence of all parties, and specifies programmes and resources for each joint or shared research unit.
In addition, an in-depth analysis of all the 109 **doctoral schools** in which INRA teams participate led to the view that seven of them are of strategic importance and should thus receive particular support from INRA (see Chapter 9.3.).
Finally, INRA offers universities its support to ensure the synergy of research exploitation in the particular field of agriculture.

Ongoing partnership initiatives

RTRA (Advanced Thematic Research Networks) are designed to group top-level researchers around a precise scientific theme so that they can carry out internationally-recognised projects of scientific excellence. Of the 13 RTRA retained to date, **four involve INRA** as a founder member: • Agropolis Foundation, focused on agricultural research and sustainable development, which involves teams from Montpellier and Avignon, • the Paris Economics School, • the Economic Sciences School in Toulouse, • Therapeutic Innovations and Infectious Diseases, managed by the Ecole Normale Supérieure in Lyon.
The Agropolis Foundation is distinct because it is wholly dedicated to an agricultural theme, and thus receives a major contribution from INRA in terms of permanent staff. It is thus one of the driving forces behind closer links with CIRAD and Montpellier SupAgro.

INRA is currently drawing up agreements with universities and **PRES** (Higher Education and Research Clusters), depending on the activities they share. These agreements also describe the strategic analysis shared by both parties, which is then specified for each research unit concerned.

51% of the doctoral students hosted in INRA laboratories are enrolled in ten doctoral schools, the others being spread between 99 other institutions. Since the summer of 2006, a new law has offered research organisations an opportunity to be associate members of **doctoral schools**. This new provision means that it is possible to envisage the development of training and research policies in partnership. INRA has decided to become an associate member in seven of these doctoral schools, and talks have been initiated with the university partners concerned, at the rhythm imposed by the waves of contractual arrangements agreed with the government.

The AGROVALO system provides support to synergise **the economic exploitation of research results** in the field of agriculture: proposed by INRA to its partners in order to protect patents and to search for license holders, it combines technical support at a local level with strategic assistance at a national level.

c. Structuring partnerships with other research agencies

In December 2008, INRA shared 44 Joint Research Units with other research agencies: thirteen with CNRS, eleven with CIRAD [13], six with IRD [14], and three with INSERM [15].
These structural collaborations are supplemented by incentive programmes, limited in duration and funded jointly by the partners. Thus a programme has been set up with Institut Pasteur on emerging diseases, another with INSERM on human nutrition and a third with INRIA [16] on modelling. The aim of these programmes is to encourage researchers to work together with a view to developing new networks.
Of these collaborations, that with CIRAD, with which strong institutional relationships have developed, is of particular importance because of the changing stakes of agricultural research. Another specific point concerns collaboration between different agencies in the field of food and nutrition, with the introduction of a thematic institute on "Circulation, Metabolism and Nutrition", which is coordinated by INSERM and INRA.

Closer links with the French Agricultural Research Centre for International Development (CIRAD)

The closer links initiated at the end of 2006 by INRA and CIRAD were based equally on the history and strength of these relations and on observations as to their insufficiency. Despite eleven Joint Research Units (UMR), most of them based in Montpellier, any collaborative efforts benefited from little visibility.
Closer links have thus been ensured in several ways:
• the approval of joint scientific projects concerning areas of shared interest and requiring a collaborative approach: forests, emerging diseases, horticulture, animal production, regional management, biomass for biofuels and green chemistry.
• joint foresight studies on farming and food systems at the horizon of 2050 (Agrimonde), which gave rise to the joint organisation of a major international meeting on June 3, 2008.
• the creation of a Public Interest Group (GIP IFRAI), the French Initiative for International Agricultural Research, which will soon be included in the consortium referred to above.

The example of Centres for Research in Human Nutrition (CRNH)

Centres for Research in Human Nutrition (CRNH) are essential to assessing the final effects of food and nutrition in humans. These investigative tools enable very detailed analyses of biological parameters, body composition and energy expenditure in response to diet. The four Centres for Research in Human Nutrition set up in France are all linked to nearby research and clinical units. They are run in partnership by clinical teams (INSERM, University Hospitals) and research teams from INRA and the universities. The areas covered by CRNH are complementary, and they enable a novel, high-performance, technical and thematic approach to research in the area of nutrition. It is possible to carry out observational or interventional epidemiological studies, and targeted, case-controlled nutritional procedures with the precise phenotyping of subjects based on variations to biological and metabolic parameters in response to diet. The centres also provide an excellent opportunity for joint discussions, exchanges and training for both researchers and clinicians.

5.4 International partnerships

INRA encourages its research teams to develop international partnerships in the context of scientific projects. But however interesting these may be, such initiatives alone clearly cannot constitute the Institute's international policy. Thus priorities have also been established regarding institutional support for alliances.

Overall, INRA's international partnership strategy results from its main **scientific priorities**, its choice of **thematic priorities** and **geostrategic perspectives**. Institutional partnerships are thus sought in the Mediterranean region, and in emerging countries such as China, India and Brazil; these are both essential actors from a scientific point of view and countries that are facing major problems with respect to the three areas of agriculture, food and the environment.

• In the **Mediterranean region**, the population is set to increase by more than 100 million over the next 30 years, which will pose problems of food resources in its southern and eastern parts. Faced also with important results of climate change, the vulnerability of its natural resources (water, soil, biodiversity) and numerous conflicts, this part of the world must seek to achieve

13 CIRAD: French Agricultural Research Centre for International Development.

14 IRD: Institute of Research for Development.

15 INSERM: National Institute for Health and Medical Research.

16 INRIA: National Institute for Computer Science and Control.

agriculture that is more productive, more autonomous and more environmentally-friendly, that can only be developed through the coordinated efforts of agricultural research.

• **Emerging countries** (and particularly China, India and Brazil) are confronted by rising demands for productivity, linked notably with a strong and rapid transition in dietary behaviour and growing aspirations of the population for a diet that contains more meat, is more diversified and much more calorific, thus causing major dysfunctions (obesity and diabetes) that still coexist with phenomena of under-nutrition. These demands are in conflict with the vulnerability (and, particularly in China and India) the rarity of natural resources, land and water.

a. In the Mediterranean region and emerging countries

In order to ensure global perspectives and visibility, and to implement its strategy, INRA has developed partnerships with other French research organisations involved in international collaborative efforts, and notably CIRAD.

■ Cooperation in the Mediterranean region

The **ARIMNet** project, funded by Europe and managed by INRA, is designed to coordinate national agricultural research programmes in the Mediterranean region. This project is the driving force behind development of the combined research force that will be essential to take up the challenges of the considerable diversity of Mediterranean agriculture.

Launched in November 2008, ARIMNet involves thirteen partners:

INRA and CIRAD from France, and the others from twelve countries: six EU Member States (France, Italy, Spain, Portugal, Greece and Cyprus), two associate countries (Turkey and Israel) and four countries from the southern Mediterranean rim (Egypt, Tunisia, Algeria and Morocco), for a period of four years.

ARIMNet should ultimately ensure the greater efficiency of agricultural research on issues concerning Mediterranean agriculture, thanks to an improved sharing of the stakes and orientation towards subjects of common interest to all the parties involved, which include the management of natural resources such as water and land, emerging and invasive diseases, the health safety of foods and rural development.

■ Cooperation in emerging countries

INRA has signed cooperation agreements with several emerging agricultural powers: China, India and Brazil. Partnerships have been consolidated, notably through the implementation (in China, Brazil and India) of permanent offices shared by INRA and CIRAD. These are responsible for assuring a watch on scientific and agricultural policies, thus enhancing our knowledge of these countries.

A joint call for tender was issued in 2008 with the State of Sao Paulo Research Foundation (FAPESP) which represents more than 50% of **Brazilian** research.

Two joint laboratories have been set up with the Academy of Sciences in **China** in the fields of animal biology and stem cells, on the one hand, and the genetics and genomics of wheat on the other.

Several projects have been initiated between INRA and various institutions in **India**, with particular emphasis on the issues of water, plant biotechnologies and human food and nutrition.

b. Insufficient visibility in international institutions

Through their units or divisions, INRA **researchers** are generally closely involved in international scientific initiatives, such as international consortia on plant animal or microbial genomics, or international structures focused on a specific field; for example, the International Foundation for Livestock Production, or the European Forest Institute (EFI).

INRA scientists have also contributed to some major international debates; for example, production of the last IPCC report.

However, INRA's involvement as an agricultural research institution remains limited, because it is not consulted, and thus does not participate, in most world forums. Nor is INRA represented in the consultative bodies of major international organisations such as UNESCO, FAO, FIDA, or PAM.

INRA's participation in the IAASTD (International Assessment for Agricultural Science and Technology) can be considered as the first institutional and structured intervention by the institution at this level (see box below).

Finally, the CGIAR (Consultative Group on International Agricultural Research) has now entered a phase of total reorganisation. This will lead to a repositioning of the terms and types of partnerships for all French agencies belonging to the CRAI (the commission that coordinates the French approach to the CGIAR). INRA's participation in such bodies will thus become essential.

INRA's involvement in the IAASTD

Between 2005 and April 2008, the World Bank, with the support of the FAO, UNEP, UNESCO, and certain countries, including France, carried out the International Assessment of Agricultural Science and Technology for Development (IAASTD). Some 400 scientists, representing different parts of the world, assessed the scientific advances achieved in agriculture and considered possible options for the future, comparing them with the Millennium Development Goals.
The originality of IAASTD was that its management associated both governments, scientists and economic and social actors, all of whom will ultimately benefit from agricultural research.
The timetable included periodic meetings for the authors of the final report, as well as encounters between authors and "reviewers", once or twice a year, in places chosen to reflect a balance of the regions concerned. One of these meetings was held at INRA, on January 9-12, 2006. INRA was also involved in coordinating the participation of French experts (some twenty French scientists from CIRAD, IRD and INRA) and funded this commitment.
In its foresight study on agricultural and food systems at the horizon of 2050 (Agrimonde), INRA was able to draw upon the links established through its participation in the IAASTD and the issues debated during this project.

6. A partnership approach in support of socioeconomic development

One of the originalities of INRA is the **longstanding and explicit importance of socioeconomic partnerships** to its scientific strategy. This approach is based on five objectives:

- **joint development with partners**: this interaction concerns not only the use of research results, but also the joint design of research projects and the involvement of all partners in their implementation. The translation by researchers of the priorities of stakeholders gives rise to research topics and subjects often considered as novel when compared with the issues raised by the disciplines themselves. This high degree of collaboration also enables a clearer understanding of our partners' operating systems, so that they can be oriented if necessary to increase the efficiency of the dissemination of results. An illustration of this approach could be the programme for the eradication of scrapie, described in Section 6.1.
- **the federation of actors at the level of pre-competitive research**: the second characteristic of this approach is that it ensures the optimum federation of partners around major economic issues, preference being given to investment in programmes that are far upstream of the economically competitive stage. INRA thus federates seed producers, often in the form of Scientific or Economic Interest Groups (Promaïs, Promosol, Protein seeds, Soy) in order to breed the best possible plant materials for shared objectives. This method enables both the spread of new methodologies and the creation of advanced materials without placing companies in competition between themselves, and also prevents the dilution of efforts that would arise from an overlapping of numerous programmes.
- **the promotion of public goods**: the third ambition consists in preferring the promotion and widespread use of public goods in order to situate advances in agriculture on the broadest possible foundation of shared resources, know-how and knowledge.
- **compensation for market deficiencies**: after rigorous analysis, INRA may decide to commit itself to a programme that benefits from **no upstream industrial partner**. Indeed, numerous issues may be neglected by industrial actors, simply because the market they generate is insufficient (e.g. environmental challenges, but also aromatic plants or sheep farming). In some cases, such deficiencies may also arise from the insufficient organisation of producers.
- **the expression of medium and long-term objectives**: finally, INRA's role is to anticipate and encourage a long-term view, even if an objective is not a current priority for its partners. At a time when the issue of climate change remains poorly defined, this approach can cause tensions that need to be overcome.

INRA is active in an environment that is marked **by the very weak Research and Development capacity of its industrial actors**, whether these are micro-businesses (i.e. the 400,000 professional farms) or SME (which account for the great majority of the 4500 companies active in the food sector). Although this sector is highly fragmented, it is nonetheless one of the most important in France in terms of its economic importance and performance. In addition, although INRA's partnership culture has historically been developed with both agricultural and industrial producers, the Institute is also open to partnerships with associations, notably in the areas of environmental and regional development (described in sub-section 6.3).

INRA's involvement takes the form of different types of partnerships, depending on the industrial actor concerned:

- **the first part of this chapter** presents the support it provides through different types of transfer, often via its relationships with technical centres, to the 400,000 **farms** that must adapt their crop management sequences in order to achieve competitive and sustainable agriculture.
- the implementation of valorisation policies that allow it to disseminate its innovations and knowledge to **companies**, both SME and major agro-industrial groups, whose activities lie within the scope of its research. These policies are described in the **second part** of the chapter.
- The report then presents an analysis of the organisational processes prevailing in different regions, focused not only on economic challenges but also on social or ecological issues, so that **regional or local actors** can be offered opportunities for development.

6.1 Partnership with the farming world

a. Intervention strategy

A continuum exists between a **farm** faced with complicated local dynamics, and the **planet** affected by considerable price volatility, where agricultural products and inputs circulate at a considerable rate.

For this reason, INRA must contribute to understanding these processes and provide solutions to problems that arise at different levels, through the application of a variety of methods.

Macroeconomic issues are studied by some INRA research units which, beyond the academic data they generate, also provide expert advice that is acknowledged by both French ministries and the European Commission. These units indeed collaborate with international organisations and agencies in many countries. In addition, their researchers are often asked for advice by those managing French agriculture regarding the development of specific policies.

Farms are micro-businesses that need to adapt their practices to concomitant, rapid and profound contextual changes: not only in terms of dietary habits and relationships between rural and urban communities, but also with respect to environmental issues in the context of constantly-changing regulations, aid policies or tax arrangements.

Partnerships with agriculture are also characterised by the **increasing importance of new actors in transfer**. There has indeed been considerable change since the 1960s (when INRA scientists were directly involved in developing industrial sectors) to partnerships for orientation and research, more or less directly applicable depending on the sector. Thus the animal production sector remains the most strongly integrated, while the major technical institutes are now the most powerful actors in the plant production sector. Under this partnership system, relationships with cooperatives, which remain important actors because of their influence on farming practices, have historically constituted a weak link in relations with public research. Through major targeted programmes, INRA is now trying to involve them in its work. Overall, the partnership system has generated numerous innovations that will be considered later in this document.

b. Implementation and achievements

Faced with these changes, INRA has developed new methods for its partnership collaborations:

- by encouraging the cross-over participation of professional representatives and INRA scientists in the bodies running these organisations and the Institute, and also by hosting engineers from these organisations in INRA laboratories;
- by promoting new forms of cooperation with Chambers of Agriculture and cooperatives: e.g. transfer partnerships, work in networks, opportunities for cross-over meetings;
- by initiating federative research programmes focused on agricultural sectors, in order to reconcile the objectives of productivity, product quality and environmental excellence. From their inception, these programmes involve all professional partners (technical institutes, Chambers of Agriculture, professional associations) and are also open to young and innovative service-providing companies. Inevitably, these efforts require a considerable investment in terms of management.

Some types of collaboration with the farming world

The cross-over participation of professional representatives and INRA scientists in the bodies running these organisations and the Institute: for example, Centre Presidents or regional INRA delegates participate in regional research and development committees of the APCA (Permanent Assembly of Chambers of Agriculture) and numerous INRA scientists are members of the Scientific Advisory Boards of Technical Institutes; in return, representatives from the associations that coordinate Agricultural Technical Institutes (ACTA) and Food Industry Technical Institutes (ACTIA), and a representative from the APCA, sit on the INRA Board of Directors. These relations improve reciprocal knowledge of research activities and professional concerns.

The hosting of development engineers paid by INRA was initiated in 2006. These engineers are assigned for a three-year period to a project of interest to both INRA and their organisation of origin. The career outcomes of the first three engineers concerned have been encouraging: one has created a start-up company; another will be joining INRA while continuing to work in collaboration with his previous employer.

Joint Technology Units (JTU) and Joint Technology Networks (JTN) are two new forms of partnership created by the Agriculture Orientation Law of 2006. They are designed to constitute operational and expert clusters that group research, development and training together. INRA has seized this opportunity because it enables the formalisation and structuring of existing or new links with technical institutes affiliated to the ACTA or ACTIA, with Chambers of Agriculture or with agricultural cooperatives. 62 INRA units are involved in this new type of partnership arrangement.

Agro-transfer projects, developed at the initiative of INRA and regional Chambers of Agriculture, create links within a region between the principal partners concerned by agricultural development (local breeding establishments, technical institutes, regional government bodies and institutional partners such as Regional Councils). They provide an opportunity for the exchange of views and the development of diagnostic tools, and provide advice and training that is available to all parties. Three agro-transfer projects have been set up in Picardy, Poitou-Charentes and Brittany. The project in Picardy has generated the most results so far.

Research programmes on integrated production systems were first launched during the early 2000s: "Green Piggery" and "Integrated Fruit Production". In a slightly different form, the concept was applied in 2007 to the integrated production of legume crops. This federative programme aims to generate the knowledge necessary for the development, implementation and assessment of integrated production systems, both in the field and under cover, that preserve environmental integrity and ensure the quality of products for consumers. Two other programmes, on arable crop **systems and animal production, are currently under study.**

The CIAG (Crossroads for Agricultural Innovation) were initiated by INRA in 2007. By means of direct exchanges between scientists and professionals, the aim is to generate a coherent series of analyses, innovations and recommendations on a complex subject. These meetings result in the publication of summaries in the form of an electronic journal, and an internet discussion forum. Three Crossroads were organised over an 18-month period, and this half-yearly rhythm should be pursued. In addition, INRA organises **annual meetings** with actors from different sectors.

c. An illustration of the strength of INRA's partnership strategy

The concept underlying the management of research partnerships at INRA is the conviction that there are many sources of innovation, and it is hoped that this method will produce pertinent responses to socioeconomic issues, facilitate the transfer of knowledge, and exert positive impacts at the economic, social and environmental levels. The robustness of this strategy has been proven on numerous occasions. The case described in the box below demonstrates the benefits of this method to actors in the sector, and the positive feedback achieved regarding both research and public policies.

The programme on genetic improvement for resistance to scrapie: an example of an efficient research and development system

This programme has been an essential player in the global fight against scrapie, a disease affecting sheep and goats. Initiated in 2002 for an 8-year period, it is funded by both the French Ministry of Agriculture and the European Union.
The programme is based on exploiting the polymorphism of the major gene PrP that ensures more or less strong resistance to scrapie. The general principle is that the use of rams that are homozygous for one of the PrP alleles (called ARR) rapidly ensures considerable protection for a herd against scrapie.

Partnership arrangements associating all actors:
The steering committee, chaired by the Ministry of Agriculture, contains professional representatives from the sheep and goat sector, researchers from the reference laboratory for PrP genotyping (LABOGENA), INRA and the Breeding Institute.
The strategic choice of this programme was to base it on existing breeding schemes, and thus involve the **actors most competent in the genetics of sheep and goats**. The aim was to introduce this improvement in resistance into breeding herds, after which it would be disseminated throughout the French sheep and goat populations; these breeding schemes thus represented about 2000 farms and 600,000 ewes.
The animal breeders were given four objectives: (i) to eliminate the VRQ susceptibility allele; (ii) to supply resistant rams (ARR/ARR) to herds affected by the disease; (iii) to increase the frequency of the ARR resistance allele, and (iv) to supply resistant rams (ARR/ARR) to livestock production units.

Spectacular results for the sector:
After 6 years of application, the **scrapie resistance** of animals active in breeding schemes has evolved in spectacular fashion: the susceptibility allele has been eliminated and an average 45% increase has been achieved in the incidence of the resistance allele in breeding rams. In addition, 95% of the 850,000 artificial insemination procedures performed in France now involve ARR/ARR-resistant rams. Finally, one major priority of the programme has been achieved, in that breeders are now able to supply resistant animals to repopulate farms affected by scrapie.
To a considerable extent, the efficiency of this breeding programme has been based on the excellent relations existing between different actors in research and development. This was ensured by a monitoring committee involving INRA, the Breeding Institute, France UPRa Sélection and the Ministry of Agriculture, whose technical and regulatory proposals to the steering committee integrated the scientific findings available.

Positive feedback for research and public policy-making:
Full scientific data on the PrP gene were not yet available in 2002. Because of the urgency of the situation, initiation of the programme had to be accompanied by precautionary measures, such as the storage of semen from elite rams by the National Cryobank. The data accumulated during the 2000s from breeding herds provided an opportunity for the **large-scale validation of scientific hypotheses**, such as the absence of a link between the PrP gene and production traits.
Similarly, this unique and large-scale breeding experiment on a major gene led to the emergence of new issues, such as study of the effects of rapid gene selection on the global genetic variability of populations.
Finally, the close links between the scientific and technical considerations in play also made it possible to **answer certain regulatory questions**, regarding both health policy (the need to take account of the PrP genotype in affected herds) and food safety (legislation on high-risk materials).

6.2 Partnerships with companies

To encourage innovation in all its areas of intervention, INRA's policy is based on five key principles:

- The aim is the **transfer to industry of all innovations**, without priority being given to the potential for a financial return to INRA. Some of INRA's results (know-how) become public assets, promotion of which will maximise the utility of research. Indeed, a company may not always be the best vector for transfer; in certain cases, this may be an ad hoc grouping of producers. Some innovations are of insufficient economic value to justify industrial investment, but they could be exploited through the involvement of actors in agriculture. One example of this situation is organisation of the cattle and sheep breeding sectors (cf. above).
- With respect to new plant varieties, INRA seeks not to **enter into competition with sectors where companies are active**. On the other hand, INRA can and must intervene when it is necessary to anticipate change. Thus INRA's role is not necessar-

ily to develop competitive wheat varieties, but it must prepare the genetic groundwork that will facilitate the emergence of hardy varieties.

- In this area, INRA supports French policies regarding the patentability of living organisms which can **reward research without the ownership of genetic resources**; the triple claim thus concerns a sequence (and not a genome) for a function and an application (proof obtained *in vivo*).
- When challenges are of a widely-shared nature, INRA tries to **federate all the industrial actors concerned** as from the design of programmes, and seeks to develop patent portfolios at a relevant scale, thus facilitating their future exploitation.
- Projects on valorisation in agriculture and the agro-industries generally require a **long period to reach maturity**, with numerous assessment and appropriation phases. Aware of these problems, but also of the development potential of biotechnologies, INRA provides support for young, innovative companies in the exploitation of its patents.

In support of this strategy, INRA dedicates methods and resources to innovation and cooperation with companies, and efforts are made to ensure that its intervention will take account of the growing importance of regional campuses.

a. Research partnerships

■ A partnership for the strategic management of intellectual property

INRA promotes the development of tools that combine scientific knowledge and intellectual property. In the context of a strategic analysis, this type of tool can be of assistance in positioning research upstream, thanks to information on intellectual property. It may thus be possible to avoid fields where exploitation may be restricted or blocked by existing patents. It also enables the recognition and grouping of patents in packages to facilitate their exploitation.

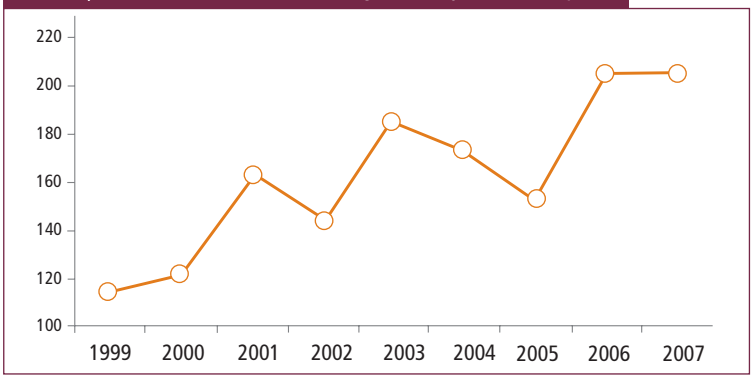
EPIPAGRI: a programme targeting patent and IP packages

The European EPIPAGRI project is coordinated by INRA and comprises ten European, public-sector research organisations as its Founding Partners. Its aim is to develop a Europe-wide database of patents and IP from public holders. In this database, patents are grouped by technology so that they can be used together to master major projects based on emerging technologies with high economic potential. In parallel, the network is working on defining a contractual framework for the holders of different patents belonging to these categories, so that appropriate licenses can be granted. Another European project, TRANS2TECH, which is also coordinated by INRA, will provide a portal to technology opportunities developed using patented results. The European EPIPAGRI project also includes watch functions accessible to all, and particularly to industrial customers.

■ Cooperation on research projects

This is characterised by the early-stage and federated involvement of industry. Research contracts reflect the contributions of all parties, and the arrangements that are necessary with respect to confidentiality, industrial property and publications.
In 2007, 205 research contracts were signed with the private sector, in line with a medium-term growth trend.

FIGURE 1 | Number of research contracts signed each year with companies



These collaborations are usually of relatively short duration, in most cases between 1 and 3 years.
However, there are some exceptions. For example, in the field of plant breeding, the cost and complexity of research on genes of agronomic interest means that this work is now carried out in the context of international collaborations, in both the public and private sectors.
The emblematic example of this trend is the **Génoplante** programme which was initiated in 1999 in order to provide France with a global, coherent and competitive system for the **study of plant genomes and exploitation of its results**. This project associates both public and private sector partners.

The Génoplante programme: a pre-competitive partnership associating public research, major industrial groups, SME and farmers

Set up early in 1999, Génoplante is a major federative programme on plant genomics that associates public sector research (INRA, CIRAD, IRD, CNRS) and private companies involved in plant breeding and crop protection. Two major industrial groups (Biogemma, Bayer-Cropscience) and one SME (Bioplante) have also participated in this programme.
This collaboration has enabled the emergence of a scientific community worthy of the stakes involved, with the pooling of molecular and biological resources and the production of results that confirm the competitiveness of French teams. Indeed, this French programme very rapidly established links with the German programme GABI, and then with a Spanish partner.
During the first phase of the programme, the aim of its partners was to develop analyses of the genome of five major species cultivated in Europe: maize, wheat, rapeseed, sunflower and pea, to protect the knowledge thus acquired through a competitive portfolio of patents, and to offer seed producers new opportunities for the breeding of varieties.
Since 1999, Génoplante has launched 300 projects, 40% of them (121) as public/private partnerships and 11% (33) in partnership with Germany or Spain. From a scientific point of view, the programme can claim 310 publications in peer-reviewed journals, and it has hosted 20 doctoral students. Its results take the form of 36 patents, 33 software programs filed with the Agency for the Protection of Programs and database applications, three commercial licences, 24 licences on BAC databanks and DNA collections and nearly 30 academic licences on software programs.

■ Training through research

In 2007, INRA hosted 20 new CIFRE doctoral students (under contracts with industry for training through research) and 13 new doctoral students whose theses were jointly funded by a company (INRA-Industry grant). These figures are stable over the long term, but lower than might have been anticipated. A study is therefore under way to understand the factors determining this situation.

b. Methods and partnerships for transfer

INRA exploits its research in the form of industrial and commercial operating licences via three lead products: patents and software; secret know-how and new variety certificates for plants.

■ Two subsidiaries for exploitation

Two independent subsidiaries, 100% owned by INRA, have been set up: Agri-Obtentions for the exploitation of plant innovations and INRA Transfert for patents, know-how and software.
Royalty payments from these two subsidiaries cover all the costs relative to exploitation: patent fees, licence brokerage fees, licence management costs, payments to laboratories and profit-sharing for researchers. The strategic choice of management through two independent subsidiaries was based on the conviction that to be pertinent and efficient, these activities needed to be managed with private actors in a shared context. It is also the only way that the rare professional skills necessary can be recruited and retained in the long term, in this highly competitive field of intellectual property management.

INRA Transfert, the reference for the exploitation of innovations in agriculture

A 100%-owned INRA subsidiary, INRA Transfert's missions are to advise the Institute on the exploitation potential of its inventions, to seek for and negotiate licensing agreements with companies on technologies arising from INRA laboratories, and also to provide support for the preparation of large-scale, European, national or regional collaborative research projects.
INRA Transfert exploits and manages INRA's technology portfolio:
- through operating agreements with industry,
- by supporting the development of innovative start-up companies,
- and by supporting preliminary end-use evaluation programmes.

These activities draw strength from the network of in-house skills available at INRA, such as: partnership managers in each scientific division, who constitute an essential link with research laboratories; INRA legal experts for the compilation and negotiation of contracts, and the Institute's researchers, engineers and technicians.
In 2007, INRA filed 21 new patent applications and 23 new software programs and databases.

Agri-Obtentions, the reference in seed breeding for sustainable agriculture

Agri-Obtentions is the 100%-owned INRA subsidiary responsible for the dissemination and exploitation of new plant varieties bred by the Institute. It holds a portfolio of more than 450 varieties covering ten different groups of species (cereals, forage crops, vegetables, fruits, ornamentals, vines etc.) that can respond to specific demands for specialised, high-quality plant production.
INRA protects its new varieties with New Variety Certificates (*Certificat d'Obtention végétale, COV*), that constitute intellectual property for a cultivated variety, and include privileged access for the breeder and farmer. Agri-Obtentions sells commercial operating licences for new INRA varieties to seed companies and plant breeders. Its strategy consists increasingly in exploiting research results by promoting varieties that will contribute to the development of sustainable and multifunctional agriculture, taking account of new demands for quality, consumer safety and protection of the environment.
The dissemination of products to farmers is based on a marketing strategy that involves numerous partners both upstream and downstream in each sector:
- determination of the performance of varieties with technical institutes,
- adaptation to different regions by Chambers of Agriculture and the Technical Departments of distributors,
- multiplication and marketing by partners: plant and seed producers,
- supply of farmers via distributors (cooperatives and trading companies).

At each stage of development, the different actors contribute their expertise and provide support for the transmission to farmers of genetic advances by means of new varieties.

A system focused on preliminary end-use evaluation

The maturation of research results (ideally, protected by patents) is a key stage in improving their attractiveness and their subsequent appropriation through exploitation with existing companies or via start-up enterprises.
This stage needs to be funded from the public purse because it necessarily precedes any search for a partner.
Three types of access to public funding are used by INRA: (i) calls for projects in different regions, funded by joint structures with universities, (ii) calls for projects by the ANR, dedicated to the biotechnologies, and (iii) annual calls for funds from INRA (with the support of the Ministry of Agriculture in 2008). These methods enable the upstream detection of research results that could give rise to subsequent exploitation.
This system, introduced in 2007, was increased during the first months of 2008. It met with considerable success, because 37 projects were submitted and ten were finally chosen for funding in 2008. This exercise will be repeated regularly in order to regenerate the production of innovations that could also result in the creation of companies.

Mutual efforts with respect to transfer: the national AGROVALO system is based on regional, thematic platforms that form part of joint university networks

INRA has positioned itself as the structure of reference for the exploitation of agricultural research, by placing its legal and exploitation skills at the services of the principal agricultural and veterinary schools and universities.
Thus Montpellier SupAgro, the INRA Centre in Montpellier and the subsidiary INRA Transfert SA have pooled their efforts to offer research units, in both the centre and the school, joint facilities to enable the exploitation of research. The AgroValo Méditerranée project has been set up to provide a simple response, via a single portal, to the needs for the pooling of resources by partners (external and internal) with respect to transfer and exploitation in the agricultural sector (in its broadest sense). Another platform, AGROVALO West, is currently being set up in Rennes.

ABA, a new tool introduced in 2008 to prolong the preliminary end-use evaluation stage and accelerate development of the best projects at the pre-seed capital stage

Drawing strength from its ability to identify and detect some thirty potentially innovative projects in different sectors of agricultural research, INRA succeeded in convincing a venture capital company to become involved at the pre-seed capital stage, so that the most promising start-ups would receive additional support.
ABA was thus set up in November 2008 as a partnership between INRA Transfert and the venture capital company Seventure. This company aims to examine a dozen projects each year and fund two of them during the pre-seed capital phase. This arrangement, dedicated to agricultural research, is an innovation in the French public research landscape.

6.3 Partnerships with regional actors

The strength of INRA's regional roots means that it is one of the principal public research actors in many regions and is closely involved in regional development and competitiveness policies, as incarnated by **State-Region project contracts**, as described in the first paragraph of this chapter, below. INRA's considerable experience in regional partnerships indeed became a research topic in the context of the **"For and On Regional Development" programme** *("Pour et Sur le Développement Régional", PSDR)*, which resulted in changes to its scope. Another development concerns the contribution of INRA to the recently-founded **competitiveness clusters**.

a. State-Region Project Contracts 2007-2013

French **State-Region Project Contracts (CPER)** lay down the programming and funding for several years of major projects such as the creation of infrastructure or support for potentially innovative sectors. This system may benefit from supplementary funding from Europe, if the projects covered by a CPER are **mainly devoted to innovation, competitiveness or sustainable development**.

The signature of State-Region Project Contracts (CPER) for the period 2007-2013 was undoubtedly the most important feature in 2007 of relationships between INRA and regional government bodies. The projects put forward by INRA, developed in collaboration with other research and higher education establishments, aimed to provide priority support for the emergence, or consolidation, of **thematic clusters of European importance**, the international reputation of which would serve the interests of both the Institute and the regions concerned.

The Institute is committed financially to 32 projects being carried out in 20 different regions. Overall, these projects represent operating costs of about €138 million (incl. VAT) (or an average of nearly €20 million per year), €46.4 million of which is provided by INRA, the remainder mainly being covered by contributions from the regions and support from European structural funds.

The resources provided under CPER are mainly used for the joint funding of property or scientific equipment acquisitions. Thus 62% of expenditure concerns property investment operations for the construction or redevelopment of laboratories, but above all to modernise common experimental facilities and technology platforms; the share reserved for the acquisition of major items of scientific equipment (laboratories and platforms) is close to 30%, while other types of support for the joint funding of doctoral grants or research programmes account for about 8%.

b. The PSDR programme (For and On Regional Development)

INRA's shift in focus has meant that **agriculture is no longer considered as an isolated sector but one which has close links with regional development and management of the environment**. This observation has led INRA to broaden the scope of its collaboration beyond its historical partners (i.e. technical institutes and Chambers of Agriculture).

Some ***ad hoc* projects** have thus been initiated to give new impetus in a region around a particular sector, such as the research and development project associating three Départements in the Northern Alps Region that reinvigorated the manufacture of Beaufort cheese.

But the main provision that has mobilised regional actors is the **PSDR programme**, carried out in partnership with Regional Councils and designed to involve all partners in focusing on the regional and environmental dimensions of development. Projects are designed and constructed within the regions concerned, and directly linked to the concerns of farmers, while also involving local government officials, the managers of regional parks, regional government bodies and agencies for regional development or water management.

After two initial periods of implementation in three and then five regions, the programme was assessed and subsequently broadened to ten, voluntary regions, in compliance with the recommendations of the assessment committee. One of the programme's ambitions, and a current subject of study, is its extension to Europe, notably via the INTERREG and ERA-Net cooperation instruments.

Lessons learnt from external assessment of the PSDR programme

In 2005, PSDR, the programme "For and On Regional Development" was assessed by an external body in order to examine its contribution to actors in regional development, the quality and originality of the research issues addressed, the value and exploitation of its results, the quality of its organisation, and project management.
This assessment found that the approach had met research needs which could not be satisfied within INRA or by the Regional Council. The assessment committee also noted that within the programme, research teams had been reorganised to help them adopt a cross-disciplinary approach to the challenges of regional development and dynamism. It welcomed the generally good quality of scientific results and greater openness towards university communities, and the significant efforts made regarding exploitation and transfer.
However, the assessors noted the problems encountered in determining the scope of investigations outside the agricultural or agri-food fields. They recommended that greater attention should be paid to developing a shared regional diagnostic tool, to identify and classify issues pertaining to regional development and allow sufficient time for a true partnership in the construction of new projects. Finally, they suggested an increase in the dimension of projects, as this could encourage regional and inter-regional scientific cooperation programmes.

Taking account of this assessment in developing the third generation of the programme
The lessons learnt from this assessment were taken into account in the third generation of regional development support programmes that was launched in 2007 for a 5-year period. Thus PSDR 3 has been extended to ten regions and concerns more than 200 research teams (about half of them being non-INRA). Collaborations between regions and disciplines are more common, and greater importance is given to transfer and exploitation. Partners have also become more diversified: Chambers of Agriculture, producer associations, agricultural unions, technical institutes, teaching and training establishments, cooperatives, agricultural or agri-food enterprises, regional government bodies, regional natural parks, associations of town mayors, environmental protection associations, and regional bodies for the management of agriculture and the environment, etc.

c. Partnership with competitiveness clusters

The French policy concerning **competitiveness clusters**, initiated in 2004, was designed to enable the association of enterprises, research centres and training organisations within a given region and committed to a common strategy concerning **innovative projects**, carried out in collaboration and **targeting a specific market**. Because of its research objectives, INRA was involved from the start in these clusters, often in areas where strong links already existed between the Institute and its industrial partners. INRA set up a system to create links via centre presidents with respect to geographical and thematic proximity with clusters, while efforts were made at a national level via a dedicated management unit. Today, INRA is a partner in fifteen competitiveness clusters.

INRA is a partner in 15 competitiveness clusters, two of which have world class status

In the plant sciences, the Institute is involved in the Végépolys (world class status), Céréales Vallée, Fibres Grand Est and XYLOFUTUR clusters. In the context of the "Industries et Agro Ressources" world class cluster, INRA has mobilised national teams on developing plant chemistry and the exploitation of agricultural resources at the service of the environment. In the field of food and nutrition, INRA is a partner in clusters that adopt a transversal (Valorial, Vitagora, etc.), sector-based (InnoViandes, the European Fruit and Vegetable Innovation Cluster), or integrated approach (qualified as an agro-chain) (AGRIMIP Innovation). In the field of biotechnologies, INRA participates in alliances between research on food and nutrition and the pharmaceutical industry (Prod'Innov), or clinicians (Cancer-Bio-Santé).
Finally, because of their recognised and specific skills, some research teams may become involved in collaborative projects organised by clusters, such as Nutrition Santé Longévité, Filière équine, Medicen, Tenerrdis, etc.

In 2008, the French government commissioned a national assessment of competitiveness clusters. The resulting report acknowledged the potential dynamism of these clusters, but underlined certain weaknesses in their governance, or the fact that some clusters addressed too many different areas without determining clear priorities. In this context, INRA is now reviewing its involvement in this recent partnership system for industry and research; the long-term future of this system now appears to be assured and it could broaden its ambitions to Europe and elsewhere in the world.

7. The adaptation of experimental facilities and the management of scientific resources

In order to ensure coherent foundations for the partnership dynamics referred to above, and the management of both its experimental facilities and its scientific resources, INRA encourages the specialisation of its centres around **thematic research clusters** that benefit from a higher degree of priority in terms of support and investment. This strategy is explained in the first section of this chapter.

The **experimental facilities** enjoyed by INRA have played an important role in its history by enabling the development of know-how and innovations that have are earned unquestionable recognition from the production sector. Indeed, experimental farms and estates, technology platforms and technical facilities enable **fundamental research** on a variety of animal, plant or microbial models. But even though laboratory tests are well-suited to the study of genes with major effects, **only trials under real conditions of use**, in the diversity of situations that characterise them, **can ensure a practical assessment of the agronomic potential of an innovation**. Experimental facilities thus constitute a novel tool for the conduct of such studies; not only on plants, animals and their products but also on the agricultural environment. The changes that have been made to these facilities to adapt them to new contexts, are presented in this report.

INRA experimental sites are spread throughout France, although their density varies from region to region. Nonetheless, they are highly representative of the agricultural and ecological conditions that prevail in France. INRA's regional roots have contributed to its maintenance of **genetic resources** that are now an envied asset. The Institute must exploit these advantages through strong policies on genetic resources, supported by faultless management of its **databases**. These policies are the subject of the last two sections in this chapter.

7.1 The gradual organisation of thematic clusters since 2005

INRA's policy is to develop **thematic clusters** that are competitive in national and European calls for tenders, visible and attractive to researchers throughout the world and benefit from original, high-performance technical facilities that enable them to publish their academic results in leading journals. The partnership dynamics referred to in the previous chapter, and the management needs for these experimental and scientific resources, are both beneficial to this **organisation**.
These are the objectives given to the 21 structuring operations that received support from the Institute during 2006-2009, supplementing the changes decided upon previously. These thematic clusters have benefited from priority support measures, notably in terms of investment (scientific equipment and property infrastructures), and guided negotiations concerning the State-Region Contracts for 2007-2013, inasmuch as these structuring operations accounted for two-thirds of the funding from regional development bodies for property investment.
This policy has enabled **the gradual development of attractive research clusters**, which are presented in Chapter 9.

Structuring operations

As a general rule, the dynamics of structuring operations involve reorganisation around a formalised scientific project, managed by a particular researcher and using shared infrastructures (laboratories, technology platforms, experimental facilities, etc.).
All these structuring operations have generally benefited from support measures in the context of the decisions taken by INRA's Management Board during 2006, 2007 and 2008. They involved 41% (or 115) of the 282 INRA research units, and between 2006 and 2008 they received 57.5% of the €10 million devoted by INRA to funding "major equipment".
In addition, 70% of the property investments made by INRA, in association with the Regions, have been devoted to these operations (State-Region Project Contracts; CPER 2007-2013).

7.2 The modernisation of experimental facilities

INRA recently initiated a programme to modernise its experimental facilities and associated equipment. The aim is to share resources as far as possible, and adapt to recent changes concerning the demands made upon INRA, to the openness of research at a European level, and to environmental concerns. The strategy followed is based on three principles:

- the need for INRA to **optimise** its experimental facilities (which have become unique in Europe) and to consolidate its management strategy for **genetic resources**;
- the essential need for these facilities to **adapt**, in the context of INRA's missions, to the new scientific, heritage, agronomic and ecological issues it must address;
- the urgency to **develop national platforms** alongside open, strategic, progressive and attractive technical and technology platforms that will respond to leading-edge investigative requirements.

A plan for the modernisation of experimental facilities

The 50 experimental units (EU) at INRA manage farms, experimental breeding units, collections for research, and above all rural areas and laboratories. They employ around 1150 full-time-equivalent staff, cover more than 10,000 hectares and are home to 94,000 animals.

The aim of the changes to the experimental facilities that were initiated in 2006 is to ensure advances in several areas: (1) the collection, conservation and characterisation of genetic resources; (2) the generation of data as a support for research; (3) environmental observations; (4) the breeding of species or genetic material; (5) the development and demonstration of new farming systems, and (6) the openness of these facilities, not only to all researchers but also to European partners in agricultural development.

These developments are being accompanied by changes to experimental practices and an *ad hoc* training plan.

In addition, greater attention is now paid to the work of experimental units when research programmes are designed, and to the allocation of resources by divisions. The encouragement of joint funding and cooperation with research teams will create conditions that are more motivating for staff in the experimental units, and will ensure a more responsible management approach by research teams.

One illustration of this strategy can be seen in the field of **environmental observations**. Traditionally focused on increasing productivity, the missions of INRA's experimental facilities have now turned towards defining production methods that will contribute to the sustainable management of resources and natural environments, as well as agri-environmental observations and experimentation.

The research performed by INRA concerning agriculture, forests or lakes throws valuable light on the changes affecting our environment and their causal factors. INRA currently manages seven Environmental Research Observatories (ORE) that associate a network of several observation and experimentation sites. The principal areas of study are the biogeochemical functioning and fate of cultivated, grassland, forest and aquatic ecosystems, and agricultural catchment areas. A factor of particular interest is how production methods interact with climate change. The principal characteristic of these ORE is the conduct of long-term observations (at least ten years) to feed databases that are accessible to the scientific community.

Environmental observations on permanent grasslands at Theix-Laqueuille: a facility of European interest

Permanent grasslands assure important environmental functions: the control of erosion, protection of water quality, soil carbon storage and a habitat propitious to biodiversity. The "Agro-Ecosystems Biogeochemical Cycles and Biodiversity" ORE (ACBB) comprises two observation sites focused on permanent grasslands that form part of the LAQUEUILLE and THEIX Experimental Units (Massif Central).

The facility compares seven different management systems for grazing or cutting, each comprising four repetitions. The experimental plots are equipped with numerous instruments that enable the monitoring of changes to biodiversity, soil carbon and nitrogen dynamics, nitrate fluxes to groundwater and greenhouse gas balances. The frequency of measurements thus covers a broad range from 20 Hz (greenhouse gas fluxes) to three years (organic soil matter) and involves several hundred sensors.

These experimental platforms are open to the international scientific community for the conduct of research on the mechanisms involved in ecosystem functioning. They serve as a substrate for supplementary experiments, particularly those concerning the impact of climate change and extreme events. ORE data are stored in databases accessible over the internet, while samples (soil, plant powders, soil solutions) are maintained in collections.

Integrated in several European Framework Programmes (CarboEurope, NitroEurope, IMECC, CarboExtreme) and French projects run by the ANR (Biodiversity and VMCS), these sites have generated original results, published in leading international journals (including two papers in *Nature*).

7.3 Investment choices concerning major research infrastructure

The adaptation of resources to new scientific, heritage, agronomic or ecological challenges is one of the most important conditions to ensure the attractiveness and competitiveness of INRA. In this respect, agricultural research has several original features that must be preserved:

- Any discussions on the development of technology platforms, which necessarily require major funding, must be accompanied by a coherent policy for the **conservation** and preservation of resources.
- The second precaution is that these assets must be **shared** as far as possible so that they constitute both investigative challenges, and opportunities to explore the frontiers of science and achieve technological progress, insofar as these platforms are constantly evolving.
- Thirdly, INRA must ensure the **coherence of all these platforms** so that no preference is given to particular analytical approaches; indeed, efforts must be made to ensure the broadest possible capabilities for the exploration of living organisms. Thus, following major investments in sequencing, high-throughput genotyping (today restricted to two INRA platforms), transcriptomics (three platforms) and proteomics (the Mass'Prot INRA network), current investments are targeting metabolomics (two sites), tilling (three sites) and high-throughput phenotyping in platforms (four sites for plants) and also in the field (one site for plants).
- The fourth requirement is that resources must be available to **analyse data** as and when they become available, which supposes a reasoned organisation of data management, whether this concerns environmental or genomic and phenotypic data. For example, in the case of bioinformatics for the processing of genomic data, resources are focused on three sites of national importance (Jouy-en-Josas, Versailles and Toulouse) where INRA bioinformatics specialists collaborate with those belonging to the national ReNaBi network, alongside teams of genomics, genetics and ecophysiology experts.

To ensure the coherence of these policies regarding major research tools, a commission has been set up, the **CNOC (National Commission for Collective Tools)**. It visits sites and emits its opinions alongside those of the IBISA Scientific Interest Group, whose mission is of national stature. Finally, INRA takes initiatives at the European level to ensure the emergence of strategic platforms recognised by the ESFRI (*European Strategic Forum for Research Infrastructure*), managing projects concerning infrastructure for research in infectious animal diseases (NADIR) or the feasibility of infrastructure for the observation of agro-ecosystems (ANAEE), or participating in the ELIXIR European infrastructure project on bioinformatics (*European Life Sciences Infrastructure For Biological Information*).

Experimental animal resources unique in France and of European importance: INPREST (NADIR network)

INPREST (the French Protected Installation for Research on Transmissible Spongiform Encephalopathies) is a Biosafety Level 3 containment facility of 4120 m^2. It has been designed to carry out research on infections in small and large animals under production conditions where animals are the subject of long-term monitoring. INPREST can accommodate 128 sheep and 24 cattle under high security conditions. This installation is open to all teams working in research and higher education institutions in France. It can also be used by private sector partners. INPREST forms part of the European network of animal infectious disease platforms, NADIR.

7.4 Ensuring the security of genetic and genomic resources

Although INRA has not formally been delegated a public service mission regarding the conservation of plant, animal or microbial genetic resources, it contributes actively to implementing national policies in this field, which are now the responsibility of the Foundation for Biodiversity Research (FRB).
These actions take two forms: the conduct of **methodological research**, and a contribution to the **conservation of collections** of proven scientific value.

The Institute conserves and maintains numerous collections of plant, animal and microbial genetic and genomic resources. Because of these collections, it has become involved in the development of Biological Resources Centres (CRB), an activity that reflects INRA's commitment to quality and traceability in this area.

- INRA thus conserves important collections on several **plant species**: priority has been given to collections on model species (*Arabidopsis thaliana* and *Medicago truncatula*) and to several collections for which the Institute ensures European or inter-

national coordination: straw cereals, grapevine (the largest collection in the world), *Malus*, *Prunus*, citrus fruits, Solanaceae and grain legumes.

- Similarly, several populations of the main farmed **animal species** are conserved and analysed. The indexing policy set up with the help of INRA more than 40 years ago is today pursued by the Breeding Institute and professional associations, in close collaboration with INRA.
- As for micro-organisms, INRA groups its collections by theme on four sites: yeasts in Grignon, filamentous fungi in Marseille, food bacteria in Rennes and animal or human pathogenic bacteria in Tours at the International Centre for Microbial Resources (CIRM).
- INRA houses two centres for the conservation of genomic resources: the French Plant Genomics Resource Centre (CNRGV), and the Biological Resources Centre for the Genomics of Domestic Animals of Economic Importance (GADIE).

All materials are very carefully preserved and made available on request. To facilitate investigations by research teams, appropriate harmonised and complete databases have been developed.

The French Plant Genomics Resource Centre (CNRGV): a centre unique in France that is also an international reference

Set up in 2004 by INRA, and based at the Toulouse Research Centre, the CNRGV is specialised in the acquisition, conservation, validation, study and distribution of plant genomic resources, as well as the computerised data relative to these biological materials. The CNRGV is run by a highly-qualified team of engineers specialised in fields with complementary skills, such as microbiology, molecular biology, bio-robotics and informatics. The centre is equipped with the necessary tools for detailed and direct analysis of the genome, and is capable of very rapidly processing large quantities of data, thanks to cutting-edge technologies. The CNRGV has implemented a quality management system in accordance with ISO 9001: 2000 standards, for which it has been certified since 2005.

Since its creation, the CNRGV has collected more than 6 million samples of large DNA fragments from more than twelve plant species, notably grapevine, sunflower, tomato and wheat. The CNRGV is recognised as the European reference centre for genomic resources on alfafa, and the international reference centre for genomic resources on wheat.

The scientific community acknowledges the strategic importance of structures like the CNRGV which guarantee facilitated access to reference biological materials and their associated data, and to cutting-edge genomic tools that ensure technical quality and reflect technological advances. More than 250 laboratories throughout the world have already called upon the resources and genomic tools available at the CNRGV. The centre is also involved in international collaborative efforts to assist consortia of laboratories with their genome sequencing projects.

The model plant Arabidopsis: an essential research tool

During the 1980s, the international scientific community decided to focus its efforts on *Arabidopsis thaliana*, a plant with a small genome and numerous advantages, because it is easy to cultivate in a laboratory, has rapid development and is prolific. INRA has contributed to increasing knowledge on this plant through the development of a major collection of *Arabidopsis* mutants in Versailles, thanks to the application of a novel methodology that is now used worldwide.

The entire genome of *Arabidopsis* has now been sequenced; most of the genes have been identified and localised and research is ongoing to establish the function of each. The study of *Arabidopsis* has markedly accelerated the acquisition of information on plants, and opened new perspectives for research and agronomic applications. Researchers have thus achieved several successes in recent years.

They have contributed to deciphering certain intimate functions, such as the mechanisms governing the epigenetic regulation of gene expression, the role of plant hormones, the course of meiosis, the synthesis of cellulose in cell walls, the regulation of plant shape or the development of different organs: leaves, roots, flowers or grains.

They have clarified factors regulating metabolic pathways, such as that of sulphur, flavonoids and seed oil, or mechanisms for plant resistance to salt.

They have also discovered certain mechanisms for disease control, such as resistance to plum pox virus, the infection of plants by *Salmonella* or plant susceptibility to aphid bites.

7.5 The development of databases

The profound transformation of biological and ecological sciences under the combined effects of the increased capacity of data acquisition technologies, the emergence of digital sciences and the growth of biotechnologies, the development of systemic approaches and the modelling required by the complexity of research topics, constitute new challenges for scientific information systems, linked equally to their intrinsic performance and their capacity for dialogue or interoperation. Furthermore, the environmental, economic and agricultural contexts of biological research have undergone considerable change, which remains unpredictable as to its future.

For these two reasons - **growth in throughput and complexity** at the same time as a changing context - INRA has chosen to reinforce its policies on databases, with the aim of **producing and integrating data of high quality**. Their analysis today will enable elucidation of the processes involved in the development of mechanisms in living organisms, and their conservation will allow future measurements and understanding of the degree of evolution that can be integrated in the analysis of biological processes.

All fields of research are concerned; for example, the constitution of cohorts in the food safety field, morphological and molecular databases for systematics and taxonomy (CIRES in Montpellier), integrated information systems for bioinformatics platforms (where links are established between genomic, genetic and phenotypic data), the management of biological resources (cf. above), and the management of data on soil (INFOSOL in Orleans [17]), climate (AGROCLIM in Avignon) or the environment (ORE [18]).

INRA is strengthening its resources by recruiting development engineers and providing financial support for the creation of databases that will **be accessible to broader scientific communities**.

The participation of strategic partners in the sharing and protection of data

CNRS, in partnership with INIST, has recently set up an international resource centre called SIDR *(Standards-based Infrastructure with Distributed Resources)*.

Two INRA teams, and six other laboratories, constitute the founding team of this centre, which will be joining the European ELIXIR programme *(European Life Sciences Infrastructure For Biological Information)*

The SIDR project aims to meet a dual strategic challenge:

- To ensure the conservation, dissemination, exploitation and sharing of resources - notably standardised quantitative data - in order to encourage systems biology approaches,
- To act as a counterweight to scientific publishers who wish to control data through the scientific publication process. Indeed, in several of the "omics" fields, such as proteomics, some journals already require the submission of raw data to their databases. In the long term, there is a considerable risk that this approach will become more widespread and lead to the creation of databases with paid access, including for academic laboratories. If nothing is done now, the scientific community may therefore lose its right of free access to data.

[17] see Chapter 11 paragraph 4.

[18] see box in paragraph 7.2.

8. Policies to improve research support services adapted to strategic challenges

In order to ensure the success of its ambitious scientific strategy and active partnership policy, and the internationalisation of its activities, in 2006 INRA initiated the **modernisation of its procedures**, its **management tools**, and more recently its **information systems**. It has also developed a **quality policy**, based on in-house or international references, as applicable.
To implement these policies designed to improve its collective efficiency, and to ensure that all internal actors share this commitment (both scientists and research support staff), central management initiated a **global action plan in 2005** with its "Institutional Plan for Efficient Administrative and Scientific Management" (PEGASE), and then in 2007, the adoption of a "Multiannual Masterplan for Management Improvements", broken down into annual action plans grouping all the projects implemented by divisions and research support services. These approaches focused on four federative areas:

- The simplification of procedures
- The harmonisation of practices
- The modernisation of tools
- Perspectives for career improvements for staff working in research support services.

These proactive policies concern a **professional group of 1360 agents, who account for around 16% of all INRA staff**. Drawing strength from the skills and resources that can be mobilised, the objective is to respond to different challenges thanks to a high-quality professional environment.

8.1 INRA's approach to quality

To reinforce the professionalism of its researchers and the excellence of its scientific production, INRA published its own quality standards in 2004, adapted to the context of the Institute and its culture. This policy was initially implemented in research units, and then applied to research support units in 2005.

a. INRA's quality policy

For research and experimental units, the quality policy fixes targets that will guarantee to third parties:
the reliability of measurable results, with particular emphasis on metrology and the validation of methods,
the traceability of research work. This dimension is of value to the production of publications, to ensuring the long-term future and exploitation of know-how and, if relevant, to defending intellectual property.
In 2005, the Institute's central management extended the quality approach to research support functions.

■ In Research and Experimental Units

To enhance the professionalism of its researchers and the excellence of its scientific production, INRA defined and published its own Quality Standards in 2004, adapted to the context of the Institute, its research activities and its culture.
Compliance with regulations concerning hygiene, safety, the environment, genetically-modified organisms, etc., constitutes a prerequisite and the foundation upon which a quality approach can be based.
By the end of 2008, 87% of units had committed to this quality approach in their research work.
Whenever justified, as in the case of analytical laboratories, research platforms or biological resources centres, some entities aim to comply with external standards, such as ISO 9001:2000 (certification) or ISO 17025:2005 (accreditation).
INRA provides support for units committed to this quality approach by carrying out advisory audits, which ensure a rigorous and independent assessment that will determine any gaps between the demands of standards and the efforts made by a unit to correct them.

12 units accredited or certified under international standards

Two ISO 17025 accreditations have been granted: to the Plant and Environmental Analyses Service Unit (USRAVE) in Bordeaux, and to the Soil Analysis Laboratory (LAS) in Lille.

As at January 1st, 2009, twelve entities were certified under ISO 9001/2000 standards:
- The Interventional Imaging Research Centre (CR2i) in Jouy-en-Josas (double certification 13485);
- The Animal Genetics Division in Jouy-en-Josas, for its official cattle genetics evaluations on farms;
- The Experimental Surgery Platform in Tours;
- The Experimental Infectiology Platform (PFIE) in Tours;
- The Genomics Platform in Toulouse;
- The French Plant Genetics Resource Centre (CNRGV) in Toulouse;
- Biological Resources Centre for the Genomics of Domestic Animals of Economic Importance (CRB Gadie) in Jouy-en-Josas;
- The French Collection of Plant Pathogenic Bacteria (CFBP) in Angers;
- The International Centre for Microbial Resources (CIRM), which comprises a centre for resources on filamentous fungi (Marseille-Luminy);
- A centre for resources on yeasts (Grignon);
- A centre for resources on food bacteria (Rennes) and,
- A centre for resources on animal and human pathogenic bacteria (Tours).

■ In Research Support Units

Since the end of 2005, INRA's central management has been committed to a quality approach based on the essential principles of ISO 9001: 2000 standards. Several projects have been undertaken in line with the Institute's action plans.

Quality approaches regarding research support

- The Clermont-Ferrand Research Centre has focused on procedures concerning human resources, the management of contracts, income and expenditure, and the provision of support to small units.
- The Paris Research Centre has defined a plan to improve its purchasing procedures.
- The centres in Sophia-Antipolis and Avignon are working on a description of all the processes that enable the supply of services to research units.
- The Toulouse Research Centre has initiated improvements in the services provided to units, with particular emphasis on support for major units.
- The Nancy Research Centre has obtained ISO 9001: 2000 certification for its research support activities.

8.2 Budget management: a change to the economic model

As a government institution, INRA receives most of its funds via programme 187: "Research on management of the environment and resources" from the Research and Higher Education budget, and only marginally via programmes 172 and 142 in this budget.

In the primary budget for 2009, **operating and investment credits** (BP2009) account for €643 million, or **83% of the Institute's income** (€772 million).
However, other resources, generated by INRA's scientific activities and their various applications, are considerable (€129 million) and make a major contribution not only to everyday operating costs and the equipment of units, but also to INRA's investment policies.

FIGURE 2 | IINRA's draft budget for 2009: presentation of the balance

EXPENDITURE			INCOME		
Activities carried out by research and experimental units	598,1	77,5%	Subsidies for public service charges	642,9	83,3%
Joint actions	38,4	5%	Mission-oriented contracts and support for research activities	84,6	11%
Support functions	134,2	17,4%	Income generated from research activities	34	4,4%
Contingency	1,3		Other grants and provisions	10,6	1,4%
TOTAL EXPENDITURE in € million	**772,1**	**100%**	**TOTAL INCOME in € million**	772,1	100%

Indeed, because the costs pertaining to the Institute's permanent staff are mainly covered by operating credits (€500 million), **resources (not including these staff costs) are provided almost equally in the form of Government grants (€115 million) and income from other sources (€131 million), notably that generated by research contracts (€85 million)**.
Thus the overall operating and investment credits allocated to research and experimental units; i.e. operating costs other than permanent staff, and fixed at €152 million in 2008, are funded to 64% by income generated by units, and to 36% from government subsidies.

FIGURE 3 | Breakdown of gross income by type in 2009, in € million

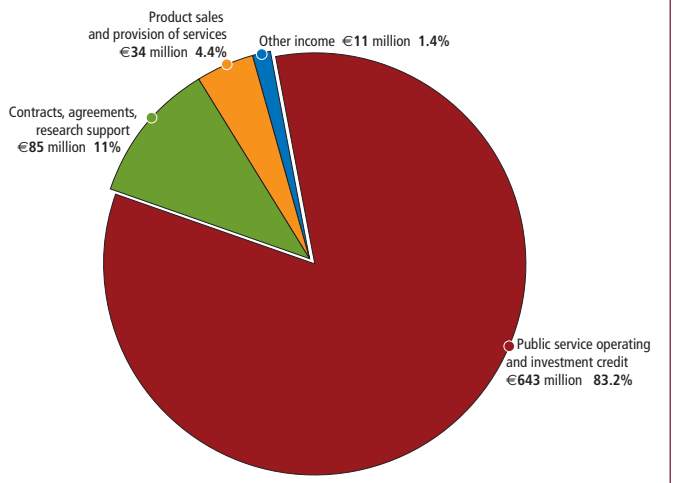
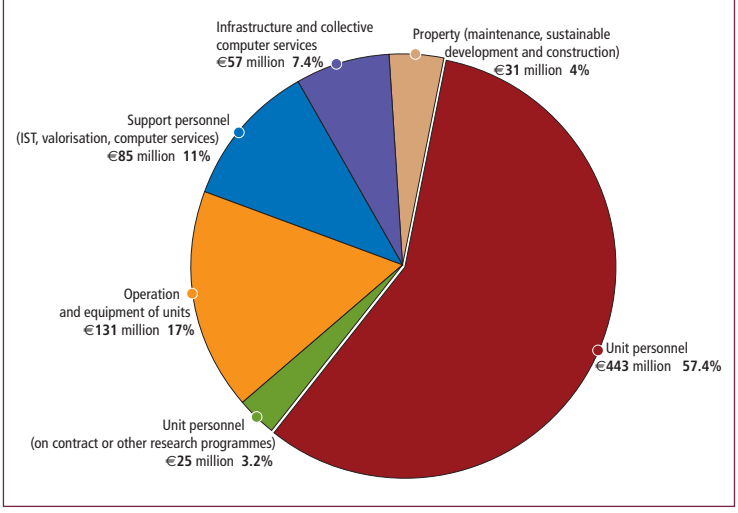


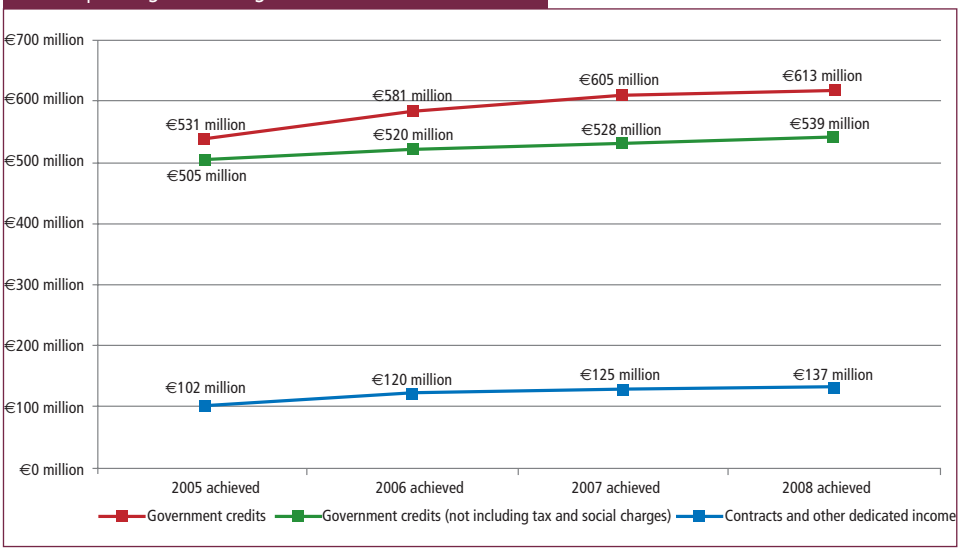
FIGURE 4 | Breakdown of gross expenditure into principal items in 2009, in € million



Concerning property management (€31.3 million), these costs also come from the government (€18.7 million) and from a series of other sources (€12.6 million), which include contributions from regional government bodies and income from the sale of INRA land and buildings as a result of portfolio rationalisation.

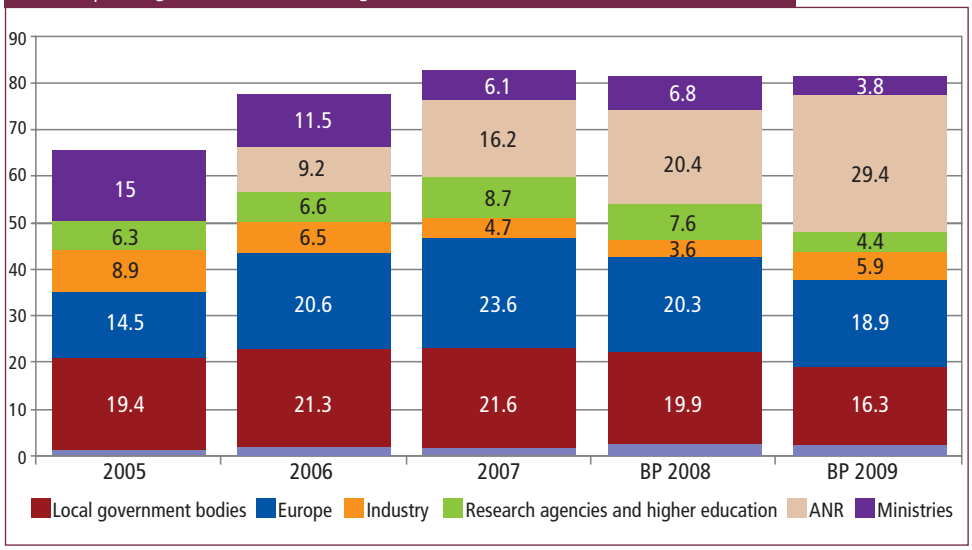
However, **the dynamics of these two types of funding are not comparable**: trends in expenditure between 2005 and 2008 showed that government credits (not including taxes and social charges) increased by 7%, while dedicated and contractual income rose by 16% (Figure 5).

FIGURE 5 | Changes to funding sources between 2006 and 2009



Increases in contractual income (see Figure 6) have mainly been achieved through contributions from European R&D Framework and French ANR programmes. Although these funds come from public sources, and INRA management provides support for its teams when they compete to obtain these projects, the uses to which the resulting funds are put are not without effect on the financial situation of the units concerned.

FIGURE 6 | Changes to the breakdown of gross income from different sources in € million



Generally speaking, contractual income currently excludes the reimbursement of infrastructure costs. However, these are seeing constant growth because the premises and facilities for research now involve advanced technologies that are extremely expensive in terms of maintenance, consumables, special fluids and energy.

Thus the "baseline metabolism" of research and experimentation is less and less being covered by the allocation of government credits between units. Researchers have some opportunities available to them to modulate their expenditure, such as the short-term hosting of young scientists, the purchasing of goods and services, and obtaining funds from contracts, the aim of which (and often the use) has been fixed by organisations external to INRA. Although there is generally no contradiction between the subject of contracts and the scientific priorities determined in-house, research programming must find a synergy between these two sources of funding.

This synergy will be even more successful in laboratories if contracts gradually start to include infrastructure costs in the fixed costs of a contracted programme budget. To achieve this, the **Institute needs to equip itself with analytical accounting that will make it possible to certify and invoice the entire costs of research so that they can then be audited by our fund-providers.**

In parallel, and in order to ensure that all INRA units benefit from sufficient operating and equipment budgets, independent of any external programme but assuring joint support functions (maintenance of major equipment, operation of joint platforms, STI, national and international cooperation, exploitation of results, property restructuring), the fungibility systems provided by its financial services must be brought into play.

In a context of high staff retirement rates, central management has chosen to smooth the recruitment of researchers and engineers in the medium term, so as to guarantee sustained recruitment in the longer term and enable selection of the best scientists. This self-regulation regarding recruitment should enable the temporary release of funds that can be used to improve the competitiveness of the Institute's scientific infrastructures.

8.3 Improving the exploitation of scientific and technical information

a. The challenges: from managing the flow of information to managing knowledge

Scientific and technical information (STI) groups all the information generated by research and necessary to both scientific and industrial activities.

By its very nature, STI is of **various types**: scientific papers, technical specifications describing manufacturing processes, technical documentation supplied with products, patents, bibliographic databases, grey literature, raw data banks, open archives and warehouses of internet-accessible data, portals, etc.

The volume of information handled by researchers is seeing **exponential growth**. For example, the bibliographic database *MedLine,* which is used by INRA researchers in the biomedical field, now has more than 16 million references, and we have estimated that the European Patent Office now manages more than 400,000 patents concerning fields exploited by INRA.

Exploiting this knowledge and optimising its transfer to different scientific communities or industry are now major challenges for research. This management challenge also concerns the **visibility of research results on the world stage**.

Faced with these challenges and a professional context experiencing major change, INRA has developed a medium-term development plan for its Scientific and Technical Information function. This plan encourages synergies with other organisations with a view to the **broader dissemination of scientific information, and access to STI for all researchers**. Some of the results of this action plan are presented in the boxes below.

b. Some important achievements

Editions Quæ: towards the broader dissemination of scientific and technical information

On July 1st, 2006, INRA Editions merged with the publishing arms of three other research agencies: CEMAGREF, CIRAD and IFREMER, to form an Economic Interest Group called Editions Quae, which now benefits from nearly 1000 titles in its catalogue.
The decision to publish documents in an electronic form (PDF), which was tested initially on two re-editions, has now been extended to new publications (books in English and/or with a limited audience).
In addition, Editions Quae has launched a development project concerning the digital publishing of new products, a change to the editorial cascade and the introduction of new circulation methods.

Facilitating citations by changing the model for the circulation of scientific journals

INRA is owner or joint owner of seven academic scientific journals, all referenced by ISI. Within INRA, each scientific journal is linked to a scientific division that holds responsibility for editorial policies.

In 2004, INRA decided to modify the economic model of its journals: from a downstream model (the current model of payment by the purchaser or reader) it would turn towards an upstream model (*open access*: or in short, payment by the author) for journals subscribing to this scheme. The free access model is particularly attractive because of the **impact it can have on the number of citations**. Two years later, it can be seen that the expected trend towards a generalisation of *open access* articles has not developed. Above a certain value, estimated at between €300 and €500 euros per article, authors do not wish to pay for open access. In 2009, one or two of INRA's journals will migrate completely towards an *open access* model.

Facilitating the publication of work on farmed animals: creation of the European journal "Animal"

In January 2007, the *British Society of Animal Science* (BSAS), the *European Association for Animal Production* (EAAP) and INRA signed an agreement concerning the launch of a new journal on animals sciences, *"Animal"*. This generalist journal aims to **reduce the current worldwide fragmentation of publications in the animal sciences field**. This new journal resulted from the merger of three previous publications: *"Animal Science", "Reproduction, Nutrition, Développement"* and "*Animal Research*".
The new journal is thus called: *Animal - The International Journal of Animal Bioscience.*
Within the next three years, it aims to become one of the leading journals worldwide for the dissemination of scientific knowledge on animal sciences dealing with all aspects of farmed animals: physiology, breeding, genetics, reproduction, health and welfare.
It also focuses on animals used as models for humans.
"*Animal"* is published monthly, producing about 165 papers each year on 1600 pages.

Bibliome: an innovative tool for the analysis of scientific and technical information

The Bibliome team in the Mathematics, Informatics and Genome Unit (MIG) develops platforms and new technologies in response to the need to assist researchers and decision-makers in their searches for scientific, technical and strategic information, in different types of documents: bibliographies, intellectual property or even textual comments in technical databases.
Accurate searches for documentary information using the engines available to researchers such as Google, PubMed or the Web of Science, are not very efficient because numerous relevant documents remain undetected.
One of the main limitations arises from the fact that searches in the content of documents are limited to the precise wording of the query without any variations, while specialisations, synonyms, acronyms and ambiguities (several senses for the same term) abound (for example, gene names can have up to ten synonyms).
Access to this information, its exploitation and any cross-references with structured data from databases, requires new informatics tools. These tools have been used for the patent packages of the European EPIPAGRI project, and to produce state-of-the-art documents in the context of the Véga foresight workshop (see boxes on these projects).

8.4 Supporting the development of information systems

INRA's information systems form the core of the processes necessary to develop knowledge and play a key role in all the Institute's activities. Their ability to evolve is strongly dependent on collective efforts to deploy a **national and structured approach to orientation, and the coherent planning over several years** of resources to achieve these objectives.

- **Scientific information systems**, developed in close synergy with laboratory research, must be organised so that their use is appropriate to new scientific approaches based on novel, extremely high-throughput data acquisition tools. Meeting these scientific and technological challenges requires a synergy of skills, structured national approaches and sufficient informatics resources. These changes have given INRA greater responsibilities regarding the management and orientation of its scientific information systems. At a horizon of two years, a **master plan** will lay down a framework for the orientation and programming of INRA's scientific information systems. The accreditation mid-2008 of 23 "automated data processing centres" (given the task of providing services to large scientific communities and taking over all INRA's informatics functions) constituted the first important step towards encouraging the sharing of skills and the networking of tools.

- The **institutional information system** must, on the other hand, offer support to laboratories regarding the management and exploitation of their activities, and be aligned with the Institute's strategy. In addition, project-based contractual arrangements between the government and its research operatives involve new demands that constitute new challenges for institutional information systems: assistance with management, greater openness, the simplification of management, assistance with reporting, the exploitation of activities and results, etc. INRA has gradually been **reforming its institutional information system** (S2I): Finances in 2006, Human Resources in 2007, Activities and Products in 2009. As a vector for the modernisation and simplification of management, operational deployment of the information system at the level of the Institute can improve the management and follow-up of its activities at all organisational levels, by providing all those concerned with relevant data using high-performance tools. This increasing maturity of the institutional information system, both in terms of its scope of application (management software) and its technological capacities (urbanisation and the trend towards a service-oriented architecture) means that it is able to meet follow-up and reporting needs at all levels of the Institute.

8.5 New instruments to serve the international ambitions of INRA

The international dimension of an organisation such as INRA is not restricted to its cooperation activities, however well-structured and monitored they may be. An organisation that is recognised internationally must ensure the **evolution of its procedures** so that they can be understood by its partners, while at the same time **complying with international standards** (in terms of visibility, transparency, assessment criteria, and the rapidity of resource implementation, etc.).
Furthermore, an ambitious partnership policy at the European level requires sufficient control over the **legal aspects of project organisation and management**.
The organisation of an institution with international ambitions will thus be affected.

a. Support for the organisation and management of major European projects

Since 2005, INRA has produced information and ensured support for its researchers who put themselves forward to coordinate major European projects.

Support is now given to researchers when they assess the feasibility, organisation and negotiation of a project. Researchers are also assisted in the management of selected projects so that the objectives can be attained and results delivered within the time allotted. From the initial results of FP7, it appears that these incentives to participate in Framework projects have been successful amongst INRA researchers; the number of projects coordinated by INRA has markedly increased.

Growth in the number of European projects coordinated by INRA

At the completion of FP6 (2002-2006), 133 collaborative projects involving INRA had been funded by the European Commission, which represented a 44% success rate, to be compared with the national average of 21.2% and the general European average of 18.2%.
INRA coordinated 43 projects, five of them of major importance (EADGENE, ENDURE, BASYSBIO, CO EXTRA, EVOLTREE).
At the end of the **first two years of FP7 (2007-2008)**, an analysis shows that INRA presented 204 projects, or on average nearly 20% more in two calls for tender than for the whole of FP6. The success rate regarding coordinated projects reaches 26%, versus a European success rate of 14%. Following the first two calls for tender, INRA is now coordinating 14 projects (out of the 53 submitted):

- four major collaborative projects,
- five small collaborative projects,
- four projects in the context of the "Infrastructure" section of the Capacities programme,
- one Marie Curie network.

Once again, incentive policies regarding project coordination are very visible.
Beyond these figures, it can be seen that the European culture amongst different INRA actors is becoming much stronger, but still needs to be consolidated.

b. Cooperation tools adapted to the development of international partners

■ Support for the establishment of researcher-driven partnerships

At the initiative of researchers and at scales appropriate to the normal development of their research activities, this type of international cooperation requires administrative support from the Institute, which has resulted in advances regarding:

- the preparation and signature of **standard scientific cooperation agreements** (purpose of cooperation, methods, procedures, rules - notably concerning publications and intellectual property - conditions for assessment and renewal) with different institutions, made necessary because of exchanges and cooperation between researchers;
- **improvements to cooperation tools**: the most significant advance has been the extension to INRA of expatriation arrangements and redefinition of the conditions for the hosting of foreign researchers.

■ Clear procedures for institutional cooperation

The INRA procedures that might apply in its activities as an international actor need to be reviewed with respect to their clarity concerning practices that are widespread at an international level, and the changes necessary to render them effective in this context.
Thus the **"bilateral cooperation package"** is a cooperation instrument that is proposed to certain international partners. This tool for the support of joint research projects is based on two principles: firstly, their organisation on a competitive basis, i.e. via a joint response to a call for tender, and secondly, a good balance between the two partners in terms of their relative contributions of funds or resources. The format of selected projects comprises a coordinator, the recruitment of a post-doctoral fellow and the funding of operating costs.

The first programme was initiated in 2006 with the BBSRC in the field of plant sciences, with the selection of three four-year projects and the recruitment of three post-doctoral fellows. Four other programmes have also been launched (with Poland, the Netherlands, Sweden and Brazil) and enabled the choice of ten projects, which are currently being set up.

This "package" system is a powerful tool for structuring bilateral cooperation, but it is only being introduced gradually because negotiations between partners are generally lengthy.

Analysis of these initial experiences shows that although the selection criteria for projects are well-defined (quality and originality), further efforts are necessary to explain the assessment procedures and accelerate the availability of resources, notably in terms of staffing.

Results

9. INRA results that benefit research and higher education

During recent years, INRA has attached particular importance to consolidating its academic potential, thanks to **three initiatives** that have contributed to its visibility and efficiency. The first concerns **scientific production**, the second the **organisation of research into attractive clusters**, and the third a strengthening of its commitment to **training**.
INRA now has the resources to ensure the in-depth analysis of its **publications**, which are both increasingly numerous in the leading international journals and spread amongst a variety of media. It has also initiated discussions on the use of these factors for management purposes.
Based on an analysis of the quality of its research, local scientific contexts and the demands of regional government bodies, INRA has increased the **implementation of integrated research clusters** that group sufficient researchers from several disciplines around a theme and an ensemble of technological platforms and training facilities.
INRA has developed its involvement in **training**, so that its results become knowledge on the one hand, and on the other that they develop the thinking of future managers in the economic and political spheres related to agriculture, the environment and human food and nutrition.

9.1 Scientific production

"We should look at ourselves as others see us" could be the slogan that underlies all the bibliometric analyses carried out by INRA, and allows it to share their results with others [19]. INRA thus decided to analyse its results in each of the research disciplines where it is active. Based on tools and data [20] from Thomson Reuters, a system for the production of standardised bibliometric indicators was designed with the participation of the Science and Technology Observatory (OST) on the one hand, and an in-house team of documentalists specialised in bibliometrics on the other (CREBI).

a. Analysis of bibliometric indicators

■ INRA is a recognised research player in its fields of competence

Using the ESI tool, and with INRA as the only institution mentioned in the authors' address, the 18,900 papers published by the Institute between 1998 and 2008 received around 232,000 citations. Under this classification, **INRA is ranked within the top 1% of the most cited institutions in the world**.

When INRA's position is studied using an initial sorting of 22 of the ESI disciplinary fields ESI [21], the citations received mean that INRA ranks within the top 1% of the organisations most frequently cited in twelve fields:
• Plant & Animal Science • Molecular Biology & Genetics • Agricultural Sciences • Engineering • Microbiology • Chemistry • Environment/Ecology • Pharmacology & Toxicology • Biology & Biochemistry •Computer Science • Clinical Medicine •Geosciences

[19] With this objective, INRA has chosen to study its academic scientific results using the tools provided by Thomson Reuters: ESI (*Essential Science Indicators* - classification into 22 disciplinary fields) and SCIE (*Science Citation Index Expanded* in the *Web of Science* database - classification in 172 specialities). These databases are the reference tools of bibliometricians, but do not accurately reflect European results in the social sciences.

[20] The data shown in the different tables arise from studies performed at different periods and on different sources, which may explain the differences in the values given to the data.

[21] Thomson Reuters ESI classification: about 10,000 journals are broken down into 22 disciplinary fields; each journal is only included in one disciplinary field. Using this tool, institutions are penalised when the authors do not use a standardised name for their institution, and do not mention their institution in the first line of their address.

In terms of the number of citations, INRA has maintained its ranking as second in the world in the two fields that lie at the core of its missions: "Plant & Animal Science" and "Agricultural Sciences", and is a leading worldwide institution in "Microbiology" and "Environment/Ecology."

Table 1 | Position of INRA within the top 1% of the most cited institutions

(based on citations received by papers published between January 1st, 1998 and August 31, 2008)

Disciplinary field	according to the number of citations received		according to the number of papers published	
	World ranking	French ranking	World ranking	French ranking
• Plant & Animal Science	2nd/813 institutions	1st	4th	1st
• Agricultural Sciences	2nd/394 institutions	1st	2nd	1st
• Microbiology	16th/304 institutions	2nd	8th	2nd
• Environment/Ecology	36th/498 institutions	2nd	19th	1st

For each of the disciplinary fields that count more than 200 papers per year, the international position of INRA among the other institutions contributing to the field can be seen in the tables that follow.

Tables 2 and 3 | Ranking of institutions in ESI disciplinary fields over the past 10 years

by decreasing number of citations received - Period 01/01/1998 to 31/08/2008

Data from ESI Thomson Reuters; surveyed on-line on November 28, 2008

PLANT & ANIMAL SCIENCE

Rank	Institution	Citations	Papers	Citations Per Paper
1	USDA	107 980	13 323	8.10
2	**INRA**	**68 046**	**6252**	**10.88**
3	UNIV CALIF DAVIS	66 736	6433	10.37
4	CORNELL UNIV	55 892	4823	11.59
5	MAX PLANCK SOCIETY	52 217	2686	19.44
6	WAGENINGEN UNIV	50 134	4148	12.09
7	UNIV WISCONSIN	45 098	3824	11.79
8	CSIRO	44 634	3794	11.76
9	UNIV FLORIDA	41 442	5820	7.12
10	CSIC	39 843	4583	8.69
11	JOHN INNES CTR PLANT SCI RES	39 332	1164	33.79
12	UNIV GEORGIA	38 915	4388	8.87
13	UNIV CALIF BERKELEY	37 742	2053	18.38
14	MICHIGAN STATE UNIV	36 416	3350	10.87
15	N CAROLINA STATE UNIV	35 474	4170	8.51
16	SWEDISH UNIV AGR SCI	34 701	3727	9.31
17	UNIV TOKYO	32 778	3997	8.20
18	UNIV ILLINOIS	32 494	3259	9.97
19	TEXAS A&M UNIV	32 111	4208	7.63
20	UNIV MINNESOTA	31 739	3381	9.39

AGRICULTURAL SCIENCES

Rank	Institution	Citations	Papers	Citations Per Paper
1	USDA	58 250	7611	7.65
2	**INRA**	**31 215**	**3230**	**9.66**
3	CSIC	25 602	3081	8.31
4	WAGENINGEN UNIV	23 351	2443	9.56
5	UNIV CALIF DAVIS	19 454	1954	9.96
6	CORNELL UNIV	17 096	1557	10.98
7	AGR & AGRI FOOD CANADA	14 997	2005	7.48
8	CSIRO	14 655	1685	8.70
9	UNIV WISCONSIN	14 326	1428	10.03
10	UNIV GEORGIA	11 629	1464	7.94
11	UNIV ILLINOIS	11 328	1287	8.80
12	UNIV GUELPH	10 556	1314	8.03
13	IOWA STATE UNIV	10 212	1309	7.80
14	UNIV HELSINKI	9905	779	12.72
15	ROYAL VET & AGR UNIV	9842	1013	9.72
16	UNIV MINNESOTA	9691	1141	8.49
17	UNIV FLORIDA	9595	1546	6.21
18	UNIV NEBRASKA	9576	1081	8.86
19	PENN STATE UNIV	8 727	984	8.87
20	OHIO STATE UNIV	8 559	1079	7.93

■ The academic production of INRA has increased regularly each year, and by 17% over the period 2001-2006

Table 4 | Annual number of INRA papers and share of French, European and world publications, all disciplines taken together

Data from Thomson Reuters - OST processing - Shares expressed as a fraction

INRA	2001	2002	2003	2004	2005	2006
Number of papers in WOS SCIE - not incl. HSS	2 430	2 533	2 573	2 613	2 829	2 857
Share of French papers (%)	4.15	4.30	4.15	4.13	4.11	4.13
Share of European papers (%)	0.58	0.59	0.56	0.55	0.54	0.54
Share of world papers (%)	0.21	0.21	0.19	0.18	0.18	0.18

Over the period 2003-2006, although the total number of scientists on the payroll remained stable, the number of publications rose by 11%, thus maintaining INRA's French, European and world shares.

■ Positioning of excellence in its core skills

Between 2001 and 2005, INRA contributed to 155 specialities out of the 172 defined in the Thomson Reuters Web of Science database, thus illustrating the diversity of its skills and approaches.

However, INRA is an institution that clearly **focuses on its core skills**, because more than 30% of the publications were shared between four specialities ("Plant Sciences", "Biochemistry & Molecular Biology", "Food Sciences & Technology" and "Agriculture, Dairy & Animal Science"). Finally, 66% of the publications were spread between 17 specialities.

From standardised production indicators based on "market share" or "specialisation indices" [22], the position of INRA in French, European and worldwide production rankings clearly indicates that:

- INRA is a dominant organisation in "Agriculture, Dairy and Animal Science", "Agronomy" "Horticulture" and "Forestry". This visibility is sustained at the French (share of between 51% and 74%), European (5.8 to 8.4%) and international levels (1.58 to 2.69%), with world specialisation indices that are always higher than 8 (Table 5).
- furthermore, at the national level, INRA also accounts for more than one third of French publications in the "Agriculture, Multidisciplinary", "Agriculture, Soil Sciences", "Food Science & Technology"; "Plant Sciences" and "Nutrition & Dietetics" specialities (French shares >29% and indices > 6.2) (Table.5).

Table 5 | Share of French, European and world publications, and world specialisation indices

of the principal INRA specialities, as average annual values for 2001-2005
(from OST data for 2007)

Speciality	French share	EU share	World share	Specialisation index	No. of publications in terms of number	No. of publications in terms of percentage
Agriculture, Dairy & Animal Science	74%	8.4%	2.69%	13.8	190	96
Agronomy	63%	7.6%	2.07%	10.6	156	59
Horticulture	53%	6.7%	1.58%	8.1	78	22
Forestry	51%	5.8%	1.97%	10.1	73	40
Agriculture, Multidisciplinary	46%	4.5%	1.21%	6.2	76	24
Agriculture, Soil Science	44%	5.1%	1.61%	8.3	69	32
Food Science & Technology	40%	5.0%	1.92%	9.8	253	112
Plant Sciences	39%	4.3%	1.52%	7.8	318	143
Nutrition & Dietetics	29%	3.5%	1.25%	6.4	114	48

The breakdown of INRA productions as a function of the **reputation** [23] of journals highlights the relative constancy of the strategy concerning INRA's publication results over time (see Figure 7):

- 13% of them are published in "exceptional" journals;
- 54% in "exceptional" or "excellent" journals;
- 80% in "exceptional", "excellent" or "satisfactory" journals.

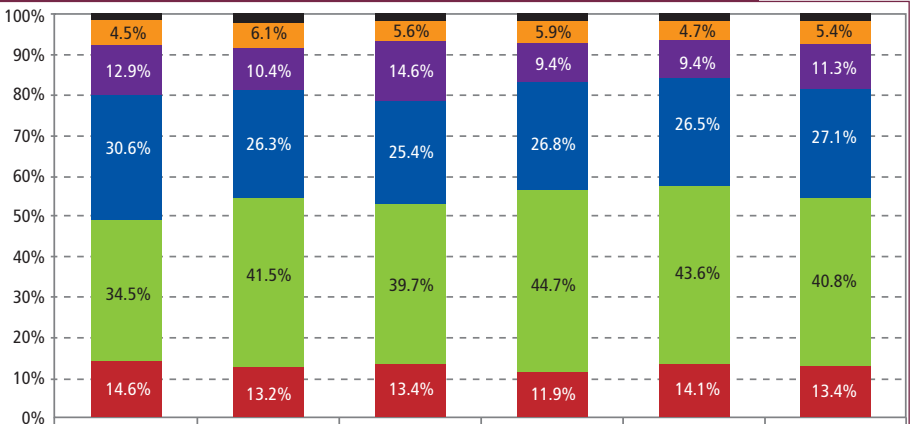
This constancy in quality is sustained despite the regular increase in the number of publications (growth from 2426 in 2001 to more than 2550 in recent years).

[22] Definitions of share and specialisation index (these indicators are based on the percentage number of publications); the French (or European or world) share of publications (%) is the ratio between the number of INRA publications in the speciality and the number of French (or European or world) publications in the speciality. The specialisation index is the ratio between the world share of publications by INRA in the speciality and the world share of INRA in all specialities taken together. A specialisation index of 1 indicates a neutral situation in the speciality; if it is higher than 1, there is over-specialisation; on the contrary, if it is lower than 1, there is sub-specialisation.

[23] The reputation of journals is determined by an annual statistical analysis of the distribution of the impact factor frequency in each speciality (SCI JCR data/ Thomson Reuters; processed by INRA/CREBI). When a speciality contains fewer than 10 journals, the reputation of these publications is not determined.

FIGURE 7 | Annual breakdown of INRA publications for 2001-2005 as a function of the reputation of journals

(%, OST data for 2007, CREBI processing)



	2001 2 426 publ.	2002 2 530 publ.	2003 2 567 publ.	2004 2 593 publ.	2005 2 551 publ.	2001-2005 12 667 publ.
Non-peer-reviewed journals	41	39	30	24	16	150
Non-analysed journals	1	1		9	3	14
No impact factor	31	24	3	1	25	84
Poor reputation	109	155	143	152	119	678
Acceptable reputation	312	263	375	245	240	1 435
Satisfactory reputation	742	665	651	695	676	3 429
Excellent reputation	836	1 049	1 020	1 158	1 113	5 176
Exceptional reputation	354	334	345	309	359	1 701

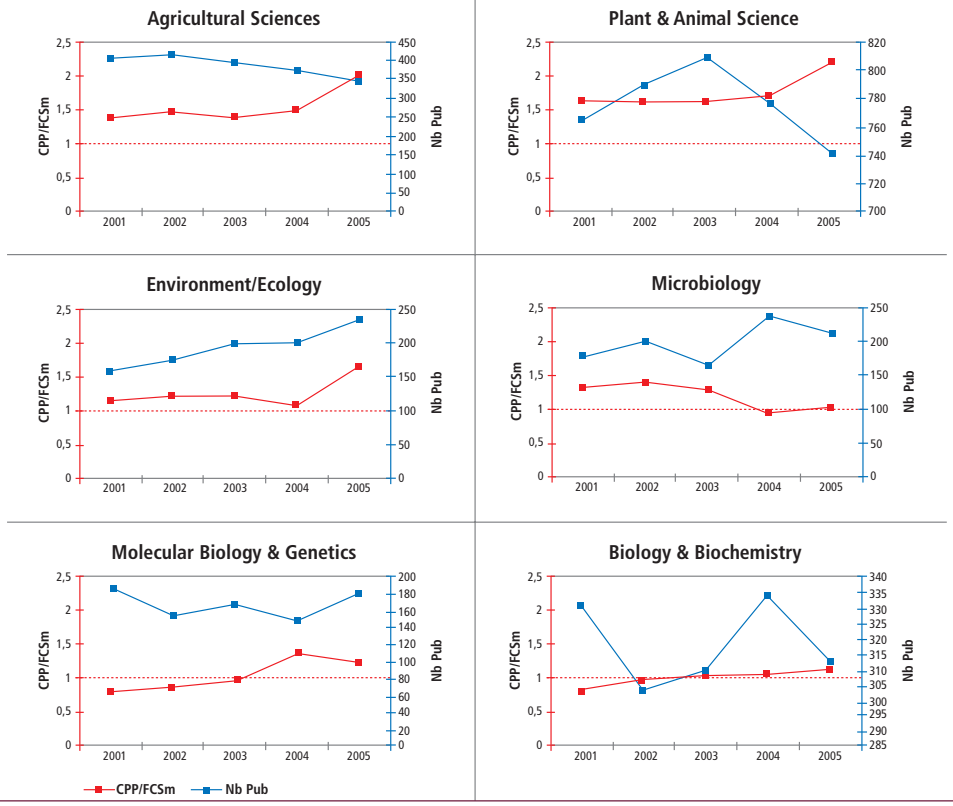
A high citation impact

Based on standardised citation indicators, such as the relative impact indicator [24], the impact of INRA results has been studied in the 22 principal disciplinary fields of the ESI classification.

The graphs below (Figure 8) reveal an excellent performance in "Agricultural Sciences", with a rise in the impact index from 1.4 to 2 between 2001 and 2004, and in "Plant & Animal Science" where it increased from 1.5 to more than 2.

This indicator is higher than 1, or became so since 2004, in "Environment/Ecology" (rising from 1 to 1.5) and in "Molecular Biology & Genetics". The indicator is stable, at around 1, in "Biology & Biochemistry" and "Microbiology".

FIGURE 8 | Annual relative impact index (CPP/FCSm) for INRA in six ESI disciplinary fields over the period 2001-2005



[24] The relative impact indicator (also referred to as "CPP/FCSm" or "Crown Indicator") enables a comparison between the mean citations of INRA publications in a given field with a reference value for the same field at a world level. It indicates whether INRA's impact is higher than (>1), equal to (~1) or lower than (<1) the standard international impact in this field.

■ The significant impact of international cooperation

The numbers of publications shown in the tables below benefit from the most recent scans and updates. For this reason, the numbers counted each year differ slightly from the figure and tables above.

INRA is a research institution that is open to cooperation with any country, as shown by Table 6. Between 2001 and 2006, the proportion of papers published jointly with at least one foreign author increased markedly each year, from 34% in 2001 to nearly 41% in 2006.

Table 6 | Percentage of INRA jointly-published papers

as a function of the origin of other signatories; all disciplines concerned taken together (2001 to 2006)
(data from Thomson Reuters, OST 2008 processing)

	INRA: percentage share in all publications					
Status of joint publications	2001	2002	2003	2004	2005	2006
In-house joint publication	17.7	18.8	17.6	20.1	18.4	21.3
Joint publication with other French authors	36.0	36.4	38.6	40.8	44.5	43.1
Joint publication with authors in other countries	34.1	34.9	37.0	38.1	40.3	40.9
Joint publication with European authors	19.6	20.8	20.5	21.5	23.5	22.6

b. Use for management purposes

Bibliometric analysis is also used by INRA managers to monitor trends in different divisions or disciplines, and thus provides a basis for decision-making.

■ The priorities retained in the orientation document were followed by effects

Table 7 | Breakdown of INRA publications as a function of strategic area over the period 2001 - 2006

Area	2001		2002		2003		2004		2005		2006	
A• Environment	427	17.6%	466	18.4%	450	17.5%	565	21.6%	636	22.4%	759	26.2%
B• Food and nutrition	187	7.7%	215	8.5%	224	8.7%	257	9.8%	411	14.5%	355	12.3%
C• Agricultural products	477	19.7%	492	19.4%	460	17.9%	457	17.5%	488	17.2%	556	19.2%
D• Generic strategies	396	16.3%	417	16.5%	424	16.5%	321	12.3%	387	13.7%	384	13.3%
E• Adaptation of agriculture	926	38.2%	925	36.5%	995	38.7%	996	38.1%	894	31.6%	786	27.1%
F• Actors strategies and public policies	13		17		15		15		17		57	
Total	2426		2532		2568		2611		2833		2897	

*The six scientific areas are listed p.7.

Thus in 2000, it was decided for the period 2001-2004 to strengthen the "Environment" (A) and "Food and Nutrition" (B) areas, to the detriment of agriculture (E) and (C).

Over a period of several years, analysis revealed the impact of INRA's policy concerning the increase in its publications, because in line with the decisions taken in 2001:

- Areas A and B, emblematic of the environmental and food and nutrition pillars, were, as desired, seeing growth;
- the expected decline of Area C was halted because of the development of green chemistry;
- Area D stabilised at around 15%;
- the sustained reduction in the relative share of Area E was anticipated, because resources were allocated to Areas A and B as a priority;
- the figures concerning Area F were of little significance, as this field is very poorly represented in international bibliometric databases.

■ The prioritisation of themes is both quantitative and qualitative

In a few months' time, and for the first time in its history, INRA will benefit from resource indicators that can be compared with these production indicators.

Already, when applied to each division, a detailed review of this **bibliometric analysis** may encourage them, when relevant, to **improve their international positioning**. To draw optimum advantage from this situation, a training course has recently been initiated, because it is essential to consider these analyses over time and to share them with research teams.

The example of the Nutrition, Chemical Food Safety and Consumer Behaviour Division (ALIMH)

The challenges

For some ten years now, the ALIMH Division has been faced with renewed challenges. Indeed, global under-nutrition continues, despite the paradoxical growth of diabetes and obesity. In such a context, research in the division can contribute to elucidating the determinants of consumption, and understanding the links between food/diet and nutrition. To achieve this, the division must first of all establish external scientific partnerships while at the same time stabilising its research clusters on nutrition. It also requires the acquisition of data from human cohorts that are the subject of increasing exploration, and the constitution of integrated investigative platforms. Finally, toxicology, as the portal of entry to food safety, is a major challenge where INRA must establish unquestionable leadership in the study of low doses and combined effects.

Bibliometric analysis over the period 2001-2005 concerning ALIMH provided a true reflection of changes in this field.

- Thus its academic production grew by 67%; this corresponded to a marked increase in the number of papers per researcher, which rose from 1.8 in 2001 to 2.3 in 2005. This rise was not to the detriment of the quality of the journals where they were published; 10% of papers appeared in "exceptional" journals and 42% in "excellent" publications.
- The division was in a strong position concerning its strategic areas; notably "Nutrition & Dietetics" (324 papers in 5 years and a specialisation index higher than 10); Food Science & Technology" (116 publications);"Endocrinology & Metabolism" (127 papers). Over the years, ALIMH has gradually withdrawn from the "Agriculture, Multidisciplinary" field, to focus on specialities linked to nutrition and diet. But particular efforts now need to be made in the field of "Toxicology", where the specialisation index fell dramatically between 2001 and 2005.
- ALIMH has become a major actor in the field of human food and nutrition. At a national level, it is even an important leader, both in terms of its production and its citation rates. With 324 papers published, ALIMH accounts for 17.2% of all French publications in Nutrition & Dietetics.
- Internationally, ALIMH partnerships developed considerably over this five-year period, with an increase from 45 jointly-signed papers (23%) to 118, or 37% of production in numerical terms.

The successes recorded thanks to strong and clear editorial policies and unprecedented international openness now need to be **consolidated**:

- by developing skills in writing and presentation, to give even greater visibility to this work,
- through cooperative projects with several teams from INSERM or from other countries,
- by opening new fields of investigation, notably in support of metagenomics or integrative biology, in order to accentuate the originality of research by ALIMH,
- through the upcoming creation of a toxicology cluster in Toulouse.

9.2 The organisation of research in attractive clusters

Since 2005, INRA has deliberately organised its research into **attractive clusters** focused on the scientific demands of its missions. This is not a new policy, and in the past it led to the emergence of integrated clusters for plant sciences in Versailles, Bordeaux, Toulouse and Montpellier, or in animal sciences in Jouy-en-Josas or Nouzilly. However, it is the importance given to this dynamic, around 21 structuring operations, that characterises the efforts of recent years.

INRA's global vision of its scientific challenges, conjugated with its capacity for regional negotiations, have contributed to **structuring research around thematic clusters**, often rooted in the **local economic environment** but preserving the national coherence of scientific resources, thus enabling gains in visibility and reactivity. Six clusters have thus acquired a truly **European dimension** in the context of coordinating important FP7 projects. The map overleaf illustrates the distribution of the 21 INRA research clusters that have recently been reinforced, and the general themes addressed by them.

The 21 thematic clusters and their contribution to regional and European dynamics

- Horticulture in **Angers** (linked with a competitiveness cluster and a regional training cluster)
- Fruits and vegetables in **Avignon** (linked with a competitiveness cluster and training cluster)
- Human nutrition in **Clermont**/Theix/Lyon (linked with a competitiveness cluster)
- Cereals in **Clermont** (linked with a competitiveness cluster, coordination of the European *TricitaeGenome* project)
- Human nutrition and flavour in **Dijon** (linked with a competitiveness cluster and a regional training cluster)
- Regions and development in **Dijon** (linked with a regional training cluster)
- Agroecology at the plot level in **Dijon** (linked with a competitiveness cluster and a regional training cluster)
- Environment in **Grignon** (linked with a competitiveness cluster and a regional training cluster)
- Microbiology of the digestive tract in **Jouy-en-Josas** (linked with a training cluster, coordination of the European *MetaHIT* project and the Marie Curie *Cross-Talk* project)
- Developmental biology (Physiopole) in **Jouy-en-Josas** (linked with a regional training cluster)
- Bioenergy in **Lille**/Mons (linked with a competitiveness cluster, coordination within the European Bioenergy project)
- Agronomy in **Montpellier** (linked with a regional training cluster)
- Forest-wood in **Nancy** (linked with a competitiveness cluster, a regional training cluster, coordination of the European *ENERGYPOLAR* project)
- Biopolymers in **Nantes** (linked with a competitiveness cluster and a regional training cluster)
- Agrifood economics in **Paris**
- Human nutrition in **Paris/Saclay** (linked with a regional training cluster)
- Animal agri-food industry in **Rennes** (linked with a competitiveness cluster and a regional training cluster)
- Plant health in **Sophia-Antipolis** (linked with two competitiveness clusters, coordination of the European *ENDURE* project)
- Food toxicology in **Toulouse** (linked with a competitiveness cluster and a regional training cluster)
- Animal health in **Tours** (linked with a competitiveness cluster, coordination of two European projects (*NADIR* and Era-NET *EMIDA*)
- Plant biology in **Versailles** (linked with two competitiveness clusters and a regional training cluster)

FIGURE 9 | Map of INRA research centres and recently reinforced thematic clusters

9.3 The commitment of INRA researchers to higher education

In 2007, more than 20,500 hours of teaching were given in higher education establishments such as universities and agricultural and veterinary schools, by 1150 researchers and engineers from INRA. In addition INRA research units hosted 1833 doctoral students in 2006-2007 (69% from France, and 31% from other countries). INRA also managed numerous degree students and postdoctoral fellows in 2007, including 58 foreign degree students and 133 postdoctoral fellows funded by INRA, and 97 postdoctoral fellows funded by the Ministry for Research. These future researchers, both French and from other countries, actively contributed to the work of INRA while being trained in research processes.

INRA's commitment to higher education has mainly developed at the **initiative of researchers and engineers**. Although they often work in the context of training for existing master's or doctorate courses in order to present their own research findings, some projects correspond to a much more intense involvement in the design and management of training for a master's degree or a module for a doctorate. In such cases, teaching activities far exceed the strict context of the research carried out by the researcher providing this training. The purpose is indeed to transmit a coherent body of knowledge that will not only benefit the few students who intend to carry out research themselves, but will also help those who will subsequently become active in the farming or food industry, banks or politics, so that they can base their future thinking on the knowledge they have acquired. In this context, particular mention should be made of:

- the **merger of master's degree courses**: the team at the Angers-Poitiers Centre provided support for the merger of master's degree courses in plant sciences dispensed by schools and university establishments in Angers, Nantes and Poitiers.
- the **introduction of new disciplines** such as metagenomics, in partnership with AgroParisTech.

To supplement the efforts made by its researchers, INRA decided to become involved in a **selective policy of institutional associations** with seven doctoral schools amongst the 109 in which its teams participate. In 2007, this policy resulted in an association with two doctoral schools in Montpellier and Toulouse. Partnerships are also envisaged with doctoral schools in Nancy (forests), Paris 7 (frontiers of the life sciences), Paris 11 (plant sciences), Agroparistech (Abies, environment) and Rennes (life sciences). In the context of these partnerships, INRA will exploit the know-how acquired thanks to the Marie Curie site projects (Initial Training Network) in which it participates.
In the context of the research and higher education **consortium** that is currently being developed, one of INRA's priorities will be to anticipate future global changes by preparing young people to adapt societies, companies, farming and the environment to these unavoidable trends. It can be hoped that this strategy will ensure a dual synergy: between researchers in temperate zones and specialists in tropical regions on the one hand, and between researchers and teachers on the other. This dynamic should attract not only French students but also those from other countries.

The BioVIGPA master's 2 course: the federation of a body of knowledge consistent with the socioeconomic context of western France

The BioVIGPA master's 2 course (Integrative Plant Biology from Genes to Plants and Agrosystems) results from the collective desire of higher education establishments (universities and specialised schools *(Grandes Ecoles)*, agricultural research centres (INRA) and other research agencies in western France to share and federate the skills of their teacher-researchers, researchers and engineers (about 350 scientists in all), and to offer coordinated, high-level training in the principal areas of plant sciences and their agricultural and technological applications. This federation exploits the diversity and complementarity that exists between the different teaching and research teams working on plants, distributed throughout different sites in this geographical region. These close links are remarkable both in terms of the disciplinary fields concerned and the experimental models employed, as well as interactions with other sectors of competence (food sciences, animal biology and livestock breeding, ecology, environmental sciences, human and social sciences, applied mathematics, chemistry, etc.).
This master's course is appropriate to the economic and social importance of agriculture, the agrifood industry and the bioindustries in the regions of western France. It is also linked to the recognition of competitiveness clusters concerning its areas of activity, as these are indicative of the excellence of the regions involved with respect to training, research and technological innovation in the different sectors of plant production and exploitation.
The BioVIGPA master's 2 course is jointly accredited by the Universities of Angers, Western Brittany, Nantes, Poitiers, Rennes 1 and Tours, and the National Horticultural Institute schools in Angers and Agrocampus Rennes. Managed in partnership with the INRA centres in Angers-Nantes, Poitou-Charentes and Rennes, the Universities of Caen Basse-Normandie, Orléans, Limoges and Angers Agricultural School (ESA), it welcomes 60 students each year, from both France and other countries.

INRA's involvement in the renewal of disciplines taught in master's degree courses by AgroParisTech

INRA is closely involved in profound renewal of the master's degree courses offered by AgroParisTech. Thematic working groups include researchers from the Science and Technology of Living Organisms and the Environment cluster (STVE), which includes all INRA centres in the Ile-de-France region. Because the objective is to open training opportunities to Europe and other countries, INRA was asked to emit proposals with respect to training targets and to identify new European partnerships, because of its experience in the organisation of European projects.
Thus assistance was sought from the Micalis project, that groups 14, INRA-associated research units from the Ile-de-France region working on the "Microbiology of Food at the service of Human Health". Amongst the **innovations suggested by microbiologists from the Micalis cluster regarding the master's degree course**, mention can be made of:
• A new specialisation in the Integrative Biology module: Systemic and Synthetic Biology (BSS) - from modelling of the functioning of natural biological objects to the creation of synthetic objects. This specialisation was jointly designed with the Université d'Evry Val d'Essonne (UEVE), the Ecole Centrale de Paris and the STVE cluster. Although the Ecole Centrale and UEVE are responsible for most of the mathematical content (statistics, modelling), INRA's contribution is essential to the biology component. The overall contribution of INRA scientists is estimated at more than 35 hours of teaching for the course.
• Two new courses (Digestive and Cellular Physiology, the Intestinal Microbiota and Metagenomics) in the Applied Microbiology and Biological Engineering (MAGB) specialisation of the Foods, Bioproducts, Nutrition and Health course. Nine of the 21 host teams accredited for this specialisation are from INRA (Jouy-en-Josas, Grignon).

10. Innovations for industrial actors

A mission-oriented research institution such as INRA must contribute to the development of knowledge, but must also propose sustainable and competitive innovations that will benefit industry. This chapter presents a panorama of advances proposed by INRA. After an overview of the specificities of innovation at INRA, the chapter focuses on the products proposed to the **farming world** (new varieties, animal breeding, dissemination of know-how, biological control, regional policies), **rural areas** (regional approaches) and **enterprises** (patents and licenses, start-up companies and technical innovations for SME). Because of the **time required to develop and disseminate innovation**, INRA's ability to produce innovations can only be illustrated by describing those that have marked the past and still exert an impact on the present. This section will therefore present some **relatively old innovations** that continue to have a strong economic impact, and a few **more recent examples** which seem to be set for a promising future.

10.1 Difficult evaluation because of diffuse exploitation

First of all, it is important to recognise the major difficulties encountered when trying to describe and quantify research products that are not publications, and also to measure their impact.

This well-known problem is further exacerbated by the **characteristics of innovation at INRA**: the time lag, the need to work in "packages" or groups, the strength of partnerships and the profiles of innovators.

One specific characteristic of the innovation processes to which INRA contributes is probably their highly specific **time lag**: the trajectories of innovation are variable, but it is often necessary to wait for 10 years to see any results. The dissemination of an innovation in agriculture is also a generally lengthy process. Indeed, it depends on the **decisions of a large number of actors**: farmers themselves, upstream and downstream sectors, and public authorities (both French and European). The conditions for the dissemination of an innovation can be limiting in the long term when the strategies of different actors do not converge.

The second characteristic of innovation at INRA concerns its **definition and open nature**. In many cases, it is not a specific object but a series of innovations that are concerned, involving products, processes and organisation. Thus in the case of Beaufort cheese, illustrated in this chapter, INRA's areas of intervention concerned the development of new cheese ripening techniques, the design of a mobile milking machine and the outlines of a marketing circuit, etc.

The strength of the links between INRA innovators and their external partners may mean that INRA's contribution to an innovation **may not be sufficiently visible** outside this network, and the results may not attributed to the Institute. On the other hand, it is possible that other actors will consider that INRA's contribution is too visible (e.g. agricultural or food producers whose communication is based on their heritage image and who may be reluctant to explain any changes that have been made to their manufacturing processes).

These different characteristics highlight the problems encountered when trying to assess the impact of INRA innovations.

10.2 The principal innovations

Retrospective analysis of the innovations presented in this chapter highlights an important **factor for success.** Whether an innovation concerns an advance in animal genetics, the creation of a new plant variety, the dissemination of know-how or a study on regional dynamics, its success is principally dependent on the ability to **mobilise different types of actors around a common, federative project.**

a. Genetic selection:

■ Innovations in animal genetics

The history of animal genetics at INRA is closely linked to the 1966 law that organised animal breeding at a national level and entrusted INRA with the responsibility for genetic evaluation in four species: cattle, goats, sheep and pigs.

During the 1960s, few structures had been organised for breeding, and INRA developed different **nucleus herds to facilitate dissemination.**

The economic impact of nucleus herds

These herds were generally transferred to private breeders or breeder associations. Several of them, transferred during the 1970s, **exerted, and sometimes still continue to exert, a strong impact**, such as the Vedette hen (made available in 1973, 75% of the French market for chicken meat and 8% of the world market), rabbit lines for meat production (made available in 1975, 75% of the French market and widely present in other countries), hyperprolific pigs, or the INRA401 sheep population which is both hardy, displays good conformation and is prolific; this became the Romane breed in 2007.
Although they are destined to be transferred in the short or medium term, some herds are still managed by INRA, such as Orylag® rabbits (patent filed in 1989), which are reputed for both their fur and their meat quality, the hypermuscled INRA96 cattle line which is used for terminal crossbreeding for dairy breeds (approximately 60,000 inseminations per year) or Créole cattle and goat herds in Guadeloupe.

However, **the most important impact of INRA's work on genetic selection has been achieved through partnerships**.

Genetic evaluation is an essential process that determines not only the orientation and efficiency of selection, but also commercial aspects of genetic selection and the value of breeding animals.
To achieve successful evaluation, INRA manages national databases on genealogy and performance, compiled using data from several hundred breeding organisations. This privileged role for INRA has enabled it to weigh heavily on the definition of breeding objectives and their gradual modulation in favour of product quality and adaptive traits, while at the same time preserving diversity. This process concerns **the entire ruminant herd and 70% of the pig herd** which thus benefit from **genetic advances of about 2% each year** regarding selection targets, so that France benefits from a high-performance and diversified herd.
In a general climate of State disengagement, the recent Agriculture Orientation Law in 2006 reaffirmed INRA's position and thus implicitly acknowledged the coherence and efficiency of its methods, both in different sectors and in the public interest. It should also be noted that since 2006, all genetic evaluations on cattle benefit from ISO9001 certification.

This very close and historic partnership has continued **with the emergence of genomics in selection**. Since 2002, the Agenae Scientific Interest Group involves INRA, CIRAD and four professional sectors involved in the orientation, funding and exploitation of genomic research in animals. In addition, a massive programme of selection for resistance against scrapie (nearly 100,000 animals typed each year) has enabled the eradication of susceptibility in all ovine breeding males. And again, in partnership with the cattle industry since 2000, marker-assisted breeding now forms an integral part of the breeding scheme for three types of cattle - Holstein, Normande and Montbéliarde - or **99% of the dairy herd. This has improved the efficiency of breeding schemes by around 15%**. Since 2008, methods have shifted towards genomic selection, the efficacy of which should restrict, or even annul, the need for testing on the progeny of breeding animals.

Two illustrations of partnerships with different sectors

Close partnerships with industry can also be illustrated by a **common structure, the Labogena GIE (Economic Interest Group)** which was set up in 1994 by INRA and six professional organisations. Labogena is a genotyping company that now employs 60 staff, and carries out controls on filiation (approximately 120,000 controls per year), the selection of genes of interest (approx. 100,000 analyses per year) or genomic selection, in 13 species. In this way, research-generated innovations are transferred almost immediately to industry.
In the **poultry and fish-farming sector,** INRA provides support for the French Union of Poultry and Aquaculture Breeders (SYSAAF) and has developed a long-term partnership with this professional body which groups breeders (often of a small size) and thus enables the sharing of technological innovations. In this way, INRA has broadly disseminated the Prosper method, developed in 1994, that can optimise mass selection in fish without the involvement of maternal or competitive effects.

■ The breeding of plant species

The breeding of most cultivated plant species has followed another path. Indeed, the demonstration in numerous species of the effect of heterosis opened the way to both **important margins for progress** for farmers and major markets that only specialised **private companies** could enter. INRA has made a considerable contribution to this dynamic.

As early as the 1950s, INRA was contributing to initial advances **in major agronomic species** by creating wheat, maize and rapeseed varieties that were greatly superior to those available at that time. These pioneering varieties, protected by new variety certificates (COV) were then used as genitors by private breeders. This partnership encouraged the development of companies such as LIMAGRAIN. The same pattern **continues today** in wheat, as illustrated by the KORELI variety, whose market share is minimal when compared with its performance but which is very frequently used for introgression schemes that will very soon produce privately-bred commercial varieties.

Historical advances for major agronomic species

The same applies for **wheat**, where INRA has boosted French production thanks to emblematic varieties such as Etoile de Choisy. After widespread use during the 1960s, particularly in southern regions, it was subsequently used for crossbreeding that gave rise to new, high-performance varieties.
The same path was followed by **maize**; thanks to the initial hybrids, developed by INRA, between American genitors and local French populations, most of the major French companies, including LIMAGRAIN (the fourth largest seed-producer in the world) experienced considerable growth.
Some twenty years later, and while pursuing its studies on maize and wheat, INRA was confronted by the need to develop new varieties of rapeseed on the one hand, and oilseeds on the other. In collaboration with the private sector, INRA contributed to the creation of very high-performance **rapeseed** varieties that differed as a function of their food or industrial end-uses. The most important feature regarding this species was INRA's development of a process to ensure male sterility that is now employed throughout the world by seed companies. **Field bean** has also benefited from considerable advances, notably through the creation of "double 0" varieties.

Since the 1980s, the **private sector has been able to assure the creation of new varieties of major species**; INRA has thus deployed its potential in **complementary markets** and for **very long-term research** (in areas such as the functioning of plants and the development of biotechnologies to **rationalise selection)**, which do not meet the short and medium-term criteria for commercial profitability. During the 1980s, INRA thus launched projects aimed at broadening the genetic base for selection, such as "source populations" for maize. In the field of **sustainable agriculture**, INRA has deliberately focused on supplying genetic material to producers who will then supply the market when it has reached maturity.

In 2007, the ten species of most importance to INRA in terms of the **royalties received on new variety certificates (COV)** were: sunflower, soft wheat, cocksfoot, rapeseed, potato, garlic, shallot, triticale, maize and durum wheat.

Genetic advances in complementary markets

Advances have also been achieved in **fodder plants** such as triticale, a hardy species introduced into France by INRA in 1980, and now cultivated on some 330,000 hectares. INRA has also focused its efforts on the earliness of maize varieties and their adaptation to animal nutrition as silage. In the same way, some ten years ago, INRA decided to contribute to setting up a winter protein plant sector, based on both pea and fieldbean, to make up for the considerable deficit of protein seed cultivation in France.
More recently, INRA designed a new **sunflower genetics** programme in response to the need for biofuels. Thus, having selected male sterility in this species so that the creation of hybrid varieties would be possible, and having built up a world-class collection of genetic resources on the species, INRA developed a new programme in Toulouse combining genetics, ecophysiology, pathology and agronomy.
Grapevine plays a particular role in INRA's work because it is the only species where INRA benefits from both exclusive rights to new varieties and the creation of a commercial brand, "INRA-ENTAV", because of a lack of private sector actors. INRA is focusing on several areas, such as the creation of rootstock varieties, wine grape varieties (Marselan was registered in 1995) and table grape varieties (Danuta, the first pip-free variety, was registered in 1990), the principal objective being tolerance of the principal diseases that require the use of pesticides.
Fruit production: During the 1980s, INRA focused on creating more flavoursome varieties, such as the Garriguette strawberry (20% of French production) or more recently the revival of other sectors (the Angelys pear, introduced in 1998).
Support for sustainable agriculture: in the context of approaches aimed at designing low-input cropping systems (described in the paragraph below), genetic responses adapted to the needs of profitable agriculture, a reduction in inputs and ecological requirements, this is a crucial and strategic area for the Institute. Among the successes recorded, mention can be made of the Ariane apple created in 2003, which has enabled a 50% reduction in the use of plant protection products, the soft wheat varieties Renan (1989), and more recently Koreli (created in 2006).

b. The dissemination of know-how

The invention of new production systems and the dissemination of know-how, alongside the creation of new plant varieties and the improvement of animal breeds, constituted the principal contributions of agricultural research to the modernisation of farming during the second half of the 20th century.

The two emblematic examples illustrated in this report are the development of managed fertilisation and rationing systems for livestock.
Since the 1970s, INRA has participated in the development of **managed fertilisation**, particularly in partnership with soil analysis laboratories. The balance sheet method, applied to arable crops over the past twenty years, has enabled environmental benefits by decoupling an increase in yield and greater fertiliser use, notably in the case of beet and soft wheat.
INRA has published a series of manuals on **livestock rationing systems**: thanks to a partnership established with milk recording agencies (which in France determine the rations for dairy cows) 75% of the national herd are concerned by this innovation.

INRA has also achieved advances in numerous other areas, such as more environmentally-friendly cultivation methods for integrated fruit production (the PFI charter on apples concerns 60% of production) or the diagnosis of plant diseases, etc.

The important contribution of INRA to managed fertilisation

INRA's contribution has been crucial to the development of managed fertilisation:
This method was applied at a large scale *via* soil analysis laboratories. For **elements other than nitrogen**, INRA developed the CERES software during the 1970s, which gradually equipped all soil analysis laboratories (up to 80% of the 400,000 analyses performed each year). The interpretation of soil analyses can generate fertilisation recommendations at the plot level. A new software (RegiFert) has been available since the 2000s. Used to interpret 20% of soil analyses, it enables a marked reduction in fertilisation.
For **nitrogen**, INRA developed the management tool JUBIL (based on analysing plants) during the 1990s for use on cereals and potatoes, and then in 2005 the Azofert tool which has been tested successfully by the Beet Technical Institute (ITB) (38,000 plots).
The results achieved through the use of decision-making tools for nitrate fertilisation have been **spectacular in arable crops**. In the case of sugar beet, nitrate fertilisation per tonne of sugar produced has fallen by 45% in 20 years (source: ITB). For soft wheat, the adjustment of nitrate doses using a management tool during cultivation concerns 22% of the land used (source: Agreste 2005). The fractionation of nitrogen has also been applied at a regional scale. In particular, this inspired the Fertimieux system for managed nitrate fertilisation aimed at restricting nitrate pollution, which involved up to 27,000 farmers, or 1,900,000 hectares *(source: IFEN 2006)*.

The widespread use of recommendations concerning livestock rationing systems

The **Tables of composition and nutritive value of feed materials** for livestock (200 feeds and by-products) are an INRA bestseller. Translated into English, Spanish and Chinese and updated in 2004, more than 12,000 copies have been sold to date.
INRA has also published a **book on ruminant feeds** that has sold 9000 copies. The second edition (2007) profoundly updated the feed recommendations for cattle, sheep and goats, and clarified the composition and nutritive value of 1250 types of forage.
Finally, INRA develops **software programs to manage rationing** for animals: INRAtion for ruminants (3500 licences sold, translated into English, Spanish and Rumanian), and INRA Porc (300 licences sold in 16 countries).
Their use by the industry is very widespread with respect to **ruminants**: the rations of 3 million dairy cows in France (75% of the herd) are designed using feed software programs developed by the milk recording agencies (*Contrôle Laitier)* (SIEL, OSMOSE), which integrate INRAtion and INRA tables. The use of INRA products by Teagasc in Ireland concerns around 50% of Irish farms.
Use of the INRA Porc tool is also very widespread when determining pig rations: nearly 500 training licences have been sold and some twenty training sessions on use of the software have been organised in about ten countries. In view of these results, it can thus be said that almost all the companies involved in pig nutrition in France, and more than half in Europe, have now been trained in use of this tool and apply its concepts and data.

c. The implementation of regional dynamics around new sectors

The three examples shown in the table below illustrate the impact of methods developed jointly with a variety of actors in rural areas and linked to a production sector. The originality of these approaches has been the creation and transfer of a package of innovations rather than just one alone; this has sometimes involved initiating a market that did not previously exist and restructuring the links between different actors.
It is very difficult to evaluate this type of activity in terms of publications in international, peer-reviewed journals, or theses. A careful watch must thus be kept on the evolution of such projects, which are of considerable originality and are now taking on new importance in a context of economic downturn that has redistributed economic activities, where the links between towns and rural areas are changing and demographic trends are having important effects on different regions.

The Alpes du Nord Scientific Interest Group (GIS) and revival of the production of Beaufort cheese

During the 1970s and 1980s, studies performed by INRA in a cheese sector experiencing decline - Beaufort - concerned the search to improve its bacteriological and gustatory quality, and to develop new technologies that could reduce the onerousness of milk production (mechanical milking in mountain pastures, and the partial mechanisation of haymaking). Cheese production was revived, rising from 500 tonnes at the end of the 1960s to 4330 tonnes in 2007. A thousand jobs were preserved or created by the Beaufort sector in farms and production workshops. Numerous farmers indeed have two jobs, one on the farm and the other linked to the winter sports industry.
During the 1980s, this approach was extended, in the context of another GIS, to the three départements of the Alpes du Nord region (Savoie, Haute Savoie, Isère), and work continued during the 2000s, to the benefit of cheese producers in mountainous areas (not only Beaufort, but also Reblochon, Abondance, etc.). The sensory differences between valley and mountain-produced cheeses were indeed demonstrated, thus scientifically strengthening the typicality of a local product.

Protection of the mineral water catchment belonging to the Société des Eaux de Vittel

Eau de Vittel, the third leading French mineral water with a production of 900 million bottles a year, emerges from a calciferous plateau situated to the west of the Vosges mountains. To prevent any risk of pollution, the company has created a protected area of 5000 hectares (catchment area for water collection), with a high-priority perimeter of 3000 hectares. Work by INRA (five teams were involved) in collaboration with two universities and CEMAGREF enabled protection of this catchment basin and revised the methods to maintain tourist areas. This work, carried out between 1978 and 2004, involved the 40 farms present in the area (replacement of maize crops by alfafa, a new balance in animal rations, new methods for the treatment of slurry effluent) and regional actors. This first operation to protect a mineral water production basin was then adapted to other contexts (Ferti-Mieux then Agri-Mieux operations, etc.).

The restoration of Lac Léman

In order to reduce the eutrophication of Lac Léman, its restoration was started in the 1970s. Through its research laboratory in Thonon, INRA was involved in this initiative by monitoring the evolution of water quality and the lake ecosystem. Today, it holds a lengthy series of physicochemical and biological data on this environment.
The fish population, exploited by 150 French and Swiss professionals, was dominated by perch during the period of eutrophication. The perch fishing industry collapsed as restoration work started on the lake, but no other species compensated for this lack of fish resources. Fishermen left the profession. In this crisis situation, INRA research during the period 1985-1995 provided support for the development of other emblematic lake fish populations, such as whitefish, working in close collaboration with local government authorities and what remained of the fishing industry. The growth in these fish populations, achieved by stocking with young fish and laying down rules such as the mesh size of nets, accompanied restoration of the quality of the lake ecosystem. Today, whitefish production has reached more than 300 tonnes a year (as opposed to less than 50 tonnes before 1990), and perch fishing has remained at about 50% of previous levels. Professional fishing is once again a profitable activity, and young fishermen are now starting to set up in business.

d. Biological control

During the 1960s, INRA was the first institution to design a commercial insecticide based on *Bacillus thuringiensis*. At that time, and despite major efforts regarding quality, INRA did not succeed in convincing any industrial partners to invest in this bacterium, although its subsequent worldwide commercial success is now acknowledged. It was fifteen years later that a commercial biological control product based on trichograms was developed in collaboration with the In Vivo cooperative. This product is still used successfully on more than 100,000 hectares. In parallel, several other commercial products were developed using predatory ladybirds, baculoviruses, entomopathogenic fungi or insect pheromones. However, the greatest agronomic successes achieved by INRA in the area of biological control are not of a commercial nature; they concern the advances achieved in acclimatizing auxiliary species for the control of biopests.

Some examples of products or organisms used in biological control

Versus the white leafhopper, an exotic invasive species originating from North America that had become a major pest in Europe, the release since 1996 of populations of an American microhymenoptera *Neodryinus typhlocybae*, which is both a parasite and a predator, have been successful. Once acclimatization of this auxiliary was considered to be successful, its use was developed and several hundreds of sites, in 21 French Départements, have now been covered.
Mention should also be made of other INRA innovations in the area of biological control: predatory bugs to control whitefly, an entomopathogenic bacterium against the pine processionary caterpillar (approved in 1976 and used in 98% of treatments), a fungus employed against sugar cane whitegrub (*Beauveria brongniartii*, approved in 1993), control by means of sexual confusion in viticulture and arboriculture (as early as 1989), and a viral preparation against codling moth.

e. Important patents for innovation

Between 2001 and 2008, the value of royalties paid by industry to INRA increased three-fold, to reach €5 million. In parallel, a portfolio of more than 350 licences covering all sectors of the Institute's activities was built up.
These figures must be taken in context: in certain areas of INRA's activities, such as plant biotechnologies, the percentage of patents that have already given rise to the granting of licences has remained low in all countries.

INRA's "lead" patent concerns cytoplasmic male sterility in crucifers, the so-called OGU INRA system (1991), which is the subject of numerous licensing contracts for its use. In 2008, half of all hybrid rapeseed and cabbage varieties cultivated throughout the world were developed using this process. To consolidate its position, INRA purchased the "fertility restoration" patent from a Japanese company, so that it could offer a full technological package. The ten INRA technologies with the highest economic value over the past five years are shown in the table below.

TABLE 8 | The ten leading patents in terms of royalty payments (in thousands of Euros)

	2003	2004	2005	2006	2007
Technology for rapeseed and cabbage hybrids	1 225	370	1 057	1 630	2 035
Preparation of lactic acid bacteria	32	109	94	125	364
Electrodialysis of wines	58	58	67	58	153
Rhizobium activators			63	96	116
Flash détente	26	31	60	52	65
Rabbit strain for fur production	55	49	58	73	52
Myxomatosis vaccine				50	50
Ruffle oak plants	33	35	39	42	48
Carpovirusine against codling moth	52	42	90	50	47
Avian cells	11	61	26	10	47

Patents with an industrial impact in a variety of sectors

The principal patents concern the agrifood sector (lactic acid bacteria for the manufacture of cheddar cheese in the USA, vinification), and also the veterinary industry (vaccines against Chlamydia, coccidiosis, myxomatosis), biopharmaceuticals industry (culture of avian somatic embryonic cells), agronomic innovations (*rhizobium* activators, truffle oak plants, viral preparations) or selection tests in pigs to eliminate major meat defects.
Some **patents currently under technology transfer** have promising applications; for example in nutrition and health (substances to combat osteoporosis, compounds for the prevention and treatment of hyperglycaemia, or probiotic strains for digestive tract diseases), or the agrifood industry (yellow food colorant extracted from apples to replace chemical colorants, or use of the beneficial bacterium *Lactobacillus sakei* for meat conservation).

An example of a patent currently under technology transfer: a process for the decontamination of poultry meat

Despite the hygiene measures applied between slaughter and packaging, pathogenic bacteria can proliferate in poultry carcasses. In this context, INRA researchers have developed a process that can thermally decontaminate poultry skin while conserving the "fresh" state of the product. Based on using superheated steam jets at atmospheric pressure, this technique does not involve any chemical substances or irradiation. It is the subject of a patent that was filed in 2005.
Trials are currently under way in partnership with CIRAD **so that this process can be adapted for use in developing countries**.

f. Company creations and innovations for SME

Over the past eight years, INRA has participated actively in supporting the incubation of **some forty innovative start-up companies**.

This support has essentially been scientific and technological, through hosting by INRA laboratories. It is supplemented by the action of ten regional incubators in which INRA is a participant. INRA never acts as an investor at the seed-capital stage, but works indirectly through the BIO-AM fund dedicated to biotechnologies. The ABA vector described in Chapter 6.2. is the most downstream stage at which INRA provides financial support.

Three distinct market segments characterise the portfolio of start-up companies that have been based on INRA technologies:

- a group of highly-specialised service-providing companies with modest growth and funding needs, but which play a virtuous role in exploiting know-how and expertise that would otherwise remain in laboratories; in terms of the number of start-ups, these account for half of projects.
- a group of start-ups that develop projects targeting the agrifood industry: these companies often encounter problems during their growth phase and have a need for capital, but the venture capital funding model is inappropriate so an industrial backer must be found at a relatively early stage.
- a group of companies with high technological and commercial potential that are closer to the models funded by venture capital investors and are the preferred targets of ABA (high-potential gazelle companies). After creating value, some of these companies will either pursue their development through a call for outside funding, or be taken over by an international group.

A few examples

During the early 1980s, BIOTOP, a pioneer in biological control using trichograms and then ladybirds, was set up in collaboration with the In Vivo cooperative.

INRA has supported companies with high potential that have since become success stories in the Paris market.

Numerous INRA innovations have been transferred to the winemaking industry: the flash détente process (more than 2 million hectolitres of wine), the tartaric stabilisation of acidity (6 million hectolitres of wine in France and Italy) and the lowering of alcohol content.

Other SME have benefited from INRA research: pre-cooked durum wheat (sold by many distributors in France and the USA), propionic starters for cheese flavouring and the microfiltration of milk (50% of the Canadian market for ESL milk).

11. Scientific support for public policies

INRA's contribution to supporting public policies takes the form of four, specific activities:
- through the participation of its researchers in **expertise** activities, either individually or in a collective context such as that of health agencies;
- through the **publication of collective expert reports** that allow INRA to answer the questions raised by politicians,
- through the development of studies oriented towards **support for public decision-making**,
- through the execution of **public service missions** on behalf of the government.

In addition, other activities carried out by INRA, such as the **foresight studies** referred to in Chapter 3.2., contribute to informing the long-term challenges of public policies.

11.1 A few quantitative data on expertise

The Research Programming Law of April 18, 2006 stipulated that expertise is one of INRA's missions, in the same way as the production of knowledge, the provision of training, and the exploitation and dissemination of scientific and technical culture. **Alongside the collective scientific expert reports (ESCO)** described in the section below, the framework of which is determined by explicit reference documents, **numerous expertise missions are carried out under less formal conditions** and managed by one scientist or a small group of researchers or engineers. Because of this method, these expertise activities are incompletely listed in the INRA information system, apart from those that are the subject of contracts. In order to identify and quantify these expertise missions, during the last quarter of 2008 INRA thus completed an initial inventory of all the information recorded in the assessment dossiers of its scientific staff. The initial statistics arising from this survey on half of all researchers and engineers indicated that 17% of them were involved in providing expert advice. Of these, 41% devoted more than ten days each year (more than 5% of their time) to this activity, and 19% more than 20 days a year to this activity.

The method retained

The expertise activities and results taken into account in the survey

The expertise activities referred to in this survey consisted in making knowledge available to sponsors or clients outside the research world. They thus complied with one of the following criteria:
- they were initiated because of an explicit request that corresponded to a mission of limited duration and generally led to the compilation of a report for the sponsor. This report would review the scientific data acquired, could contain information and results generated by existing models using data supplied by the sponsor, and could also contain recommendations;
- or they formed part of the activities of bodies whose mission is to provide expertise; in this case, the agents concerned would participate regularly in a committee of experts for a health safety agency.

This survey did not cover a series of activities that could contribute to support for public policies or assist industrial actors, but were considered as providing expert assistance:
- activities forming part of a research programme, even if it was mission-oriented,
- expert reports on research projects or scientific papers,
- activities corresponding to the transfer of knowledge or the production of new decision-making tools (e.g. activities in the context of AgroTransfer structures),
- anything connected to undefined and long-term partnership activities with the "usual" partners of agriculture that could not be identified in terms of a specific question or a given period of time. In particular, account was not taken in this survey of participation in steering committees or scientific advisory boards (technical institutes, professional organisations, industrial groups, etc.),
- the provision of services, the production or supply of data that was not analysed by INRA before being transmitted,
- consultancy work for companies or associations resulting from a personal commitment (not performed on behalf of INRA).

The different ways of providing expert advice are **very varied**, and this survey recorded around 400 instances. With the notable exception of collective expert reports (which usually involve more than a dozen INRA scientists) the great majority of these actions only concerned **one INRA staff member**. Note should also be taken of the considerable involvement of INRA scientists **in expert committees for national or international expert agencies**, in the forefront of which was AFFSA [25] (52 scientists).

[25] AFSSA French Agency for Food Safety.

Expert reports are usually compiled **for government authorities**. Indeed, approximately 22% of the activities included in the sample analysed were destined for international public bodies, 68% for national or regional government bodies and 10% for professional organisations.

Table 9 | Customers for expert reports by INRA

PUBLIC BODIES	
22%	**International** organisations (world): OECD, WHO, World Bank **European** organisations: EU Commission *(Directorate General for Health and Consumer Protection*, etc.), European Agencies *(European Food Safety Authority* (EFSA), *European Environment Agency* (EEA), etc.) National bodies in other countries
68%	Public organisations in **France**: Ministries and permanent committees under their tutelage (CORPEN, CTPS), National Genetic Improvement Commission (CNAG), **Specialised French organisations or agencies**: AFSSA, AFSSET, **French public establishments**: specialised or permanent groupings (not agencies): ONF, INERIS, INAO, ONEMA, GEVES, GNIS, Parcs Nationaux de France (PNF) **Local** government bodies: Regional Councils, Departmental Councils, Municipalities, natural parks
PROFESSIONAL ORGANISATIONS	
10%	Professional organisations in the fields of agriculture, food and nutrition, the environment, and the management of rural areas

An **analysis of the type of expert advice** given showed that 37% of the results were destined as an aid to decision-making by public bodies, 25% concerned risk assessments, 14% were contributions to regulations, standards or verifications of compliance, and 16% were expert reports on commercial products.

Table 10 | Breakdown of products by type of expert advice

37%	Contribution to the **analysis or orientation of public policies**, support for decision-making and implementation, assessment of public policies. Often in the form of a prognosis, and the role of model use Examples: • benefits and costs of different hypotheses concerning the future of the CAP • feasibility, benefits and costs of reducing pesticide use • feasibility of a return to the Nitrate Standard regarding water quality in Brittany • factors governing variations in pollen flow, the risk of GM contamination and the coexistence of different sectors • assessment of drought-resistant cropping systems, • contribution to the work of the CORPEN, • impact of climate change.
25%	Diagnosis of, or watch on, a risk. Assessment following an experiment or a crisis Examples: • environmental or health impact of chemical contamination • environmental impact of biological contamination (pathogens, parasites, pests, invasive species, etc.) • toxins, new technologies, catastrophes, • work by the Genetic Engineering Commission (CGB)
14%	Opinions on compliance with a regulation or standard or a contribution to drawing up regulations or standards Examples: • regulations and standards, qualification of products and processes, good practices, INAO labelling, ethics (animal welfare), legal rulings
16%	Expert advice on a commercial product Examples: specifications for Label Rouge products
8%	Other

This preliminary survey demonstrated the diversity of expert practices at INRA and the importance of individual expertise. Its results will give rise to strategic discussions on the contributions of these different types of actions to the missions of the Institute, and a comparison with practices in other national and international research organisations involved in the same areas of agriculture, the environment and food and nutrition. INRA must also consolidate its reporting methods concerning expertise activities in order to rationalise these practices and, when justified, enhance their integration and recognition in the assessments of individual scientists.

11.2 Collective expertise to inform public decision-making

Collective scientific expertise (ESCO), or a critical synthesis of the knowledge available, is an activity designed to inform public decision-making that is consistent with the objectives of a mission-oriented research institution. It responds to a **question posed by an outside sponsor** - generally public authorities - by drawing up an inventory and making a critical, multidisciplinary analysis of the scientific data available and any pending issues on a given theme. Experts from different backgrounds are involved in this work, which is based on the world scientific bibliography.
Collective expertise has two objectives:

- **to inform public decision-making** through an inventory of the scientific knowledge available: acknowledged findings, uncertainties, controversies and deficiencies.
- **to inform public debate** by making available a corpus of validated knowledge on a subject of general interest.

It can give rise to discussions as to future programmes, in order to define a research project that will provide responses to the principal questions that are still pending, and that the public authorities consider it should be possible to determine.

Collective expertise at INRA is a recent activity that has grown up gradually as with the growing number of reports commissioned by the Ministries for Ecology and Agriculture (often both). After an initial phase (2001-2004) during which its feasibility was tested, a rhythm of expertise was established (2004-2008) at one report per year, to be governed by a **Charter**.

Experience acquired through the conduct of six collective expert reports:

- Agriculture, regions and the environment (2002);
- Mitigation of the greenhouse effect: Increasing carbon stocks in French agricultural soils (2002);
- Pesticides, agriculture and the environment (2005);
- Drought and agriculture: adapting agriculture to the risk of water deficit (2006);
- Fruits and vegetables in our diet: the challenges and determinants of consumption (2007);
- Agriculture and biodiversity: encouraging synergies (2008).

The 2009 expert report will focus on animal welfare and suffering.

INRA does not view ESCO as providing targeted services. The issues addressed by ESCO are generally **very broad and concern developing scientific areas**. The type of subject usually corresponds to a sensitive area of public policy and/or its positioning in European or international negotiations. Thus INRA has produced expert reports that lie at the crossroads of issues of importance to society (on pesticides), politics or industrial sectors (the consumption of fruits and vegetables). The "Drought" ESCO, on the other hand, which might have proved a sensitive subject, benefited from the rainy summer of 2006. The ESCO on Agriculture and Biodiversity had less impact outside the Institute as the conclusions were deemed somewhat unspectacular, although innovative.
Expert reports on the environment have also contributed to the **reputation** of INRA, notably with environmental protection organisations and in particular by calling into question its image as an unconditional supporter of the dominant farming model. Thanks to their media impact, these reports contribute to **informing public debate** on these issues. They have also inspired policy orientations by the government, and the preparation of its decisions. Thus the **ESCO on Pesticides** contributed to the emergence of a consensus on the need for ambitious policies to reduce the use of plant health products, while ensuring the competitiveness of farming. As a result of the Environment Round Table, France decided to reduce its pesticide use by half within the next ten years, and to gradually ban the most dangerous compounds from the market.

How can the effects of collective expertise be measured?

Each collective expert report is the subject of communication to the public, a public meeting, syntheses, press relations operations and articles in magazines or on the Institute's website.
Since 2006, interest in these documents has been monitored through consultations of the website, the quantitative and qualitative study of reports in the press (repetition of messages) and analysis of the communication tools used by different partners (key words). However, INRA cannot generally obtain a full view of the operational consequences of its ESCO in terms of how they affect the public sponsors of its work (measures to reorient public policies, new regulations), because this does not fall within its remit.
For example, analysis of the press repercussions of the expert report on fruits and vegetables in November 2007 showed that this work by INRA was the subject of considerable attention. Thus 144 articles served to feed public debate on this issue. The principal results of the expert report were described in the press, and notably the insufficient consumption of fruits and vegetables when compared with the guidelines. Similarly, the French government's position during the Environment Round Table debates was very similar to the conclusions reached by the expert reports on pesticides and drought and agriculture.

11.3 The implementation of specific programmes as an aid to public decision-making

Some of INRA's research programmes are deliberately designed to supply public actors with information, or tools, that will provide foundations for their decisions and strategies. This section **describes three examples**. Thus research at INRA has made it possible to analyse the effects of public policies, as well as providing platforms for negotiation at a European level (CAP: Common Agricultural Policy) or internationally (WTO: World Trade Organisation). Two other examples concern food and nutrition policies, and the coexistence of GM and non-GM production sectors.

a. Research in support of agricultural policies (CAP-WTO)

INRA develops **economic models** at the scales of the planet, the European Union, France, its regions, specific sectors and farms, grouped by type. The two principal stakeholders in this type of research are, on the one hand, the European Commission (Directorates General for Agriculture and Trade), and on the other hand, the French Ministry for Agriculture, who may use these models, notably to assess the possible consequences of proposals for CAP reform or compromises under WTO agreements.
The model systems developed by researchers are **difficult to exploit** without the aid of their authors, insofar as the implementation of a particular reform requires adaptation of the tool. In practice, the response to any request is dealt with by working groups that associate both stakeholders and researchers.
One **example** is the work carried out in partnership with Dutch researchers on the consequences of different scenarios for changes to European dairy policies (on behalf of the Commission and in the context of the 2003 CAP reforms, now referred to as the CAP health check process). On behalf of the French Ministry for Agriculture, reports have been compiled, for example, on the decoupling of farm income support, the future of grazing-based livestock farming, or policies for rural development under the second pillar of the CAP, etc.

b. Research in support of food and nutrition policies

INRA carries out research on issues of importance to French food policies:
- research that tries to better understand consumer behaviour and **dietary preferences**, in the light of numerous physiological, psychological or socioeconomic determinants. In particular, this research focuses on the elderly and young children, in order to combat obesity and pathological states related to overweight.
- research to understand the **impact of diet** - nutrients, whole foods but also weight-reduction diets - on human physiology and psychology is another, particularly innovative challenge, as the aim is to determine its global impact over long periods of time, and understand the underlying mechanisms.
- finally, other research concerns **improvements to food safety** and the development of food quality.

The importance of childhood to the **acquisition of dietary preferences** has been demonstrated during studies conducted by researchers from INRA and the Faculty of Medicine in Dijon. Preferences and dislikes observed at 2 or 3 years of age were shown to remain relatively stable, although slight changes occurred during adolescence with respect to certain foods. This work is continuing in the context of the OPALINE observatory, which aims to gain a clearer understanding of how taste develops and evolves in infants, from the uterus to around two years. The EduSens project targets the effects of sensory learning on dietary preferences and behaviour in children aged 8 to 10 years.

INRA research concerning the **impact of diet** can be illustrated by the original example of the characterisation of simultaneous **risks and benefits related to the consumption of certain foods**, such as **fish** (which is beneficial in terms of its omega 3 fatty acid content, but constitutes a risk because of its content in heavy metals). This research also considers the messages that must be communicated to consumers in this respect.
Other research projects, described in the box below, have focused on controlling the quality of **cured meats and cheese**, or the risks related to **trans fatty acids**.

As for **food safety**, the multidisciplinary research unit Métarisk (Paris), set up in 2004, develops methods for the analysis of food risks. The analysis of health risks is a fundamental issue for public decision-makers, because it forms the basis for the

design of health policies and information for consumers, such as the definition of standards and controls for foods. The stakes are also international with respect to **trade**, both in terms of defining standards and resolving disputes at the WTO. Indeed, since 1994, agreements on health and plant protection require scientific and analytical proof that there is no risk attached to putting a new food on the market. In this context, research concerns the characterisation of health risks and drawbacks, the modelling of consumer exposure to risks and the socioeconomic analysis of risk management measures.

Studies to ensure the quality control of cheeses and traditional charcuterie products

The sensory quality of fermented foods (cured meats, cheeses) is closely linked to the microbial communities present in them, which include staphylococci. INRA researchers have determined the diversity of coagulase-negative staphylococci, i.e. those other than *Staphylococcus aureus*, and their associated risk factors.
This approach was necessary in order to comply with the recommendations of the French Agency for Food Safety (AFSSA) and the European Food Safety Authority (EFSA).
The results obtained contributed to drawing up guidelines on good hygiene practices, thus providing producers with a working tool adapted to traditional charcuterie products that would comply with the food safety regulations promulgated by European legislation.

Studies in support of regulations on trans fatty acids

A fatty acid can take two, geometrically-different forms, referred to as "cis" and "trans", which are metabolised in different ways by the body. Several countries, such as the USA, restrict the use of "trans" fatty acids, which are widely present in the agrifood industry, and suspected of causing a significant increase in the cardiovascular risk. The source of these "trans" fatty acids (animals, partial hydrogenation of unsaturated plant oils or frying) may be important. Thus research was coordinated by the Human Nutrition Unit in Clermont-Theix, in association with several industrial partners and the Centres for Research in Human Nutrition for Auvergne and Rhône-Alpes. By combining animal studies with a clinical study performed in two centres and work on myotubes in culture, it was possible to show that trans fatty acids in milk, and resulting from the hydrogenation of lipids of plant origin, did not affect the insulin sensitivity of muscle, even in situations propitious to the presence of lipotoxicity. This demonstration of the lack of any deleterious effects should call into question the decisions taken by the USA concerning their overall ban on these fatty acids in foods.

c. Study of the coexistence of GM and non-GM crops

INRA has been particularly closely involved in **coordinating two European programmes** on the coexistence of GM and non-GM crops: SIGMEA focused on gene dispersion from GM crops, and CO-EXTRA has developed methods to organise **the coexistence of these two sectors**.

The **European SIGMEA programme** enabled the development of a decision-making tool that can be used to answer the following questions: what happens in terms of **gene dispersion** if a particular GMO is introduced into a particular European region? How can crops be organised to remain within legal threshold limits for the fortuitous presence of GMOs in conventional crops? Simulations showed that the risks are graduated as a function of the cropping context and the characteristics of the GMO envisaged. In some cases, it is sufficient to organise separate harvesting; in others, additional management precautions must be taken regarding sowing dates or crop rotations. A geographical separation between GM and conventional crops is necessary in some situations. Without prejudging political decisions and the thresholds fixed, this tool provides an understanding, under each scenario, of the possibilities of gene dispersion and the methods to be implemented in order to minimise them.

The **European Co-Extra programme** (CO-EXistence and TRAceability of GM and non-GM supply chains) has generated **inexpensive methods to organise the coexistence** of GM and non-GM supply chains, by defining the conditions necessary for the harvest and processing of these products. As a corollary, the programme has enabled the development of control and traceability methods for products throughout the chain, so as to ensure reliable labelling. Thus consumers, industry and farmers can retain their free choice with respect to the use - or not - of GMO, as they have demanded and as is required by the regulations.

11.4 Participation in public service missions

Over the years, INRA has been entrusted by its Ministries with a certain number of official missions which have created very strong links with actors in the regulatory field, in industry and in associations, for example:

a. The Research and Control Group for Varieties and Seeds (GEVES)

The GEVES (Research and Control Group for Varieties and Seeds) is a Public Interest Group (GIP) that involves 179 agents from INRA and around 70 GIP employees. Its prime mission is to propose to the Permanent Technical Committee for Seed Selection (CTPS) an analysis of new varieties that is based firstly, on their homogeneity, distinctiveness and stability, and secondly on their agronomic and technological value. The GEVES also studies seeds in terms of their germination capacity, purity and health status. These two missions require both the high quality and throughput of analyses, and the development of methodologies and strategies concerning changes to these analyses in a context of the changing expectations of agriculture. For this reason, GEVES has reinforced both its own methodological capacities and its links with INRA teams. These changes gave rise in particular to a joint GEVES-INRA presentation to the INRA Scientific Advisory Board prior to renewal of the contract for this GIP (2007).

b. The Genetic Data Processing Centre (CTIG)

On behalf of the Ministry for Agriculture and of breeding agencies, the CTIG assures the management of national livestock databases on cattle, sheep, goats and pigs. Based on these data, researchers can estimate the genetic value of breeding animals in order to ensure the genetic improvement of livestock. INRA is doubly equipped to carry out these tasks, which to a great extent determine the commercial value of a potential genitor. The centre focuses skills in this area and provides a guarantee of neutrality for operators in the sector.

c. Soil databases (INFOSOL)

Because of the considerable variability of soils and their properties, thorough knowledge of soil characteristics is necessary to assess its aptitude for different uses and its contribution to environmental quality, and to propose the most appropriate methods for long-term management. The threats of degradation that affect this non-renewable resource require long-term monitoring to quantify changes and define any conservation methods that need to be encouraged.
INFOSOL (18 INRA staff and two engineers from IFEN) carry out national soil inventories and monitor soil quality. The unit manages the National Soil Sample Collection. It ensures links between soil databases and the thematic tools generated by INRA research. The unit's programmes are managed by the Soil Scientific Interest Group (GIS), which includes members from the Ministries for Agriculture and the Environment. INFOSOL plays an important role in coordinating specialised European programmes, in close collaboration with the European Soil Bureau Network (ESBN) located at the Joint Research Centre (JRC) of the European Commission, Ispra (Italy), and the European Environment Agency (based in Copenhagen, Denmark). Thanks to this investment, the efforts made since 2001 to ensure that France caught up with other countries regarding soil data have enabled it to become a European reference in this field, and make a major contribution to the methodologies proposed to inventory and monitor soils in Europe.

d. The Observatory on Food Quality (OQALI)

The National Nutrition and Health Programme for 2006-2010 (PNNS) was designed to improve the health of the population by acting on nutritional determinants. Thus the French government and the National Food Council commissioned the French Agency for Food Safety (AFSSA) and INRA, working in partnership with industry, to set up the Observatory in order to ensure the global monitoring of foodstuffs and measure changes to the nutritional quality of products (nutrient composition, portion size, nutritional information on packaging, etc.), while taking account of various socioeconomic characteristics (consumption data, prices, market segments, etc.). OQALI constitutes a valuable tool to evaluate and monitor the efforts made by the food industry to develop products in a way that is favourable to consumer health.

12. Contribution to interactions between science and society

Science can help us to dream about hopes of the technical advances it might achieve and the global well-being it might ensure. But citizens are also affected by science, either because it is controversial or because it is the source of innovations that revolutionise social and economic equilibriums, profoundly modify our everyday environment or raise **questions of ethics, standards or collective safety**.

For several years now, research in the life sciences has thus been central to the debate that has focused public opinion on issues of scientific and technical development. The relationships between man and nature, biotechnologies, food safety are all issues that are both **subjects of important research by INRA and controversial arguments in society**.

Scientists and research agencies are sometimes placed in the centre of the public arena in debates with a strong ideological content, faced with questions at the limit of their knowledge and their ability to establish the facts. Suspected of imposing values or choices on society, scientists and their institutions must be able to justify their actions **to society**, and no longer just to their peers.

Thus there is every reason for INRA to participate in the science/society dialogue that is triggered as a result of the applications, assessment and monitoring of research. However, developing **such a partnership with society** is not a simple affair, because of a lack of structure in civilian society and the complexity of the issues addressed.

- In this context, INRA has benefited for the past ten years from the presence of an **Ethics Committee**, responsible for the independent examination of the social implications of agricultural research. The work of this committee, and how it has evolved, are the subject of the first section in this chapter.
- Using the issue of genetically-modified organisms (GMO) as a case study, the next section illustrates the relationships between science and society that have been established by INRA in **a controversial situation**.
- INRA's initiatives to find a **forum for dialogue** with society before any programming decisions are taken, are illustrated in the third section, the example being the CAP-Environment project.
- Finally, INRA has improved its public image by structuring its **institutional communication and conjugating this with the freedom of speech of its researchers**.

12.1 The role of the Ethics Committee

Aware of the concerns expressed by civilian society about the benefits or risks of research applications, INRA set up its Ethics Committee, as an independent, consultative body, in 1998.

The first committee to be set up was called the **Ethics and Safety Committee on Agricultural Research Applications** (*Comité d'éthique et de précaution pour les applications de la recherche agronomique*, or **COMEPRA**). The name of this body clearly illustrates the novel position that was adopted at that time by comparison with other ethics committees, which mostly focused on either biomedical ethics or professional standards and practices in research. COMEPRA's mission was to **reflect on the relationships between science and society** in the fields of agriculture, food and nutrition and the environment, and the impacts and ethical acceptability of the applications of agricultural research by civilian society, and to emit opinions and recommendations in this context. COMEPRA's purpose was not to reach decisions on controversies or develop standards, but on the contrary to provide a means to open a debate.

Made up exclusively of outside personalities from a variety of backgrounds (philosophers, legal experts, scientists and teachers in different disciplines, representatives from civilian society chosen from professional groupings close to the areas of application concerned), the COMEPRA was qualified to respond to requests from INRA managers, but could also decide itself to initiate debate on certain issues. In 2003, this ethics committee became organically common to INRA and IFREMER.

Because the non-renewable mandate of COMEPRA members expired in April 2007, this opportunity was seized to "re-found" an ethics committee that would take account of evolutions affecting the context and nature of issues addressed by public agricultural research in the framework of its missions. **The creation of a new, Common Advisory Committee for Ethics in Agricultural Research, in the first instance common to INRA and CIRAD, was decided upon**. It was thus necessary for the scope

of this new committee to be broadened to include methods of cooperation with southern countries, as well as to the issues of sustainable development; its composition was therefore reviewed in line with these needs.

The first two issues on which the Committee's opinion was sought after its installation in January 2008 concerned **biofuels** and **global food safety**, and its reports should be published during 2009.

Work by the COMEPRA

During the eight years of its existence (1998-2006), the work of the COMEPRA focused on:
- animal cloning in 2000 (at the request of INRA)
- partnership in 2001 (at the request of INRA)
- the patentability of living organisms in 2002 (decided upon by the COMEPRA)
- oyster farming and biotechnologies in 2004 (at the request of IFREMER)
- plant GMOs in 2004 (at the request of INRA)
- expertise in mission-oriented research agencies in 2006 (at the request of both INRA and IFREMER)
- consideration of the direction taken by genetic advances in 2006 (decided upon by the COMEPRA)

Follow-up by INRA as a result of these opinions

Reports on the activities of COMEPRA were presented by its Chairman to the INRA Board of Directors on a regular basis.

The work achieved by COMEPRA was also the subject of widespread in-house and external communication, and debates with researchers. The debates - or even controversies - aroused by these opinions bore witness to the value of stringent ethical reflection to informing public debate and providing scientists with references concerning the approaches they could adopt.

INRA has remained attentive to recommendations made by its ethics committee when compiling documents that are the subject of wide-ranging consultation. Thus the Partnership Charter, the position of INRA concerning the patentability of living organisms, the Charter on Expertise or the Institute's position regarding plant GMOs, validated *in fine* by its Board of Directors, took account of some of the conclusions reached by the Ethics Committee.

12.2 GMOs as an emblematic case of debate between research and society

With the "mad cow" crisis, and the controversies aroused by genetically-modified organisms (GMOs) and health or environmental events, INRA often found itself at the focus of sometimes conflictual debate on the effects of research. A review of how the Institute dealt with the GMO issue allows us to draw certain lessons from this experience and to **propose a generic approach** to the governance of **issues that are the subject of scientific and social controversy**.

During the 1990s, INRA participated in numerous public debates and expert bodies concerning the GMO issue, such as the Citizens' Conference organised by the OPECST [26] in 1998. Despite taking initiatives on institutional communication (publication of an information document on GMO-related research issues, information on the website), INRA's approach tended to be relatively **reactive**, mainly providing support for external initiatives.

As from the early 2000s, in a context rendered increasingly tempestuous by a series of public consultations whose recommendations did not appear to have been followed, INRA adopted a more **proactive** strategy. This was necessary because the Institute had now become one of the targets of anti-GMO movements. It also resulted from maturation of in-house debate at INRA and from its research work on science-society relationships.

The challenge was thus to **restore the conditions for dialogue** between research and society, which required three, complementary actions:
- to **listen** to social actors,
- to supplement this dialogue by **in-house debate** in order to define the Institute's position,
- to encourage **the development of research projects** corresponding to these orientations.

Rather than taking the initiative for a general debate on GMOs, INRA chose to organise experimentation on a specific, emblematic, issue. The aim was to work with all actors to define the conditions and criteria for in-depth discussions on the stakes of this research, and how it would be implemented, so that general lessons could be drawn concerning the role of INRA. The issue chosen was a research programme on grapevine in Colmar.

[26] OPECST: Parliamentary Office for Scientific and Technological Choices.

Involving the general public in decision-making: the example of INRA's Grapevine Project

A **participative (jointly-developed) assessment of a research programme** on transgenic vine rootstock was designed in 2001, in order to reconcile demands for democracy and innovation, in a context of serious conflict concerning GMOs, and on a product with strong symbolism in France. The research programme focused on fanleaf of grapevine, a viral disease transmitted by parasitic nematodes in the root system, where transgenesis can provide a useful solution via intervention on the rootstock.
This experiment, the first of its type in France, was managed using rigorous procedures and methods that were validated by **scientific publications** in leading scientific journals.
Consultation took the form of in-depth discussions by a **pluralist** working group (researchers, professionals, ordinary citizens) that took account of the diversity of world views, the quality of wine, the implications of transgenesis and the role and status of science.
The expert report issued by the group in 2002, upon which **INRA managers based its action programme**, recommended in particular:
the exploration of other research options to combat vine viruses,
the creation of a local committee responsible for monitoring the trial,
that any commercial applications should not be introduced without further consultation.
The trial was initiated in 2005 at the Colmar Research Centre, and has since constituted an exemplary platform for the joint production of knowledge by the different parties participating in the monitoring committee and the research team involved. Thus INRA's commitment to dialogue with society made it possible to develop trusting relationships with the different parties, even in this particularly controversial case of field research on a GM grapevine.

The recommendations made by the working group were clearly of **general value** to INRA. In controversial areas of research, it can be expected that public research will explore the different options available, that it will work according to the principles of transparency and will make a clear distinction between the period of research and that of commercial exploitation.

Following this project, INRA asked the **Ethics and Safety Committee (COMEPRA)** and its Scientific Advisory Board to emit their opinions on the scientific and ethical challenges of research on GMOs.

Based on the results of all these discussions, INRA thus prepared a **policy document on plant biotechnologies, which was adopted by the Board of Directors** on June 27, 2007. In this document, INRA emphasised the importance of the contribution of plant biotechnologies to meeting the major challenges confronted by agriculture, and defined the different dimensions of this contribution: to produce basic scientific knowledge, to build up public resources and facilitate access to technology, to contribute to innovation and to reinforce French capacities for public expertise.
In terms of **innovation**, the priority of INRA research is to focus on targets of collective importance that correspond to the major challenges faced by agriculture, food and nutrition and the environment. Transgenesis can be envisaged on the basis of a comparative assessment with other possible innovations; this choice will be the subject of debate open to different stakeholders. With respect to **expertise**, INRA places emphasis on the research necessary for a global, systemic and multidisciplinary assessment, at different scales of time and space, of the impacts and risks of different types of innovations, transgenic or not. For this purpose, INRA has enhanced its research potential, notably in the fields of agroecology and risk analysis. Today, the Institute is the European leader in these research fields, as clearly manifested by its coordination of several projects (Co-Extra, SIGMEA, ENDURE, etc.).

A **similar approach**, combining in-house cross-disciplinary debate and external consultation procedures, was also adopted for **animal biotechnologies** in 2007. The aim was to define the Institute's position in the research field, which is characterised by marked uncertainties, the considerable complexity of the issues raised and disagreements concerning the values and objectives to be pursued.

12.3 Finding a forum for dialogue between researchers and citizens

a. The CAP-Environment project

Regarding the environment, dialogue between INRA and other stakeholders is complicated by the number of bodies involved (associations, elected representatives) and the lack of resources that deprives our interlocutors of the expertise they require to deal with the complex issues concerned. The **CAP-Environment** project (Consultation Upstream of Programming) was a **pilot project** for the design and implementation of a **participative system to detect high-potential themes in the field of agriculture-environment interactions**. It resulted from INRA's desire to adapt its partnership and orientation relations to a new context, notably because of a broadening of the scope of its missions and the transformation of relations between society, science and innovation.

The system was based on **dialogue between researchers and actors in society** (companies, professional groupings, associations, elected representatives, public decision-makers, NGOs, etc.); the panel met on several occasions to clarify their views on: 1) research priorities in the field of agriculture-environment interactions, and 2) methods that could improve relations between researchers belonging to a mission-oriented research institution and actors in society.

The lessons of CAP-Environment: how to improve relations between researchers and actors in society

Between January 2006 and June 2007, CAP-Environment organised meetings of a panel of 80 people, half of them researchers from different disciplines and from a variety of French research agencies, and the other half social actors from other institutions. During these workshops, the participants clarified their expectations with respect to the generation of knowledge in four principal areas:

- The design of innovation and adaptation strategies for farming systems in a context of global change,
- Interactions between agriculture, regions and sustainable development,
- The effects of lifestyle, and notably diet, on agriculture-environment interactions,
- Tools to aid decision-making.

These discussions also led the participants to reach the following agreement: if INRA is to pursue, and in certain cases amplify, its production of knowledge, determining advances can also be achieved through its relations with potential users (decision-makers/citizens). The aim is not solely to improve the "transfer" of knowledge but also to generate new data thanks to interactions between researchers and other actors. The challenge is that scientific and technological choices should become the true choices of society. For this purpose, the panel proposed several methods to improve relations between INRA and its partners, and in particular:

- To propose syntheses of knowledge that are easier to use by decision-makers,
- To reinforce the operational nature of tools to aid decision-making that are produced by research, by better organising the links between research and engineering, by implementing appropriate projects, and by ensuring appropriate interface skills and organisational systems,
- To carry out anticipation and alert missions,
- To create a regular and permanent process for collective expertise.

b. The lessons of the Environment Round Table

The Environment Round Table *(Grenelle de l'Environnement)* was organised by the French government to provide a forum for the debate of environmental policies (discussed in six thematic groups) with constituencies representing different interests in society (administration, private sector, environmental organisations). INRA participated in the group working on methods for sustainable production and consumption, which was set up in July 2007. It also took part in the interdisciplinary group on genetically-modified organisms (GMOs).

The Environment Round Table revealed four major needs: to fight against climate change, to preserve and manage biodiversity and natural environments, to preserve health and the environment and to introduce ecological democracy. In order to provide practical responses to these challenges, 33 operational committees were set up in 2008. Actors in research, and in the first place INRA, were involved at the request of the Ministries for Sustainable Development and Research in the operational committee on Research, which focused on translating the priorities identified by the Round Table into concrete research orientations. A report on the results of its discussions was submitted to the Government in September 2008.

The Round Table highlighted the strong views held by society concerning the themes addressed by INRA: particular mention was made of research on productive and ecological agriculture, bioenergy and adaptation to climate change. Although the Round Table did not give rise to any really new challenges, it nonetheless called for a different collective approach by the Institute. In addition, beyond the implementation of thematic programmes, it implied that there was a need for ambitious collective projects on the creation of tools (observatory and experimentation networks, databanks, modelling platforms) and the development of methods (integrated assessment, construction of scenarios). It also posed the challenge of improving the structure and diversification of partnerships in the field of the environment.

12.4 INRA's management of its reputation and institutional image

Between 1946 and the end of the 1990s, INRA's image was that of a research institution at the service of productive agriculture that could supply healthy, inexpensive food. The more recent integration of food and nutrition and environmental issues within the scope of INRA's work raises the question of how these institutional changes have affected perceptions of its public image.

An image analysis in 2005 demonstrated that INRA **suffered from a public image problem**. According to professionals, INRA had gradually cut itself off from the farming world, but without being recognised as an actor in the fields of the environment or food and nutrition. Nor were ongoing changes affecting the Institute and its identity clearly perceived by the general public. Its activities and research were still deemed to be too closely associated with those of intensive agriculture that manipulated the mechanisms of living organisms in response to needs that were not always legitimate. The Institute thus needed to make considerable efforts to explain its activities and results to different audiences.

In reaction to this, INRA refocused its communication on the **fundamental messages** concerning its identity. As a result, all aspects of its institutional visibility were enhanced, as attested by the **image analysis performed in 2008** on target audiences.

This study examined how the general public and professionals perceived the legitimacy, legibility and visibility of INRA regarding the three pillars of its thematic tripod. It concluded that **INRA was now legitimate, understandable and visible regarding its new research orientations**. The target audiences perceived mission-oriented research as a benefit that strengthened proximity with the economic and industrial worlds and society. The quality of the research carried out was acclaimed with almost total unanimity, as was confidence in the information provided.

This qualitative image analysis was accompanied by more quantitative surveys which confirmed that INRA was now in phase with the expectations of society. For example, the value of INRA research was emphasised by 92% of **visitors to the INRA stand at the Salon international de l'Agriculture (SIA) in 2008**. When questioned following the special meetings organised during the SIA in 2008, the professional audience all declared that they knew that INRA worked in the field of sustainable agriculture and on "clean" and sustainable farming systems.

However, when questioned, approximately 60% of professionals and 44% of the general public considered that INRA did not sufficiently inform citizens about its data and research, and that greater access should be ensured to information on its strategies and research programmes.

The assessment system

13. The utilisation of assessment

Research functions as a motor for progress: programming, implementation, assessment and then feedback on the decisions taken. Any assessments must be both objective and strategic. This means they must be exhaustive and coherent with the missions of the entity under study, at a frequency that allows a long enough period for there to have been sufficient opportunity to achieve significant advances. For this reason, assessment forms part of the Institute's **strategic management system**: it must enable a check that the orientations that have been defined are being implemented, and that successes and problems are identified so that the organisation or use of resources, and the strategy of the establishment, can be adapted appropriately. A clear separation must therefore be ensured between the body that carries out an assessment and the body which takes decisions on the points to be followed up, in the light of its results and the strategy being pursued. Three major principles govern the assessment method adopted by INRA:

- Assessment is based on **methods appropriate to the missions and practices of mission-oriented research**. Account must therefore be taken of: the different methods used to define research issues; the role of relationships with non-research partners and stakeholders; the interaction loops between fundamental and mission-oriented research, between the synthesis of knowledge in support of public policies or economic actors, and the emergence of new research paths. The different impacts of results are also aspects that need to be explained and taken into account in assessments. INRA thus pays particular attention to its assessment system and methods, and regularly reviews the results in order to identify any changes that may have become necessary.

- INRA also ensures that **the results of assessment are actually taken into account** in decision-making processes; this does not always mean a follow-up of the conclusions, but an explicit and transparent examination of them.

- Assessment also provides an opportunity to contribute to the **coherence and cohesion of the system**. First of all, that it federates all the actors in the entity being assessed during the self-assessment, which will lead to compilation of a collective document. And also because all these actors are concerned by the different processes that result from assessment. These must therefore be identified and clearly articulated. INRA has set up **methods for the assessment of its research** at different levels: divisions, units and personnel, both researchers and engineers. It has also introduced **internal audit procedures** to assess research support functions.

13.1 Methods for intervention

a. The different levels of research assessment

The INRA assessment system concerns three levels of organisation. The different assessments are defined so that there are no overlaps between the different aspects assessed, and correspond to the specific missions of each entity.
Research **divisions** are assessed every four years by an international committee; these assessments, organised by central management, are under the control of the Institute's Scientific Advisory Board.
From the end of the 1980s, units were assessed every four years in the context of a process managed by the research divisions and involving their scientific advisory boards and central management. Since 2007, research **units** have been assessed by the AERES according to the four-year university timetable. Divisional scientific advisory boards and central management integrate the results of these assessments in the Institute's strategy, in order to define new objectives for each unit.
Researchers are assessed every two years by specialised scientific committees (CSS), half of whose members come from outside the Institute.

Alongside biennial interviews with their line managers, **engineers** are assessed every four years by commissions organised as a function of their principal missions.

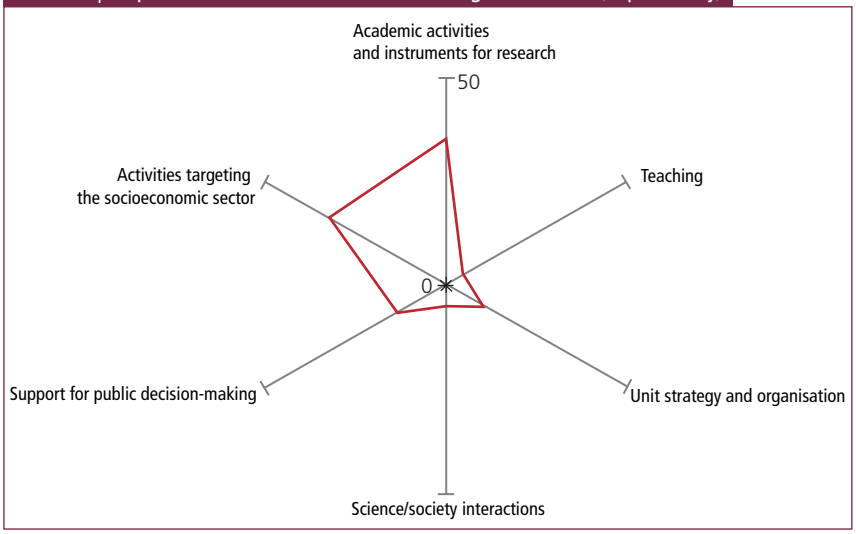
b. A framework to analyse mission-oriented research activities

In order to specify its quality requirements concerning the non-academic components of its activities, in 2006 INRA, in liaison with other agencies, defined a classification of the activities and products of research units, based on which these units could describe their profile while explaining the investment of their resources on the one hand, and their results on the other.

Development of a classification for the activities and products of research units that describes the profile and project of each unit

Under this classification, activities are distinguished according to the different **components in society** with which the unit interacts: the research world, industrial actors, public authorities and society as a whole.
They are also broken down as a function of their **type of activity** and where they are situated in the research process.
Activities to produce knowledge lie at the heart of the missions of research organisations. These are combined with the construction of relationships and collaborations with the research and industrial sectors, as well as with the availability of syntheses of knowledge, methods and scientific instruments.
Indeed, the importance of establishing long-term partnerships in the context of innovation processes means that this activity can be considered alone and its intermediate results can be measured, as they reflect the confidence achieved by researchers in their relations with professionals and the concrete development of joint projects.
The third type of activity concerns the generation of syntheses of knowledge to assist decision-making by both public authorities and other social actors, as well as making available techniques, instruments and scientific resources to the research sector and professionals.
By crossing **these two analytical angles, six "elemental activities" are obtained**, from which a very accurate determination of the specific profile of each unit can be developed.

FIGURE 10 | Representation of the breakdown of working time in a unit (% per activity)



c. The internal audit function

In 2006, an internal audit function was set up by INRA to supplement the collective assessment system, until then reserved for scientific activities only. The skills references of this function resulted in the **compilation of a charter** in 2007.

The provisions of this charter generally follow the framework of recommendations issued by the French Institute of Internal Audit, but adapted to the specific context of a research institution. In particular:

- the internal audit restricts its field of investigation to research support functions,
- when carrying out an audit, the auditors are no longer dependent on their usual managers but report directly to the President of INRA.
- as well as a standard verification of compliance and performance, the aim of an internal audit is to check on the **correct understanding of the Institute's strategy** by its staff on an everyday basis. The choice of an "advisory audit" was thus made, which implies the implementation of an action plan after each audit.

It is also stipulated that an external audit will be performed on this function after two annual programmes before any necessary changes are made.

13.2 Lessons drawn from assessments

a. The assessment of divisions:

We have seen that divisions are the key scientific entity in the organisation of INRA. It is at this level that strategic decisions are translated into research operations, and that the skills and experimental or technical resources are determined and deployed. To achieve this, timetables for divisional assessments have gradually been aligned with their strategic plans.
The self-diagnosis stage that precedes the assessment of a division, and the periods of interaction with the assessment committee, and the divisional or INRA Scientific Advisory Board, are important opportunities during which it is possible to:

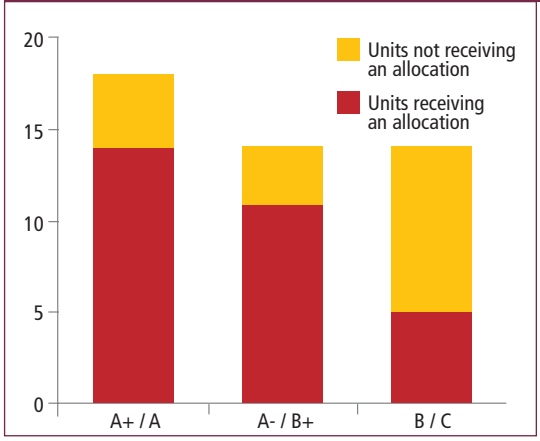
- reposition the **missions** of the division,
- identify **projects that are more visible and transversal** to several divisions, so that major issues can be addressed collectively,
- assess the impact of an **orientation**. Despite the methodological difficulties involved, it has been possible to achieve this on two occasions. Thus development of the choices of species to be improved within the Plant Breeding and Genetics Division was concomitant with its assessment. In the Environment and Agronomy Division, the demand for clarifications in the field of agroecology followed assessment of the division.

Assessment by an external, international committee, introduced in 1998, is a four-year event which is **still recent** when compared with the duration of execution of strategic plans. Following completion of the second cycle of divisional assessments, it is clear that conduct of this system provides a **positive opportunity for reflection** that focuses researchers on the challenges and issues they have not had the time to consider with sufficient attention in the everyday exercise of their activities. **Advances** could be achieved through an improved compilation of mission statements, and better preparation for visits by assessment committees, as the latter are often initially surprised by the organisation of the Institute. It is provided that the **Scientific Advisory Board is responsible for the actions to be taken** following a divisional assessment. In the future, we would like to **consolidate the method** for the assessment of divisions in the light of studies carried out, notably in the UK (reform of the Research Assessment Exercise), the Netherlands (EriC project) and in Finland (work by the Finnish Academy).

b. The assessment of units

The assessment of units is clearly a prerequisite **to their development and to defining their scientific projects for the next four years**. However, in a context of mission-oriented research, this definition also depends on the scientific ambitions of the establishment regarding a unit's research themes, in the context of a partnership policy that forms part of the centre's dynamics. To manage implementation of these necessary changes, INRA has formalised the concept of the **life cycle of units**. It is now accepted that a unit is not a perennial structure but that its existence is dedicated to completing an explicit and coherent scientific project, assessed every four years. The assessment of units constitutes a stage in their life cycle; it triggers, or accelerates, thinking on the changes necessary with respect to the scientific priorities, internal reorganisation or even closure of units.

FIGURE 11 | Allocations of new posts: what correlation with assessment? (units assessed in 2005)



Among the resources controlled by INRA, **staff allocations** have the most effect on structuring the medium and long-term evolution of research unit projects. When arbitrating on the allocation of new researchers or engineers, post-doctoral fellows or thesis grants, INRA is extremely attentive to the quality of a unit's scientific dynamics and results. The opinions of assessment committees are thus taken into account in these decisions, alongside strategic choices such as the development of high-priority themes or localisations that are appropriate to a structuring operation. The graph below gives an a posteriori view of the actual link between the results of assessment and the allocation of posts.

The number of permanent posts (researchers and research engineers) allocated between 2006 and 2008 to the 48 units in wave D, assessed in 2005, shows that units that were the subject of reservations (scored B and C) received significantly fewer allocations than units scored A or B+. Thus 78% of units scoring A or B+ benefited from at least one recruitment, and only 36% of units scoring B or C. Of the units with less good assessment results, these resources were only allocated to make up for an absence of leaders or to support the reorientation of one of INRA's strategic themes (e.g. ecotoxicology).
Finally, since 2007, the life cycle of units takes account of the project-implementation-assessment phases.

Two examples of units where assessment accelerated a dynamic for change

The Animal Infectious Diseases and Veterinary Public Health Unit in Tours forms the core of INRA's Animal Health cluster, and its research must respond to important challenges in animal and public health. It was assessed in 2008 by the AERES, which confirmed that it possessed know-how in the field of infections and immunity in farmed animals that is unique and recognised. This unit was nevertheless invited to review the themes covered by its research. As a conclusion to this assessment, the new managers of the unit proposed the reorganisation of its 15 specialised teams (bacteriology, parasitology, virology and immunology) arising from two previous units, and the construction of a truly common project that would federate a new unit around clearly-defined biological issues, using the most relevant animal models. INRA's central management will be recruiting a new Senior Scientist to provide support for these changes.

Over time, **the Agronomy Unit in Laon** has developed recognised skills in the fields of agronomy and biogeochemical cycles, notably those coupled with nitrogen and carbon in the soil. However, at the initiative of the Environment and Agronomy Division, changes to the unit in terms of its research themes, internal structure and partnerships, were envisaged. Generally speaking, this project consisted in:

- developing in the Laon-Mons cluster a unit of national importance focused on assessing the environmental impacts of the carbon and nitrogen cycles linked to agricultural practices (production of tools, methods and models based on information in its databases). The unit would be attached to the EGER consortium (Environment and Management of Rural Areas), which groups ten research units working on the theme of the sustainability and environmental functions of agriculture,
- by means of the mobility of scientific and technical staff, developing a team in the Joint Research Unit for the Fractionation of Agricultural Resources and Environment (FARE) in Reims focused on analysing the biodegradation of plant components in the soil and on associated biogeochemical cycles, thus contributing to the dynamic of the Renewable Carbon (CarBio) cluster on this site.

The assessment committee examined these changes proposed by the division, and pronounced in favour of this reorganisation. Furthermore, as an outside assessment body, the committee contributed to validating the diagnosis of these necessary changes, and facilitating dialogue between the division and the unit.

c. The assessment of researchers

Researchers are assessed using three specific methods:
The first concerns **recruitment and promotion**, which are dependent on special competitive procedures; this is the case to enter the category of Junior Scientist (all classes taken together) or to enter (or be promoted to) the category of Senior Scientist. However, promotion to 1st Class Junior Scientist is decided upon by management, based on a proposal by the **Specialised Scientific Committee (CSS)**. The CSS also monitors scientists outside the context of any promotion. As far as possible, scientists are assessed by the CSS at the same time as their research unit is being assessed.

■ Specialised Scientific Committees (CSS) in support of the Institute's strategy

Confronting a scientist with the opinion of his or her peers can contribute to the emergence of an interactive community. For this reason, in 2003 INRA decided to organise two CSS to give greater support to strategic scientific changes: a committee on integrative plant biology (which enabled the simultaneous assessment of molecular biologists and ecophysiologists) and a committee oriented towards systemic approaches so that all researchers using these methods in the context of agricultural systems, grasslands, forests or livestock breeding, could be grouped together. At the end of their mandate in 2006, these committees made a very positive assessment of this reorganisation. In the same way, the two genetics committees were merged in 2004.

■ Alert procedures

At all times, INRA seeks to improve the efficiency of its alert procedure regarding difficult individual situations. In the interests of both researchers and the Institute, any problems must be detected early, support provided as soon as possible and decisions taken without delay.
Thus between 2003 and 2007, the committees alerted central management regarding the case of 137 researchers whose production was insufficient. By the end of 2007, only 43 researchers were still under scrutiny, 19 of whom had been followed for more than two years. Measures were implemented by the divisions or central management to solve these problems. Thus the Agriculture and Agronomy Division set up an exemplary procedure to develop a shared diagnosis and then redefinition of a career path. Implemented with respect to 15 researchers for 6 months to 2 years, in almost all cases this approach led to thematic, functional or geographical mobility, either in the context of a redesigned research project (80% of cases), or a new project in a research support function (20% of cases).

This system, integrating promotion, assessment and support, is clearly quite complicated. But it is accepted by researchers and by the experts involved in assessment, as shown in the comments below.

Testimony of a committee member

The viewpoint of Kay-Uwe Goetz, Director of the Bavarian Institute of Animal Production (Munich, Germany) regarding researcher assessment

K.-U. Goetz was member of the CSS on Animal Genetics.

"During the period I participated in an INRA researcher assessment committee, the form and content of the dossiers improved considerably. The introduction of "light" assessment, alternating with more in-depth examinations every four years, has reduced the efforts required by both researchers and committees, and the in-depth examinations are now more detailed and of much better quality. Experts on the committee gave a great deal of advice about the compilation of reports. Personally, I encouraged researchers to clearly explain how their activities formed part of the unit's strategic project, and, in order to clarify the understanding of external experts, to outline and explain the management system operating in their unit.
INRA's approach to researchers with insufficient production is very constructive. It looks at the problem from the human resources point of view, expressing confidence - in principle - in the researchers and trying to create a conducive atmosphere for them to express their qualities.
I also agree that the assessment of researchers should not depend solely on determining their scientific production. INRA's method concerns all facets of their activities in the context of mission-oriented research, and also takes account of the changes that can affect activities during a career."

d. The assessment of engineers

INRA is one of the rare research agencies that has decided upon the systematic assessment of its engineers. This approach is motivated by the importance of this category specific to France and highly developed at INRA. Assessment also provides support for the career development of engineers, which is often complicated by major technological, methodological or conceptual changes. Finally, it provides an opportunity for an in-depth examination of an extremely diversified activity within the Institute.
Thus INRA's own image of its engineers was undermined by the results of a study performed on their activities between 2004 and 2007. Contrary to what was expected, this study showed that INRA engineers estimated that they devoted 50% of their time to the development of methods, techniques and tools for research projects, and only 10% to projects concerning industrial partnerships, which should form an important part of their activities.
The study also highlighted the fact that engineers responsible for the management of experimental facilities, measurement platforms or resource centres (10% of engineer time at INRA) found it difficult to maintain a balance between the different activities that formed part of their mission: innovations regarding methods and techniques, the management of groups, the organisation of services for "customers" and partnerships with research teams. Once it had been made aware of the risks that threatened the development of skills by these engineers in the medium and long term, central management thus implemented measures to ensure they would receive greater support from the scientific advisory boards for these experimental units.
This assessment thus demonstrated the need to reinforce the role of engineers in partnership projects and the transfer of innovations.

e. The audit of research support functions

The internal audit group is small, comprising a full-time manager, a secretary and seven auditors who are made available to this function for one-quarter of their time.
This method forms part of an approach to ensure the constant improvement of support functions at the service of research actors, by identifying potential levers for progress and the simplification of procedures in each case.
The first audit was performed at the end of 2007 and concerned the implementation of a management modernisation programme (PEGASE). The 2008 audit programme comprised two structural audits: (DIFAG, Toulouse Research Centre) and three functional audits: the management of contracts and agreements, the management of non-full-tenure staff, and the management of working time.

Lessons from the audit on the modernisation of management

An audit was performed at the end of 2007 on the implementation of a programme to modernise management systems (PEGASE). The principal recommendations concerned the finalisation of a project on missions, the automatic integration of invoices in the accounting software, and major efforts concerning communication by different actors. These recommendations were implemented in the context of action plans concerning management improvements.

List of acronyms

ACTA	Association for the Coordination of Agricultural Technical Institutes
ACTIA	Association for the Coordination of Food Industry Technical Institutes
AERES	Agency for the Evaluation of Research and Higher Education
AFNOR	French Standards Institute
AFSSA	French Agency for Food Safety
AFSSET	French Agency for Environmental and Occupational Health and Safety
AFSSAPS	French Agency for the Safety of Healthcare Products
ALIMH	Nutrition, Chemical Food Safety and Consumer Behaviour Division, INRA
ANR	National Research Agency
BBSRC	Biotechnology and Biological Sciences Research Council (UK)
BV	Plant Biology Division, INRA
CEN	European Committee for Standardization
CEPIA	Science and Process Engineering of Agricultural Products Division, INRA
CGB	Biomolecular Engineering Commission
CGG	Genetic Engineering Commission
CIRAD	French Agricultural Research Centre for International Development
COFRAC	French Accreditation Commission
CORPEN	Orientation Committee for Environmentally-friendly Farming Practices
CNAG	National Genetic Improvement Commission
CNLC	National Commission for Labels and Certification
CTIG	Genetic Data Processing Centre
CTPS	Permanent Technical Committee for Seed Selection
EA	Environment and Agronomy Division, INRA
EFPA	Forest, Grassland and Freshwater Ecology Division, INRA
EFSA	European Food Safety Authority
EPCS	Public Establishment for Scientific Cooperation
EPPO (OEPP)	European and Mediterranean Plant Protection Organisation
EPSCP	Public Scientific, Cultural and Professional Establishment
EPST	Public Scientific and Technological Establishment
ERA-NET	European Research Area Network Scheme
GA	Animal Genetics Division, INRA
GAP	Plant Breeding and Genetics Division, INRA
GEVES	Research and Control Group for Varieties and Seeds
GIE	Economic Interest Group
GIEC/IPCC	Intergovernmental Panel on Climate Change
GIP	Public Interest Group
GIS	Scientific Interest Group
GNIS	French Association for Seeds and Seedlings
IFEN	French Institute for the Environment
INAO	National Institute for the Registered Designation of Origin
INERIS	National Institute for the Industrial Environment and Risks
INRIA	National Institute for Computer Science and Control
INSERM	National Institute for Health and Medical Research
IRD	Institute of Research for Development
ITA	Engineers, technical and administrative staff
MIA	Applied Mathematics and Informatics Division, INRA
MICA	Microbiology and the Food Chain Division, INRA
OCDE/OECD	Organisation for Economic Cooperation and Development
OMS/WHO	World Health Organization
ONEMA	French Agency for Water and Aquatic Environments
ONF	National Forestry Commission
OPECST	Parliamentary Office for Scientific and Technological Choices
OSEO	Agency providing support for the innovation and growth of SME and VSE
OST	Science and Technology Observatory
PCRD	EU Framework Programme for Research and Development
PHASE	Animal Physiology and Livestock Systems Division, INRA
SA	Animal Health Division, INRA
SPE	Plant Health and Environment Division, INRA
SAD	Science for Action and Sustainable Development Division, INRA
SAE2	Social Sciences, Agriculture and Food, Rural Development and Environment Division, INRA
SDAR	Research Support Services, INRA
SYSAAF	French Union of Poultry and Aquaculture Breeders
UMR	Joint Research Unit, INRA
UE DG SANCO	EU Directorate General for Health and Consumer Protection
UPRA	Union for the Promotion of French Farm Animal Breeds
WUR	Wageningen University and Research Centre (Netherlands)
WGL	Leibnitz Institute (Germany)

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