Sustainability Science in the International Knowledge Economy. Strategic Analysis and Opportunities for INRAE

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INRAE

Sustainability science in the global knowledge economy

Strategic analysis and opportunities for INRAE

Mission report

Claire Weill

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Short version

Findings of a working group comprising Gabrielle Bouleau, Pierre Cornu, Olivier Hamant, Pierre-Benoît Joly, Christophe-Toussaint Soulard, and Claire Weill

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Preface

Since its creation in 2020, INRAE has incorporated sustainability into its scientific strategies, an emphasis that can be traced back through its longer institutional lineage. This positioning gives rise to a question: must the institute also espouse "sustainability science", a step taken by other scientific institutions in France and around the world? In 2022, the Deputy Director General of Science and Innovation submitted this query to a multidisciplinary working group led by Claire Weill.

Over 35 years have passed since the Brundtland Report formally defined the concept of sustainable development, and work towards the 2030 Agenda for Sustainable Development Goals (SDGs) is still underway. Against this backdrop, sustainability-oriented initiatives have proliferated in research and higher education. Across the globe, sustainability science has grown in remarkable ways, a process that has been characterised by striking epistemological, collaborative, and institutional creativity. In tandem, within national and international academic circles, rich and lively debates are exploring how to best contribute to the agenda of required transitions. These discussions are shaped by exchanges with societies as well as with governmental and supranational bodies (or authorities).

In 2020, our institute published its strategic roadmap, INRAE 2030, which declared a commitment to investigating possibilities for dramatically transforming agricultural, food, and environmental systems. This triad's ever-growing interconnectedness demands that we identify the highest-level solutions that can be produced by publicly funded research institutions that take their responsibilities seriously. In this report, we dedicate ourselves to understanding the forces behind current transformations, with a view to generating actionable knowledge for solving the complex conundrum of meeting fundamental human needs while also ensuring planetary sustainability.

Global changes are causing mounting instability, and the 2030 Agenda's mid-term review has revealed persistent difficulties and stressors at all levels. In response, a research institute such as ours must ensure consistency and synergies between its internal organisation, partnerships, and objectives, in order to effectively tackle global sustainability challenges.

This report draws on the results of a broad international survey and the analysis of foundational texts in sustainability science. It both characterises this field of research and furnishes a semantic, epistemological, and foresight analysis of its development. Based on over 70 interviews with scientists working on sustainability transitions and transformations, this document highlights the most inspiring scientific proposals and institutional initiatives in France, Europe, and the world. Finally, it evaluates INRAE's organisational structure and strategic research priorities from a sustainability perspective, and then uses this springboard to recommend pathways for creatively and powerfully aligning the trajectory of our institute with that of sustainability science. Let us hope this convergence will help international research efforts better confront global changes.

Carole Caranta,
Deputy Director General of Science and Innovation, INRAE

Foreword

Carole Caranta entrusted me with a mission focused on the topic of sustainability science. This assignment lasted 1.5 years, from September 2022 to May 2024, and had the four following objectives:

1. Clarify what is meant by the polysemic term "sustainability science"
2. Analyse existing initiatives, particularly in INRAE's areas of expertise, and assess their similarities, differences, support actions and instruments, deliverables, and actionable measures
3. Determine the ways in which sustainability science informs public policy and, depending on context, gives rise to transformative public action
4. Evaluate the challenges and opportunities for INRAE.

This work was accomplished by a multidisciplinary working group under my leadership, whose members were Gabrielle Bouleau, Pierre Cornu, Olivier Hamant, Pierre-Benoît Joly, Christophe Soulard, and myself (short biographies below). Our group met monthly and also engaged in quarterly exchanges with a monitoring committee made up of Carole Caranta, Patrick Flammarion, Jean-François Soussana, Thierry Caquet, and Christian Lannou. Additionally, our group had a coordination committee–composed of Pierre Cornu, Pierre-Benoît Joly, and myself–that met once a month to organise our work activities.

Our overarching goal was to carry out a strategic benchmarking of current initiatives by research institutes, establishments of higher education, and research-oriented think tanks whose aim is to contribute to sustainable development goals and, if applicable, to the field of sustainability science itself. To this end, we utilised semi-structured interviews as well as qualitative reviews of both foundational texts in sustainability science and the strategic roadmaps of the above mentioned institutions.

First, we defined the scope, methodological approach, and analytical approach for the interviews. Next, we conducted over 70 interviews. The interview process began in France before being expanded to Europe and the rest of the world. We performed multiple interviews at some institutions, including at the National Research Institute for Sustainable Development (IRD) and Agricultural Research Centre for International Development (CIRAD) in France; Wageningen University & Research (WUR) in the Netherlands; the University of Sussex in the United Kingdom (where specific assignments have occurred); and the Fraunhofer Institute for Systems and Innovation Research in Germany.

I performed all the interviews, usually in collaboration with another team member. Pierre Cornu contributed his expertise in epistemology and biographical interviews; he also participated in numerous interviews. In addition, his work on the history of INRA and its partners was extremely useful in our efforts to identify and contextualise the institutional, epistemological, and political dynamics at play.

The working group collectively analysed the resulting materials, which included the interviews along with various complementary resources–articles in peer-reviewed journals, scientometric studies, strategic documents, and other information gathered online. Three preliminary analytical reports were discussed with the monitoring committee.

All working group members contributed significantly to the report. Co-author Pierre Cornu provided invaluable expertise when it came to organising and formatting the analyses. The successful completion of our assignment would have been impossible without the commitment and complementary skill sets of all the group's members. I wish to express my gratitude to each and every person on the team.

Claire Weill

Short biographies for the working group

Pierre CORNU is a professor of contemporary history and the history of science at the University of Lyon II. He is also an INRAE research director on secondment, the director of Territoires, a joint research unit in Clermont-Ferrand, and a historian with the INRAE-CIRAD History Committee. He is interested in interdisciplinary and transdisciplinary research, and he is the author of several historical and epistemological books and articles examining the role of science and publicly funded research in the Anthropocene.

Gabrielle BOULEAU is a political sociologist. A senior researcher at INRAE in an interdisciplinary research laboratory for science and innovation in societies (LISIS), she studies environmental issues and the greening of policies in France, Europe, and the United States. She explores how new environmental issues enter the sociopolitical sphere and give rise to contemporary political decisions, skills, and metrics. She is also head of the ethics committee at the French Agency for Food, Environmental and Occupational Health & Safety (ANSES).

Olivier HAMANT is a biologist. He is an INRAE research director at the Plant Reproduction and Development (RDP) Institute of École Normale Supérieure (ENS) Lyon, where he uses a combination of cell and molecular biology, mechanics, and modelling to explore how plants exploit forces to control their development. He is also part of a training programme whose focus is the many implications of the Anthropocene, at ENS de Lyon and with Berlin's House of World Cultures. In connection with this theme and his biological research, he has taken part in numerous projects involving the arts and humanities, notably those dealing with the complexity, resilience, and fragility of biological systems.

Pierre-Benoît JOLY is an economist and a sociologist. He is an INRAE research director as well as president of the INRAE Centre of Occitanie-Toulouse. A senior researcher in science and technology studies, he has extensively researched transformations in knowledge production regimes, with a special interest in the conditions and modalities related to the emergence of technical democracy. His current work seeks to improve the ability of research to help create desirable possible futures. He has published around 100 articles, including over 75 in peer-reviewed journals, and 5 books. He has also edited five special issues of social science journals. In addition, he is a member of the French Academy of Technologies and the French Academy of Agriculture.

Christophe-Toussaint SOULARD is a geographer. He is an INRAE research director who is also the head of the institute's Sciences for Action and Transition (ACT) Division. His research explores the practices and public policies that link cities, agricultural systems, and food systems in France, the USA, and the Mediterranean. His publications focus on the relationship between research and action; examine the innovations that create ties among agricultural systems, food systems, and sustainable urban planning; and delve into food justice concerns.

Claire WEILL is a physicist. A senior fellow at INRAE, she operates at the interface between science, society, and policy. Over the course of her career, she has been a climate negotiator for the French government, a senior fellow at the Institute for Sustainable Development and International Relations (IDDRI), and an advisor to the mayor of Paris, focusing on research, universities, new technologies, and education. In 2015, she was the Secretary general for the conference "Our Common Future Under Climate Change", a major scientific event held ahead of COP21. In addition to publishing various articles and policy briefs, she has edited a collective work on the third IPCC report and has written a book on the historical incorporation of environmental issues into European and global politics.

Executive summary

Increasing prominence of sustainability issues in international research

There has been tremendous growth in both publications and journals dedicated to sustainability science since the 2000s. At the same time, we have witnessed a proliferation of initiatives by higher education and research establishments seeking to contribute to the SDGs. Increasingly, institutions around the world are announcing their commitment to sustainability. Some, like the French National Research Institute for Sustainable Development (IRD), have made it their "raison d'être". At the local level, "territorial innovations " and "living labs" are catalysing grassroots initiatives and public action towards achieving sustainability, inspiring further activity by university centres.

As global changes accelerate, we must learn to live in a world experiencing major fluctuations. However, at present, research is making insufficient contributions to crucial and desirable transformations. Nor are sustainability-oriented public policies up to the challenge–they remain too one-dimensional to handle complex issues. Although the knowledge economy is still far from recalibrating itself around sustainability science, major national research organisations have the specific duty to facilitate the transformations that will help build viable possible futures. In this rapidly shifting and rather unpredictable landscape, these organisations must adapt or even completely change their strategies in order to develop the requisite skills and synergies. They must figure out how they will participate in the organised division of labour aimed at producing actionable knowledge, intended for both societies and decision-makers at all scales.

Modern-day history of sustainability science

The concept of sustainable development arose in the 1970s and 1980s. The Brundtland Report (1987) officially defined sustainable development as the political trade-off between environmental protection and development needs. During this time period, the world received its first warnings about the ozone layer and climate change; it also has seen the emergence of the concept of biodiversity. Simultaneously, there was an intensification of international efforts to build scientific programmes focused on global changes, which first addressed the climate (WCRP, 1979) and then the geosphere-biosphere (IGBP, 1986). New scientific currents appeared, provoking reflection around and shedding light on sustainable development: ecological economics (1989); the perspective of managing resources as "common goods", as proposed by Elinor Ostrom (1990); and transition studies, which emerged in the Netherlands.

In the United States, Robert Kates and Bill Clark were two leading proponents of sustainability science, and they provided the first outline of the field in a report published by the US National Research Council (NRC 1999). They helped sustainability science go global in 2001, when those involved in research programmes on global changes came together in Amsterdam. Sustainability science then underwent consolidation and became formally established through dedicated journals, training courses, and research centres, which flourished in North America, Northern Europe, and Asia. At Rio 2012, the process that led to the 2030 Agenda was launched, and the International Geosphere-Biosphere Programme (IGBP), DIVERSITAS, and the International Human Development Programme (IHDP) merged to form the Future Earth network. In 2015, the Paris Agreement was adopted, as was the universal framework for the SDGs. In 2019, an independent group of scientists produced the first report intended to inform deliberations by the United Nations General Assembly around the SDGs. While the scientists expressed great appreciation for the SDGs, they also underscored that current efforts were far from meeting existing needs (GSDR 2019).

Understanding what is meant by sustainability science

When we analysed how sustainability science has been defined, what commonly emerged was the notion of interconnectedness between societies and their environment as an object of focus, interdisciplinarity and transdisciplinarity as challenges, and actionability at multiple scales as a concern. For French public research institutions, sustainability science may translate into the following: "use-inspired research *on* and *for* planetary sustainability across generations". The term "research" is preferred over "science" because research is how science-based actions can become part of synergies with institutions and societies; it is important to specify "on and for" because this "use-inspired" research is focused on highly relevant aims, and adopts an approach that is simultaneously reflective, exploratory, and accountable.

Characterising sustainability science

A recent study on sustainability science (Clark and Harley, 2020) compiled a corpus of publications focused on use-inspired basic science; the publications were selected on the basis of co-authors' expertise. As a field, sustainability science appears to be highly interdisciplinary while also fragmented and heterogeneous. Although this study obtained rich and subtle results, a caveat is that only publications from English-language journals were utilised. Thus, the study failed to examine a significant amount of interdisciplinary and transdisciplinary work in sustainability science with contributions from the humanities and social sciences. Sustainability science is indeed a field of extraordinary potential, given that currently various trajectories can be brought into alignment.

Science of and for sustainability—a wealth of potential concepts

Sustainability science is governed by the push and pull between knowledge autonomy (driven by "curiosity") and knowledge heteronomy (driven by the need for "usefulness"). In this field, creativity arises from the ways in which balance between these two forces is achieved. In particular, the quest for sustainability has inspired efforts to redefine or revive existing concepts and to construct new concepts or neologisms.

The Anthropocene is a neologism (Paul Crutzen, 2001) that has spread rapidly and sparked great controversy. Its appearance was followed by many alternative terminologies, reflecting our struggle and need to understand the multifaceted processes that have led to an alarming lack of sustainability in our societies. The concept of the Anthropocene is based on an indisputable observation–humans, as a species, have played a dramatic role in major environmental changes. That said, it lacks substance and direction and must be fleshed out using more operational ideas. **The concept of resilience** has gradually begun to be applied to socioecological systems and has been more closely linked to the concepts of adaptation and transformation. **The concept of robustness**, in turn, has been revisited to promote the viability of socioecosystem trajectories in an increasingly fluctuating world that is subject to crises and shortages.

Two frameworks have gained prominent scientific visibility within sustainability science. Planetary boundaries (Rockström et al., 2009, Steffen et al., 2015) are largely based on the concept of **tipping points**, which originated in the field of Earth system science. In this perspective, humanity is viewed as a species whose welfare depends on an ecological habitat under threat. While this proposed framework has had a major impact, it has also been strongly criticised by various scientific communities. **Concomitantly, the study of socioecological systems** brings together a highly diverse epistemic community with roots in systems thinking and complexity theory. It has produced a theoretical framework based on a critical approach to equilibrium theory. The objective is to understand the interactions between the natural and institutional dynamics that govern natural resources depletion or renewal. Socioecological systems have been the focus of extensive research. They have often been studied at fairly fine scales, even if it has been asserted that some proposed concepts apply more generally.

Institutional strategies to integrate sustainability science

France has a long history of use-inspired research but has yet to substantially engage with sustainability science. CNRS has just began to actively incorporate sustainability issues into its strategic scientific themes; CIRAD has embraced the SDGs and transformative research; and IRD is placing sustainability science at the heart of its research priorities. The French research landscape is strongly shaped by the presence of joint research units, where the international connections of scientists and research teams are a shared resource and where the tools resulting from the various iterations of the Investments for the Future Programme have led to strong integration. Rather than viewing these institutional differences as distinct strategies, it seems more useful to interpret them as a nascent division of scientific labour. At the regional level, researchers and stakeholders are starting to co-construct various dynamics, but particular attention should be paid to promoting the longevity of these efforts. Programmes are well underway to train students in the challenges associated with ecological transitions and sustainable development, and to reduce the environmental impacts of higher education and research establishments. Contributions are being made to these programmes by ethics committees and the Labos 1point5 collective.

Northern European countries have played a pioneering role in the scientific exploration of sustainability issues. The Stockholm Resilience Centre is opting for strong integration into existing institutions, with a view to collaboratively growing an ecosystem that produces high-quality transdisciplinary research. WUR has taken the approach of developing expertise to guide changes via partnerships. Its interdisciplinary strategy combines biotechnology with project management, and it is starting to tackle transition and sustainability challenges. In Germany, there is reflection around the conditions needed to produce sustainability-oriented research; it is so well developed that, at the federal level, there is discussion about how to institutionally transform universities. The United Kingdom is unique in that it possesses world-renowned scientific institutions and strong ties with North America, yet any research not explicitly dedicated to innovation has been weakened by government disinterest. Initiatives are struggling to become established over the longer term or to take the form of international networks, such as the Social, Technological, and Environmental Pathways to Sustainability Centre (STEPS) in Brighton. The most balanced model is undoubtedly that espoused by Sweden and Finland, where a strong centralised sense of commitment is combined with great flexibility in individual and collective trajectories among research institutions, think tank activities, government services, and involvement in international spheres.

In the United States, the most renowned universities are not necessarily in the sustainability science vanguard. For instance, Arizona State University has created a School of Sustainability in order to gain a powerful academic influence and a strong capacity to constructively impact its environment. However, it is primarily large federal academic institutions that are growing sustainability science in the US, with no established link to politics.

While the EU takes a vocal political stand on sustainability issues and adopts ambitious research policies, synergies between these two priorities are still weak. European research programmes have yet to assertively incorporate the SDGs. Over the course of successive framework programmes, research themes have become more transversal thanks to joint programming in general (JPI initiatives, ERA-NET) and foresight work in particular. Yet, even if the European Commission underscores the importance of foresight approaches, such work is largely carried out internally, without inviting scientific communities to participate. Furthermore, in Europe, it is a rare occurrence for those involved in projects and programmes to make efforts upstream to include contributions from both the natural sciences, the humanities, and the social sciences, even if such efforts are a prerequisite in sustainability science.

Globally, while the 2030 Agenda seems unattainable, UN institutions appear to be organising their scientific resources around the SDGs without a clear roadmap, and support for the scientific capacity of the Global South has yet to materialise. Future Earth has had to contend with the strong inertia of large Earth system science programmes and has produced relatively little actionable knowledge. The scientific expertise provided by the Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has helped establish a framework, while also stimulating the work of scientific communities. Based on published scientific literature, they also reveal its gaps and imbalances. For IPCC and IPBES, the remaining challenge is to intensify their collaborations, including with other science-policy initiatives, such as the Convention to combat Desertification or the High-Level Panel of Experts (HLPE), while also maintaining the legitimacy that arises from their reports being approved by their constituent intergovernmental assemblies.

It would seem that the EAT-Lancet Commission and the Earth Commission have largely played a role in raising awareness. Such international expertise is needed to identify constraints at different scales, especially at the global scale, as well as to determine the requisite transformations. However, this work will have few impacts if unaccompanied by any actionable knowledge, particularly in the realm of innovation. In this respect, it is noteworthy that IPBES emphasises the notion of transformative change and the IPCC considers the potential of all forms of innovation. Great promise has been shown by the Transformative Innovation Policy Consortium (TIPC) and its work on innovations targeting dramatic transformations. However, on the whole, there is much uncertainty around future international scientific cooperation around sustainability.

Sustainability science and INRAE's strategic research priorities

INRAE research has made significant contributions to the SDGs, and most of the institute's research divisions perform work that relates to sustainability science, if broadly defined. However, applying a narrower definition (i.e., interconnectedness between societies and the environment as an object of focus, interdisciplinarity and transdisciplinarity as challenges, and actionability at multiple scales as an issue) **results in a much clearer vision of key INRAE's contributions**. INRAE engages with multiple facets of sustainability science: first and foremost, it considers the sustainability issues faced by societies and, increasingly, it is exploring the field's conceptual frameworks, methodological frameworks, and positioning. INRAE's association with sustainability science is apparent in France and worldwide because of the institute's leadership in research on agroecological and food transitions. This overarching perspective helps clarify where gaps exist and where INRAE's efforts lack visibility. While the environment is at the heart of sustainability science, the latter makes little mention of agriculture, food, and health. Similarly, the concept of environmental justice is essential in sustainability science but is largely absent from INRAE's research concerns. In contrast, INRAE seems better equipped to take a process-focused, transformative, and systemic approach to transitions. INRAE faces more than just a scientific challenge here: the institute must also increase its participation to national, European, and global scientific programmes and roadmaps.

Having defined its own strategic roadmap through 2030 (INRAE 2030), the institute could increase its contributions to collective international efforts to strengthen sustainability science. Specifically, it could carefully but resolutely orchestrate the convergence of its trajectory with that of sustainability science by 2030. Positioned as a key part of the field, agroecological research could greatly benefit from the efforts of major French research organisations, provided that the appropriate "translation" scaffolding is applied. The main advantage of the above convergence would be the resulting synergy of disciplines, communities, and resource clusters.

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