COMETS
CNRS Ethics Committee

OPINION no. 2022-43

"Integrating environmental issues into research practices – An ethical responsibility"

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I. SUMMARY

COMETS was asked by the CNRS President to address the issue of the environmental impact of scientific research. This formal internal request comes at a time when the research community is deeply concerned about the sector's responsibility towards environmental challenges. There is very broad agreement on the need for the research sector, like any other sector, to play its part in efforts to reduce greenhouse gas emissions. After establishing its carbon footprint, the CNRS is now actively setting up a transition plan. **There are, however, significant differences in opinion when it comes to choosing practical steps to follow**. Should all research that has or may have a negative environmental impact—remote sites, energy-intensive experimentation, or intrusion into a fragile environment, for example—be banned? How can environmental issues be reconciled with what are *a priori* contradictory demands for 'excellence' and competitiveness in research? Should research ethics now be supplemented by 'environmental ethics'? Would such a step not hinder the ability of research to produce knowledge and innovative solutions, including responses to environmental damage? Because the positive or negative environmental impact of research raises **many questions about the values, purpose and place of research in relation to what is a major issue for society**, it must be approached not only from a scientific or political angle, but also from an ethical angle.

In this opinion, COMETS first considers that **taking into account the environmental impacts of research should be considered as part of research ethics, in the same way as respect for human beings or for animals subject to experiments**. Like the notion of 'responsible research and innovation', research ethics implies thinking about the effects of research on society, so it is the collective responsibility of the research community as a whole to factor in its environmental dimension.

COMETS understands this **responsibility in a broad sense: it requires thinking about how to limit the footprint of 'everyday' research practices** (buying better and less, optimising the use of digital technology, limiting travel and work-related trips (hereinafter referred to as 'scientific missions'), improving the energy performance of buildings); but it **must also lead us to consider the environmental footprint of research topics and the ways in which they can be addressed**, for two reasons. Firstly, an approach designed to limit the carbon footprint is essential but inadequate in view of the challenges involved in preserving the biosphere (combating shrinking biodiversity and chemical pollution, preserving the health of ecosystems, etc.). Secondly, while research must—like any other activity—limit the footprint of its practices, its specific purpose is to produce knowledge in the service of society. This remit confers on it the particular responsibility of also questioning the uses that may be made of this knowledge (in particular its transformation into innovations) and how such uses can meet the problems encountered by society or, on the contrary, perpetuate and even aggravate them., The research community must therefore ask itself to what extent the use or development of a major piece of **equipment** (digital twin, particle accelerator, supercomputer) or work on a particular **topic** (synthetic biology, plant genome editing) is likely to have a negative impact on the biosphere, or to support unsustainable production or consumption patterns in the medium or long term, etc. Conversely, research must maximise its **role as a driving force** in producing and capitalising on knowledge that will enable solutions to be found to the ongoing environmental upheavals. While we should be wary of relying too much on the development of disruptive technologies in a relevant time frame, it is necessary to guide research more towards the pursuit of knowledge and solutions conducive to the transformation of society (multiplication of research programmes in this direction, with interdisciplinary bridges between applied and fundamental research that could support them, etc.).

COMETS is aware that environmental considerations are already an integral part of research (in fields such as chemistry, biology and nuclear energy, for example, experiments are subject to environmental standards; some research calls make funding conditional on the absence of environmental impact; many research

programmes are designed to facilitate ecological transitions, etc.). COMETS is also mindful that many members of the research community are and have been in the vanguard, highlighting environmental degradation, alerting public authorities and seeking innovative solutions. It is precisely because of this particular role of research that COMETS insists on the importance of including the environment in the ethical issues facing this community. It considers that this approach, far from hindering the freedom, creativity and quality of research, is likely to encourage the development of research that is attentive to societal issues and relevant in the eyes of both civil society and the research community as a whole.

COMETS then discusses **how the responsibility of the research community towards the environment should be exercised in practical situations**. It is not up to the committee to arbitrate, labelling as 'ethical' or 'unethical' the **often complex choices to be made in the name of this responsibility** with regard to their environmental impact (how can environmental preservation be reconciled with other imperatives of all kinds, whether human health, the training of young people, scientific sovereignty, etc.? Should we prioritise the near future by prohibiting polluting research, or the distant future by banking on the potentially useful results of this research in preserving the environment?). **It is up to the research community itself to open a broad debate on these issues. For COMETS, this is a prerequisite, well before any 'environmental assessment' bodies or criteria are set up for research projects; while these are far from unnecessary, they could foster the routinisation of a questioning process that requires, first and foremost, in-depth collective deliberation**. What is at stake is not only the awareness of the research community at large, but also the sharing of novel experiences between laboratories; the search for a good balance between frugality of research practices and too many administrative requirements; exchanges between research communities whose environmental impacts, needs and objectives are very different and between which it is advisable to prevent any risk of stigmatisation and division; an overall deliberation on research orientations and how they can meet a growing demand for justification by civil society; in the longer term, the adoption of guidelines.

COMETS recommends that this debate **be supported as much as possible with tools, methodologies and, more generally, a scientifically sound theoretical framework shared within the research community**. With this in mind, it first emphasises the importance of **measuring environmental impacts and, to this end, building up knowledge on them**, which is essential for an informed discussion and the identification of indicators and levers for action. COMETS is aware of the difficulties that such a measure raises, especially when it concerns the impact of research topics (the methods available are limited, and the time lapse between the choice of a subject and its possible impact on the environment makes any *ex ante* assessment complex). However, the committee notes that there has been an increase in work on the measurement of environmental impacts and the contribution of research to these impacts, and insists on the need to consider this a real field of research to be developed.

COMETS also calls for the environmental impact of research to be addressed from a **proportionality** perspective. While it is the ethical responsibility of research to systematically address this impact, any finding or prospect of an adverse impact does not theoretically constitute an obstacle to conducting research. The negative environmental impact must be weighed against the positive contribution of this research to the environment itself or to other values such as human health, the networking ability of young researchers and scientific geopolitics, whether in the medium or long term. In the face of various forces that lead to the expected benefits being exaggerated, proportionality implies defining, explaining and justifying the reasons for considering choosing one particular research practice, subject or item of equipment over another, and all the expected consequences.

COMETS is well aware of the operational difficulties that these recommendations imply, but believes that, given the magnitude of the challenges to be met, the research community cannot afford not to take such an approach.

Recommendations to CNRS management and research staff

Following its analysis, COMETS recommends:

1. Recognising that **consideration of the environment is an integral part of research ethics**; affirming in this respect the responsibility of research players to consider their activity in the light of environmental issues; this responsibility concerns not only the footprint of **research practices** but more generally the **negative or positive environmental impact** that the choice of a **particular research subject and a particular way of addressing it** (the research path) can have on the environment in the broadest sense, whether in the short, medium or long term.

2. Increasing the number of discussion forums enabling all research staff to debate the issues and scope of this responsibility.

Research laboratories appear to be the natural place to conduct this debate. In this respect, COMETS supports the request made by the CNRS President and the Conférence des Presidents d'Université (CPU, now France Universités) to appoint one person in each research unit as the sustainable development officer.

The debate should also be conducted in wider forums than laboratories, at the level of local, national or international scientific communities (CNRS institutes, other research organisations, university departments, research groups, scientific communities sharing the use of major research facilities, etc.) but also *between* these communities (academies and learned societies, scientific boards).

3. Providing the debate with a scientifically sound methodological framework that is shared within the research community. This framework should at the very least be based on two principles: the first is that of environmental impact measurement, itself supported by knowledge that has been built up on these impacts, and the second is of proportionality which, taking into account the peculiarities of each situation on a case-by-case basis, weighs up all the negative and positive impacts of research. **With regard to measuring impacts, COMETS**:

- supports initiatives taken to build up knowledge on the environmental impacts of research (greenhouse gas audits of laboratories, the CNRS and its institutes, in addition to research equipment);

- encourages pursuing such audits and recommends that the supervisory authorities facilitate matters, for example by simplifying the completion of an audit in the case of laboratories with multiple supervisory authorities;

- recommends that the CNRS and scientific foresight bodies support and undertake research to better measure the environmental impacts (greenhouse gases, pollution, damage to biodiversity, etc.) of new fields of research or the continuation of ongoing research;

- stresses the importance of developing an 'environmental impact culture' within the scientific community, by proposing, among other things, training courses and interdisciplinary thematic schools on this subject.

4. More specifically addressing CNRS management, COMETS:

- recommends that the CNRS sustain and strengthen the means it uses to assess its impact on the environment in order to promote organisational learning and the acquisition of consolidated experience;

- stresses the importance of recognising and facilitating the ability of laboratories to provide innovative solutions for environmentally friendly research; calls for support of approaches based on local laboratory experience; recommends that the CNRS should create an open database of innovations of all kinds developed by laboratories and make it accessible, particularly to research organisations;

- encourages **training departments** to: raise awareness and train staff in the environmental dimension of research ethics; recruit staff to organise and run collaborative workshops and develop an 'interdisciplinary culture of environmental impact'; pursue their efforts to enable research staff, regardless of their status, to devote time to the issue of integrating environmental issues into research as part of their job;

- recommends supporting research community members wishing to redirect their activities towards practices and subjects likely to contribute to better environmental sustainability.

In its **relations with public and private decision-makers**, the CNRS should give greater support to and highlight research community output (whether research, expert appraisals, alerts, etc.) that is likely to inform debates and stimulate action in favour of the environment.

5.- COMETS encourages:

- **the bodies responsible for programming and funding research**;

- **the bodies responsible for assessing researchers**;

- the bodies of the National Committee for Scientific Research responsible for planning future research fields

to reflect on how they can better factor the environmental impact of research into their work.

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II. FORMAL INTERNAL REQUEST

Formal internal request to COMETS by the CNRS President on the environmental impact of scientific research.

Dear COMETS chair,

The remit of the CNRS is to conduct research of benefit to science and to the country's technological, social and cultural progress. The CNRS also develops knowledge, innovation and partnerships in order to help achieve sustainable development goals. It is these same objectives of transforming our societies to make them more just, peaceful, prosperous and respectful of our planet that have led to the national roadmap committing France to a 30% reduction in greenhouse gas (GHG) emissions by 2030, with a view to becoming carbon neutral by 2050.

The environmental impact of scientific research therefore poses a crucial ethical question. While research is intended to provide solutions to environmental challenges, it can also contribute to the problem by conducting activities or developing innovations that are costly in energy terms[1]. It is therefore necessary to ensure that research practices are consistent with sustainable development. With this in mind, in 2019 the CNRS launched an initiative to help researchers understand and control their environmental footprint.

However, while this approach is guided by an ethical concern for individual participation in a necessary effort to reduce GHG emissions through our professional activities, and by the need to respond to the demands of many researchers—particularly the youngest—it raises a number of questions. Is it possible to pursue both objectives simultaneously, i.e. to acquire the means needed to conduct world-class research while reducing GHG emissions due to research activities? Should the CNRS adopt a roadmap to reduce its GHG emissions at the risk of compromising the effectiveness of its research? Should certain research topics be ruled out because they generate too high a level of GHG emissions or because they could lead to the development of technologies that would?

Should we encourage research that aims to reduce GHG emissions, or to develop knowledge that would make it possible to replace high-emitting technologies?

The CNRS President welcomes COMETS' recommendations on these issues.

Yours sincerely,

Antoine Petit

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[1] *For example, INRAE has produced a GHG emissions balance sheet that attributes 20% to its livestock, 18% to the manufacture of scientific equipment used, 13% to natural gas consumption, 13% to car commutes, and 9% to air travel for scientific missions... Should we encourage research that aims to reduce GHG emissions, or to develop knowledge that would make it possible to replace highly-emitting technologies?*

III. ANALYSIS

A. Scientific research facing environmental challenges

COMETS was asked by the CNRS President to address the issue of the "environmental impact of scientific research". The internal request questions COMETS on the "crucial ethical" nature of this issue: by carrying out activities or developing innovations, research can have harmful impacts on the environment that need to be reduced; but how can this necessity be reconciled with the apparently contradictory demand for world-class excellence in research, and with its very vocation, i.e. to potentially provide solutions to current and future environmental challenges?

The questions submitted to COMETS for consideration are part of a context which, in addition to the efforts undertaken by research in the name of the United Nations Sustainable Development Goals, has in recent years seen an increase in the number of groups of researchers and research staff inviting the scientific community to rethink in depth not only its practices, but also its aims and values, in order to bring them into line with the whole range of environmental challenges, which include limiting climate change and preserving biodiversity along with the quantity and quality of water resources.[1]

1. A challenge from and to the scientific community

These groups of researchers and the wider research community maintain that it would be illogical for researchers, who were pioneers in identifying environmental degradation and calling for public action, not to be both willing and innovative in changing their own professional practices.

We know the important role played in recent decades by numerous research projects (in ecology and climate sciences, for example) in diagnosing environmental degradation—the impact of the increase in atmospheric greenhouse gas concentrations on the climate, the loss of biodiversity, pollution[2]—and in explaining the causes and exploring solutions for restoring environments, limiting or slowing down their deterioration, combating climate change or facilitating adaptation to these phenomena.

These groups are also made up of scientists who have helped and who continue to actively help inform public opinion and action in the field of the environment, in particular by contributing to expert appraisals, from a very local level up to intergovernmental bodies such as the IPCC or IPBES. On a political level, many research staff have publicly called on governments to take action, particularly to protect the climate and life

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[1] The scope of the issues at stake leads COMETS to adopt a broad definition of the environment, considered more precisely as a heterogeneous system made up of "everything that surrounds us" and organised around the interaction of different spheres (biosphere, noosphere, technosphere), leading to the need to take into account issues such as limiting climate change and preserving biodiversity, water quality and use, and access to food and energy, to name but a few. These now form part of the UN Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development, along with reducing inequality and poverty and many other challenges. In this Opinion, COMETS considers the environment as a complex, multi-player, multi-factor and multi-scale system.

[2] "Climat : les scientifiques du CNRS aux avant-postes" [Climate: CNRS scientists in the vanguard], CNRS Le journal, issue no. 306, 2021, p. 6.

on Earth. To give just one recent example, 11,258 scientists from 153 countries recalled the 'moral duty' of scientists "to give clear warning to humanity of any catastrophic threat and speak truth to power"[3].

Consequently, in view of the questions raised about public action in response to environmental degradation, groups of researchers and research staff are calling on the research community to take it upon itself to deliberate, starting with a 'bottom-up' examination of the environmental consequences of its own activities[4].

It is no longer just a matter of informing public policy through expert appraisals or spurring it on through citizen involvement (the subject of 'public commitment', on which COMETS is preparing another Opinion), but also of thinking about research head-on in terms of environmental challenges: to become aware of its impact on the environment; to question the resources it uses in terms of equipment, travel, data production and storage, computing power; to limit negative impacts; to make research a place for innovative practices and policies that are environmentally friendly, and even likely to inspire other economic sectors[5]. There is an increasing number of groups of researchers calling for these questions to be considered. In France, since March 2019, the Labos 1point5 group (also a research network since June 2021) brings together scientists from various backgrounds with the aim of coordinating actions in favour of environmental preservation. Many other scientists are leading discussions and actions on this same subject and, more generally, on incorporating the environmental dimension into the way research is conducted, both in France and abroad, as the issues envisaged are by no means specific to French research[6].

The approach of these groups is in keeping with the long-standing concerns of scientists regarding their own responsibility towards society (whether it be, for example, military and then civil nuclear power, animal experimentation, genetic engineering and GMOs...)[7]. However, it appears today to be fuelled by a number of

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[3] W. J. Ripple et al., "World Scientists' Warning of Climate Emergency". OJ L 70 of 1.2020, pp. 8-12. On all these aspects, see COMETS Opinion No. 2011-23 "Aspects éthiques de la controverse sur le changement climatique" [Ethical aspects of the climate change controversy], available in French only.

[4] A survey conducted by Labos 1point5 in 2020 ("Les personnels de la recherche face au changement climatique" [The research community facing climate change"]) shows that most of those making up the research community say that they are increasingly "extremely" or "very" concerned about climate change, to the point where many of them are considering or have considered changing their field of research or profession to focus on the climate emergency. See too M. Blanchard et al., "Concerned yet polluting: A survey on French research personnel and climate change", Plos Climate, 15 Sept. 2022.

[5] On using air travel for scientific missions: A. Passalacqua, "The carbon footprint of a scientific community: A survey of the historians of mobility and their normalized yet abundant reliance on air travel." The Journal of Transport History, 42(1), 2021, pp. 121-141; J. Glausiusz, "Rethinking travel in a post-pandemic world", Nature 589, 2021, pp. 155-157; J. Arsenault et al., "The environmental footprint of academic and student mobility in a large research-oriented university", Environ. Res. Lett. 2019, 14 095001; on the infrastructures needed for astronomical research: J. Knödlseder et al., "Estimate of the loss of Carbon Footprint of Astronomical Research Infrastructures", Nature Astronomy, 25 March 2022; on the "existential questions" that the environmental crisis is posing research: E. Tannier, V. Daubin and S. Quinton, "La crise de l'esprit scientifique : une enquête, une tragédie, une redistribution collective des rôles" [The crisis of the scientific mind: an investigation, a tragedy, a collective redistribution of roles], Les Cahiers de Framespa, 40, 2022 [http://journals.openedition.org/framespa/13150].

[6] As it is impossible to be exhaustive, we can cite as examples the group "Collectif pour une recherche responsable" (INRAE), "Ateliers SEnS (Sciences, Environnements, Sociétés)", Second Nature, the Max Planck Sustainability Network, Scientists for Future (S4F International), NoFlyClimateSci, Cambridge Green Challenge, etc. As part of her doctoral work, Agnès Kreil identified more than 100 international universities and research institutions that are taking steps to reduce greenhouse gas emissions from air travel (A. S. Kreil, "Reducing the climate impact associated with air travel: Shifting perspectives within and beyond Academia", ETH Zürich, 2021).

[7] See A. Jaubert and J.-M. Levy-Leblond (coord.), "(Auto)critique de la science" [Self-critique of science], Seuil, 1973; H. Nowotny and H. Rose (eds.), "Counter-Movements in the Sciences". "The sociology of the Alternatives to Big Science", D. Reidel Publ. Cie., 1979; R. Debailly, "La critique radicale de la science en France : origines et incidences de la politisation de la science depuis Mai 1968" [The radical critique of science in France: origins and repercussions of the politicisation of science since May 1968], Sociology thesis, Paris Sorbonne University, 2010.

factors: the widely shared perception of the need to take action as quickly as possible; the irreversibility of some of the damage already observed; its propensity to affect society as a whole; the increasingly widespread awareness of the environmental issues at stake; and a critical view of public action in this area. Above all, because the issue of environmental impact presents society with important and pressing choices, it raises or revives tensions between members of the research community on the extent and ways of adapting their activities to ecological issues and, more fundamentally, on the values and purposes of research.

2. The participation of research in the effort to reduce GHG emissions

These tensions are growing, and it is against this background that the CNRS has taken actions to reduce its GHG emissions. Like other research organisations and universities, the CNRS is required to play its part in these efforts. The national roadmap for implementing the SDGs set out in the 2030 Agenda and endorsed by France within the framework of the United Nations emphasises the need to mobilise all of the country's components and organisations, including students and higher education/research institutions[8]. The law now requires these institutions and organisations to assess their GHG emissions and to draw up a transition plan describing the actions implemented in the years following the audit and the results obtained[9]. They must also implement the 20 national commitments made by the State for eco-responsible public services ('sustainable mobility' for staff, more responsible purchasing, more environmentally friendly food, energy cuts in public buildings, reduction of plant protection products, fostering the circular economy and responsible IT)[10].

It is against this general background that the CNRS has announced that it intends to play a leading role in the world of higher education and research, and to ensure that it favourably influences sustainable development[11]. It has thus set up an action plan and an internal structure to foster compatibility between its activities and the SDGs[12]. In September 2020, the CNRS set up a Sustainable Development Committee, whose tasks include understanding and measuring the impact of research practices in order to identify levers for action. This committee was responsible for the assessment of the institution's GHG emissions, the report being finalised in May 2022 and made public in November 2022[13]. At the same time, a study was undertaken jointly by this committee and a Sustainable Development Unit in order to define a low-carbon transition plan and, in particular, good practices in terms of scientific missions and associated travel, purchasing, energy consumption in buildings and the use of digital technologies. According to the CNRS GHG balance sheet resulting from this audit, these are the four priority areas for transition. This approach is intended to be applied at all CNRS decision-making levels. To this end, sustainable development officers have been appointed at the various levels of the institution—management, regional delegations, institutes—and the research laboratories are also invited to each appoint one person to be in charge of sustainable development issues to help them take into account the unit's carbon impact. In this context, laboratories are also and above all encouraged to measure the GHG emissions generated by their research activities, in particular with the GES

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[8] *French roadmap for the 2030 Agenda, 2019.*

[9] *French Environment Code, Art. L. 229-25 and decree no. 2022-982 of 1st July 2022 relating to assessments of greenhouse gas emissions.*

[10] *Circular issued by the Prime Minister on the State's commitments to eco-responsible public services, 25 Feb. 2020, No. 6145/SG.*

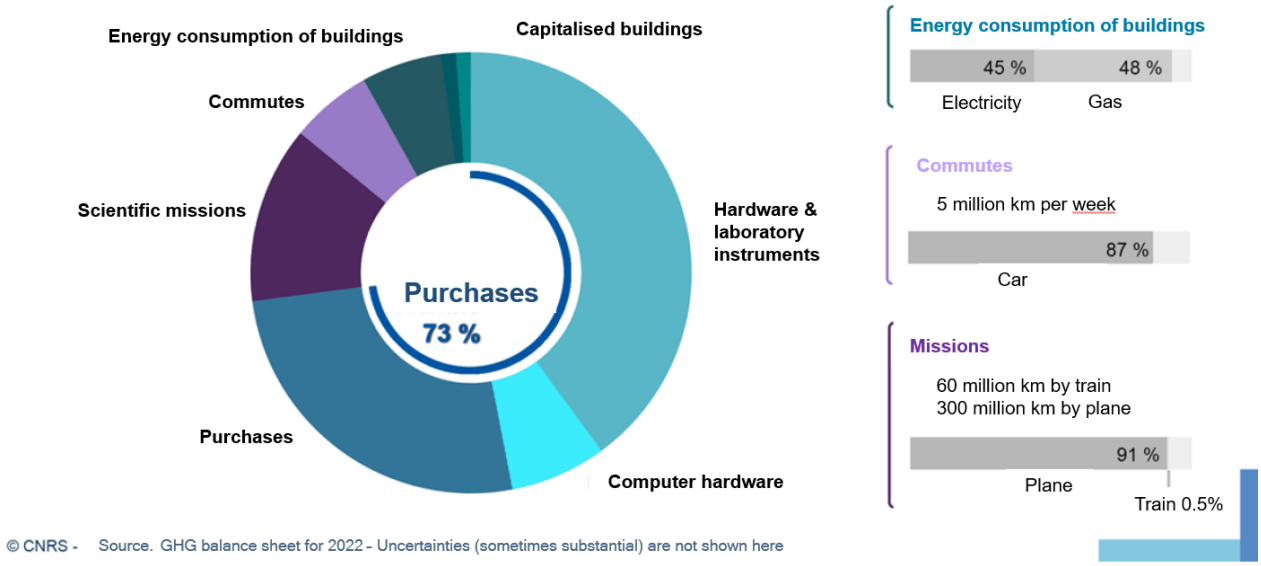
[11] *https://www.cnrs.fr/fr/cnrsinfo/transition-bas-carbone-un-plan-ambitieux-pour-le-cnrs*

[12] *The CNRS goals and performance contract, 2019-2023, §10.6*

[13] *"Transition bas carbone : un plan ambitieux pour le CNRS" [Low-carbon transition: an ambitious plan for the CNRS], CNRS Info, 14 Nov. 2022. Prior to the CNRS's GHG audit, which was based on 2019 data, an inventory of laboratory and delegation practices was undertaken during an internal CNRS seminar entitled "Impacts des pratiques de la recherche sur l'environnement" [Impacts of research practices on the environment] (24 January 2020).*

1point5 tool developed by the Labos 1point5 group[14]. This encouragement reinforces the approach taken by a certain number of researchers who, notably within the framework of this same group, had already shown a desire to lead their laboratory in this direction several years ago, and had helped it adopt new operating rules.

The CNRS GHG balance sheet
Carbon footprint (in % of emissions) of CNRS activities on a national scale



© CNRS - Source. GHG balance sheet for 2022 - Uncertainties (sometimes substantial) are not shown here

3. Research and environmental preservation: conflicting values

In the laboratories, however, the implementation of practical measures to limit the carbon footprint of research raises questions and even opposition. While it is not very productive to pin down the positions taken because they are in fact diverse—in terms of the weight given to environmental issues[15], the values that guide research[16], and the expectations placed on innovation—we can at least identify two main areas of conflict.

The first concerns the extent and nature of the efforts to be made in everyday research practices on behalf of the environment. Although there is almost unanimous agreement in the laboratories—or at least

[14] See the joint declaration by the CNRS and CPU (now France Universités) on this subject, October 2020. Other tools are available and there are no instructions to use this one in particular. GES 1point5 is, however, recommended as it is geared to the laboratory scale. It is available free of charge online. By the beginning of 2022, more than 500 CNRS laboratories had established their GHG balance sheet with this tool. See https://labos1point5.org/static/seminaires/20220501_Empreinte.pdf
[15] See, for example, M. Hulme, "Why we disagree about Climate Change", Cambridge University Press, 2009.
[16] On the use of economic analysis both to foster competition and to integrate the environmental consequences of staff decisions into their choices, see A. Pottier, "Comment les économistes réchauffent la planète" [How economists are heating up the planet], Paris, Seuil, 2016.

in those that are already aware of the issue[17]—on the need to reduce GHG emissions, divisions emerge as soon as the matter of practical measures comes up (limiting air travel, the use of digital technologies or advanced instrumentation, etc.) and of deciding whether they should be voluntary or mandatory.

For some, research will only be able to respond to environmental challenges if it rethinks its current overly 'productivist' model. This includes the "race for research projects and international conferences", the requirement to "publish or perish", the "frenetic competition", the use of research infrastructures (observatories, computers, etc.) "based on the illusion of abundant, limitless energy supplies"[18]. Others, on the other hand, point out that research is already involved in numerous projects concerning the environment[19] and is subject to numerous environmental protection standards in fields such as biology, medicine, GMOs and nuclear energy, where scientists are required to conduct their work while integrating environmental issues[20]. They also and above all insist on the risk that the multiplication of environmental protection measures could undermine high-level, internationally renowned research[21] that could actually serve the environmental cause. Air travel is certainly a major source of GHG emissions, just as working on elementary particles or running economic or climate models on supercomputers is energy intensive (more so than doing legal research!). But are these GHG emissions the price to pay for high-quality knowledge? In most fields, the novelty and relevance of scientific findings are assessed on an international scale and from a competitive rather than a collaborative angle. This means that research teams must endeavour to draw on all the conceptual and material resources at their disposal, such as acquiring, developing or using latest-generation instrumentation or computers (which are often costly from an environmental point of view and quickly doomed to obsolescence due to keen international emulation).

A second source of conflict relates more to the fundamental question of whether it is appropriate for environmental conservation to be a compass to guide research. There are two opposing views here, even among those who are convinced of the need for significant efforts on the practical aspects of their research.

Some are not in favour of research being overwhelmingly geared to environmental issues. They point out that since the knowledge it produces and the subsequent innovations it will lead to cannot be predicted, it is illusory to assess the relevance of research on the basis of a putative impact, and therefore futile to try to govern this activity, except to ensure that its diversity is preserved. They advocate above all the advancement

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[17] See, as concerns the humanities, the letter published by the InSHS, Sept. 2022, p. 5.

[18] See the opinion pieces of the group Labos 1point5: "Face à l'urgence climatique, les scientifiques doivent réduire leur impact sur l'environnement " [Faced with the climate emergency, scientists must reduce their impact on the environment] (Le Monde, 19 March 2019) and "Le monde académique doit définir une éthique environnementale de la recherche" [The academic world must define environmental research ethics] (Le Monde, 16 March 2022). The "restrictions" from which research is "suffering" are also denounced in an article published by students of the Ecoles Normales Supérieures in Le Monde on 11 May 2022: "Alignons notre pratique scientifique sur les enjeux impérieux de ce siècle" [Let us align our scientific practices with the compelling issues of this century]. See also D. Larousserie, "La recherche bas carbone met en tension le fonctionnement académique ordinaire" [Low-carbon research puts ordinary academic workings under pressure], Le Monde, 28 June 2022. There is also the manifesto for responsible research published in 2015, https://sciencescitoyennes.org/a-manifesto-for-responsible-scientific-research/

[19] Among many other examples, see Future Earth, which gathers researchers from all over the world, or CNRS research in climatology (Journal du CNRS, 16 Nov. 2022).

[20] See, for example, the French Research Code, Art. L. 253-2 or the Environment Code, Art. L. 522-1 and L. 531-2-1.

[21] In keeping with the National Research Strategy, which "aims to respond to scientific, technological, environmental and societal challenges while maintaining a high level of fundamental research" (Art. L. 111-6 of the French Research Code), the CNRS has encouraged the laboratories under its supervision to "better factor in the environmental impact of their activities while continuing to pursue outstanding research" (Annual Report, 2020, p. 29).

of knowledge, independently of the uses and applications that could be derived from it, and without making environmental issues a primary objective of the research.

Others consider that it is the responsibility of research staff to be mindful about the uses and consequences of the knowledge they produce. As such, the potential implications of research must be taken into account and, more generally, the environment must be a priority if not to say an essential part of the meaning they give their professional activity. They believe that research can create more problems than it solves, and that in many cases—chemistry is often cited as an example—it has been the main driver of innovations that have proved harmful to the environment[22]. A "profound systemic transformation" and a "reincarnation of the values held by scientists" are then advocated[23]. In a more general approach to responsibility, they invite us to leave or avoid research whose results could have negative impacts on the environment, and to redirect research towards subjects with a presumed positive impact[24]; rather than advocating the advancement of knowledge in its own right, or for the benefit of rationales unfavourable to the environment and models of society that "threaten the future of humanity"[25], they urge us to direct research in such a way as to facilitate and hasten transitions.

The long-standing question is whether research is more relevant, or even 'effective', if it is guided exclusively by the aim of producing new knowledge or whether it should be harnessed to serve social interests[26]—in this case whether any policy should give research a clear direction in favour of the environment. This recurring debate has been revived by the environmental crisis and society's growing call for scientific research that contributes to "preserving environmental conditions conducive to living well".[27].

These concerns lie at the heart of the CNRS President's internal request to COMETS. Is it possible to acquire the means needed to conduct excellent, world-class research while reducing GHG emissions due to research activities? How can research resolve the contradiction between providing solutions to environmental challenges on the one hand, and contributing to the problem on the other by, for example, developing energy-intensive innovations? How can these complementary yet conflicting objectives be reconciled?

In this respect, the issue of the environmental impact of research must be approached not only from a scientific, political, legal or organisational social responsibility (OSR) perspective, but also from an ethical perspective, since the values of scientific research and its purposes are at stake. This is the standpoint of COMETS.

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[22] For example, a large percentage of environmental issues today stem from chemical toxins. See S. Boudia and N. Jas, "Gouverner un monde toxique" [Governing a toxic world], Ed. Quæ, 2019.

[23] D. Larousserie, "Ces chercheurs tentés par la 'bifurcation' écologique" [These researchers tempted by the ecological 'turn'", Le Monde, 27 June 2022.

[24] The Labos 1point5 group thus considers (Le Monde, 16 March 2022) that "[research] institutions will have to offer scientists the opportunity of modifying their practices and of redirecting their research or activities, by placing competitiveness in second place in order to, this time, comply with the environmental ethics of research".

[25] See, in this regard, V. Daubin and E. Tannier, "(Comment) allons-nous continuer la recherche scientifique ?" [(How) will we pursue scientific research?], contribution to the forward planning days of INEE, CNRS's Ecology and Environment Institute, La Rochelle, 12-14 Oct. 2022.

[26] See the debate between Michael Polanyi and Frederick Soddy in the early 20th century in D.-H. Guston, "The Pumpkin or the Tiger?" Michael Polanyi, Frederick Soddy, and Anticipating Emerging Technologies, Minerva, 50, 2012, pp. 363-379. Polanyi "The Logic of Liberty", 1951, defended a vision of research that runs counter to 'social control' and planning. In his view, research that centrally and authoritatively plans its results in advance cannot succeed, not least because science must serve its own purpose, i.e. the production of knowledge, and neither social welfare nor the 'whims of the moment'.

[27] Horizon Terre (https://decidim.sciencescitoyennes.ovh/).

The environment, a core value of research ethics

COMETS intends first of all to recall the responsibility of research players with regard to the consequences of their activities for the environment. This responsibility should be seen as a matter of research ethics[28]. It must in fact be considered from a broad perspective, i.e. it must concern both the carbon footprint of research and, more generally, its environmental footprint, which concerns not only research practices but the subjects it addresses. All research practices, subjects and policies must be considered in the light of the positive and negative environmental consequences that may result from the knowledge produced by research and the innovations to which it may lead.

1. Consideration for the environment as an integral part of research ethics, a condition for responsible research

First of all, some of **the foundations and ethical principles of research dictate integration of the environmental dimension in the conduct of this activity**, even if this dimension was not their original inspiration.

Scientific rigour can be applied in two ways. It implies that the results of the environmental sciences or the scientific analyses and recommendations of the IPCC, for example, cannot be ignored by other areas of research. It also requires appropriate methods and optimal use of equipment and resources.

The principle of equity also leads to inclusion of the environmental dimension. Research should not contribute to environmental degradation because its first victims are the most vulnerable groups. In the name of this same principle, research cannot be excused from efforts to moderate the harmful impact of human activities on the environment.

The 'do no harm' principle, which in biomedical research in particular means ensuring that the benefits of the research are maximised while risk is minimised, similarly leads to research-related risks to the environment being identified in order to eliminate or reduce them.

It is on the basis of these principles that some research ethics committees have declared the need to "avoid degrading the living environment for future generations and irreparably jeopardising the future, in particular by depleting natural resources or endangering natural balances. Such a principle of sustainable development requires (...) working for the long and very long term, not just the short term"[29]. Note also the recent Marseille Declaration on international cooperation in research and innovation (under the French Presidency of the Council of the European Union), which identifies the environment as an "ethical concern" to be taken into account in international scientific and academic partnerships (II. 7. B).

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[28] L. Coutellec, "Penser l'indissociabilité de l'éthique de la recherche, de l'intégrité scientifique et de la responsabilité sociale des sciences. Clarification conceptuelle, propositions épistémologiques" [Considerations on the indissociability of research ethics, scientific integrity and the social responsibility of science. Conceptual clarification, epistemological proposals], Revue d'anthropologie des connaissances, vol. 13, no. 2, 2019, pp. 381-398. This is the stance that COMETS has taken on several occasions. See Opinion no. 2006-15 "Enjeux éthiques des nanosciences et nanotechnologies" [The ethical challenges of nanosciences and nanotechnologies]; Opinion no. 2018-35 "Freedoms and responsibilities in academic research"; Opinion no. 2021-41 "Science, risk and the precautionary principle". This responsibility is understood here neither from a legal viewpoint (as an imputation mechanism) or a managerial viewpoint (as organisational social responsibility) but from a collective, forward-looking perspective.

[29] Joint INRAE-CIRAD-Ifremer-IRD Ethics Advisory Committee, Opinion no. 10 on the ethical aspects of major international agreements, 2018 (available in French only. Our translation). See too COMETS Opinion no. 2018-35 "Freedoms and responsibilities in academic research" and Opinion no. 2021-41 "Science, risk and the precautionary principle".

Furthermore, the notion of 'responsible research practices' has emerged to refer to the fact that research must take into account the values promoted by the society in which it is carried out. This expression refers to research practices that not only comply with scientific integrity[30], but also avoid undermining the values shared or encouraged within a society. As early as 1992, the US Academy of Sciences noted that "scientists and the public in general are likely to grow dissatisfied with self-serving research practices that erode communal values and standards"[31]. Scientists must therefore conduct research in an "ecologically responsible manner", as stated by UNESCO[32]. In addition, the European Union's similar goal is to promote "responsible research and innovation" (RRI)[33]. Present in European research and innovation programmes, this concept invites research staff to anticipate and assess the potential consequences and expectations of society with regard to research and innovation, including environmental preservation. It expresses a future-oriented responsibility, in the sense that researchers must consider the consequences of the knowledge they produce.

From a standpoint that departs from the idea of a highly independent science focused solely on the value of knowledge—developed in particular by Robert K. Merton[34]—scientific research must therefore take place in a social context marked by the environmental crisis and must support society in the challenges to be met and transformations needed[35]. Thirty years ago, because society's relationship with animals had changed, scientists called on their colleagues to become aware that research ethics includes a component on animal experimentation. Since then, standards of behaviour have gradually been defined and accepted by all research staff. It is now accepted within the community that, while animal experimentation is not prohibited, it should be limited to cases of strict necessity[36].

Just as this rule marked a renewal of society's relationship with animals, consideration of the impacts that research can have on the environment is part of a renewed relationship between society and the environment that leads to the assertion that 'environmental value' is a condition of responsible research. Beyond each person's individual responsibility to prioritise this or that environmentally friendly behaviour, the research community has a collective responsibility to think about its activities in terms of environmental issues and to

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[30] The European Code of Conduct for Research Integrity identifies respect for ecosystems and the environment as one of the fundamental principles of scientific integrity that should guide staff in their work (ALLEA - All European Academies, European Code of Conduct for Research Integrity, revised edition of 2018). In contrast, French law has a narrower view of scientific integrity, defined as the set of rules and values that should govern research activities in order to guarantee their "honest and scientifically rigorous character" and "consolidate the bond of trust with society" (French Research Code, Art. L. 211-2).

[31] National Academy of Science, National Academy of Engineering, Institute of Medicine, "Responsible Science. Ensuring the Integrity of the Research Process", National Academy Press, vol. 1, 1992, p. 129.

[32] UNESCO Recommendation on Science and Scientific Researchers, 13 Nov. 2017.

[33] R. von Schomberg (ed.), "Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields", European Commission, 2011. Responsible research and innovation is defined as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (p. 9). See too S. Randles, E. Tancoigne, P.-B. Joly, Two tribes or more? The historical emergence of discourse coalitions of responsible research and innovation (rri) and Responsible Research and Innovation (RRI), Journal of Responsible Innovation, 2022.

[34] R. K. Merton, "Science and democratic social structure", in Social Theory and Social Structure, New York, Free Press, 1968, p. 605 et seq.; A. Saint-Martin, "La sociologie de Robert K. Merton" [The sociology of Robert K. Merton], La Découverte, 2013.

35 See L. Coutellec, "La science au pluriel. Essai d'épistémologie pour des sciences impliquées" [Science in the plural. An epistemology for involved sciences], Ed. Quæ, 2015, pp. 44 et seq.

[36] Article L. 214-3 of the French Rural and Maritime Fishing Code prohibits the mistreatment of domestic animals and wild animals that have been tamed or kept in captivity. The same applies to biological, medical and scientific experiments, which must be "limited to cases of strict necessity".

make research a component of a human community that is consciously evolving towards a more sustainable relationship with its natural environment.

2. Implications for research practices and subjects

COMETS defends a broad understanding of this collective responsibility.

Firstly, it covers the environmental footprint of research "in the making", i.e. day-to-day research practices. In the name of research ethics, **all professional practices and work behaviours** in all research communities and at all levels of the hierarchy are concerned by the preservation of the environment (researchers; technical and engineering staff who develop instruments, platforms or computer codes, who manage waste, etc.; administrative staff who organise travel for scientific missions and manage laboratory purchases). With this in mind, the CNRS's low-carbon transition plan targets purchasing ('buying better and less'), air and car travel (which must be reduced), digital technology (which must be used more frugally) and the energy performance of buildings (which must be improved). To this end, the CNRS has just initiated a national equipment exchange to facilitate the transfer or donation of equipment between research units[37].

Responsibility then concerns both research subjects and research paths[38], not only with regard to their real-time or short-term effects (energy consumption, pollution, etc.), but also with regard to their foreseeable effects in the longer term, i.e. **the environmental impact that the uses of the knowledge acquired could have**.

Indeed, considering the environmental impact of research solely in terms of the carbon footprint of research "in the making" is too simplistic for two reasons.

On the one hand, research is unlike other professional activities in that its purpose is to produce knowledge, which is likely to propose new representations of the world, to inform a particular model of society, to guide the choices of public and private actors, and to provide the basis for technological or conceptual innovations. It is also through these very diverse channels, which though not instantaneous are nonetheless real, that research can have an impact on the environment. Research can contribute positively or negatively to the environmental crisis in particular through the subjects it develops, the results it leads to, and the way in which society appropriates them. COMETS notes that the internal request at least implicitly embraces these different dimensions, and rightly so.

On the other hand, the carbon footprint does not fully resolve questions on the environmental impact of research, even if it is a relevant way of approaching them. While GHG emissions are currently easier to measure than other impacts, such as those on biodiversity, it is logical that the environmental impact of research should be assessed in all its dimensions, as is already required by numerous legal provisions that apply to research[39]. Environmental considerations on the part of research players should therefore not focus

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[37] "Transition bas carbone: un plan ambitieux pour le CNRS" [Low-carbon transition: an ambitious plan for the CNRS], CNRS Info, 14 Nov. 2022.

[38] For the purposes of this Opinion, the term 'research field' is used to refer to both a discipline and an interdisciplinary subject of study, on the scale of the keywords that define the scope of the CoNRS sections. Theme-based 'communities' come together to address their research 'subjects' or 'themes' with a specific 'approach' to each project. The subject and its approach are together known as a 'research path'.

[39] French law affirms the need for a national research strategy that is consistent with the national health strategy (especially with regard to environmental health risks), the low-carbon strategy and the national biodiversity strategy: Research Code, Art. L. III-6. Similarly, in the areas of biodiversity, climate change, the use of plant protection products, and human and animal health, European and international legislation obliges States to make binding commitments in the short term, which necessarily have a bearing on research policies.

exclusively on GHG emissions, but take into account the impacts of their activities on all environmental components[40].

This means first of all that the choice of a research subject and the ways of addressing it (use of large equipment such as telescopes, satellites, oceanography survey vessels or supercomputers, and computer modelling, field surveys, etc.) should take into account their potentially harmful environmental effects in order to minimise them insofar as possible. This approach implies that the research community must integrate the need to consider the environmental consequences of research projects from the outset. This means integrating impacts into the very process of knowledge production, clarifying the reasons for choosing a particular subject, imagining possible tomorrows: what need does the planned research meet? What could be the effects, the fate of the knowledge that will be produced? How can the proposed research change today's reality and according to which scenarios? Is it likely to support a particular consumption pattern or an unsustainable production model? The aim is to move away from an 'economy of promises' to an 'environmental impact' culture within the scientific community, to broaden the vision of the relevance of research work by questioning the usefulness of the knowledge sought and the effects of its uses[41].

This approach is also necessary in the case of expert appraisals or research whose conclusions are intended to guide public or private decision-making. It applies to all fields of research. Work on regulations to improve the attractiveness of regions, for example, cannot ignore the environmental consequences of the implementation of these recommendations by public authorities. Similarly, work on the regulation of crypto-currencies cannot simply adopt an 'asset' or 'financial instrument' angle and ignore the environmental consequences involved, with the mining of Bitcoin alone consuming around 0.5-0.7% of global electricity production[42].

Secondly, it is the collective responsibility of research to act as a watchdog. Scientists thus have a crucial role to play in alerting others to risks—as COMETS has already pointed out, "As long as they base their discourse on substantiated scientific arguments, the role of researchers in raising the alarm is particularly important in health and the environment"[43]. The contribution of scientists is also essential to ensure that public decisions are informed by rigorous assessment: toxicologists and ecotoxicologists, for example, have a key role in assessing chemicals in the face of industry lobbying. Finally, scientists must use their discernment in identifying miracle solutions and false promises. Thus, through numerical simulations, climatologists have shown that the implementation of geo-engineering techniques advocated by some to artificially and rapidly limit atmospheric warming[44] would modify monsoon patterns and rainfall distribution, with far-reaching environmental and social consequences[45].

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[40] See the definition in footnote no. 1.

[41] See in this context the Opinion of the INRAE Ethics Committee "Evaluation des impacts de la recherche publique agronomique" [Assessment of the impact of public agricultural research], Opinion no. 9, 2016. The Opinion notes that as early as 1998, the Interministerial Committee for Scientific and Technological Research proposed that research organisations—particularly those tasked with expert appraisals in health and the environment—should reflect on the "consequences of the research they conduct, both in terms of potential risk and acceptability for society."
On this point, COMETS notes the joint CNRS and IRD project—one of the ten winners of the government's call for "environmentally friendly innovation"—to raise researchers' awareness and offer appropriate training activities.

[42] J.-P. Delahaye, "Au-delà du Bitcoin" [Beyond Bitcoin], Dunod, 2022.

[43] COMETS, Opinion no. 2018-37

[44] "'Interventions' sur le climat : état des lieux des initiatives aux USA. [Climate "interventions": a review of initiatives in the US]. Embassy Report, July 2021.

[45] S. Tilmes et al., "The hydrological impact of geoengineering in the Geoengineering Model Intercomparison Project (GeoMIP)", JGR Atmospheres, 118(19), 2013, pp. 11 036-11 058.

Thirdly, it is the responsibility of the research community to strive to enhance the positive impacts of its activity on the environment. While research must reduce its own environmental footprint, it must also contribute to the 'transitions' undertaken by society, supporting the systemic transformations required. In this sense, the debate on the impact of research on the environment must focus on the conditions under which research is useful to society. The aim is not to place excessive confidence in the development of disruptive innovations within a relevant timeframe[46], but to consider research as a central tool for understanding the state of the environment, accessing means of slowing down or reversing its degradation, and providing other stakeholders in society with the knowledge that will enable them to reduce the overall environmental footprint of their activities[47]. Such incentives should stimulate creativity in transition research.

This being so, it is particularly necessary to:

- increase the number of research programmes that address 'priority' problems and, in support of society's needs, contribute more than today to ecological and energy 'transitions' (renewable energies, hydrogen fuel cells, remediation of polluted environments, substitutes for chemicals, environmental taxation, sustainable agriculture, etc.)[48];

- take advantage of research work, but also of researchers' expert appraisals—whether at regional (AclimaTerra, Ecobiose), national (collective appraisals in particular) or international level (IPCC, IPBES, HLPE), so that they constitute a reference framework known to all (research community, public institutions, private bodies). While expert reports are not binding, they must be widely disseminated and taken seriously in terms of what they say about the state of the planet. Hence the need for research organisations to consider how they can better inform and advise public authorities.

- highlight knowledge that has already been produced and that helps to maximise positive impacts in disciplines that are not primarily concerned with the 'environment' or do not focus on it;

- identify neglected areas or disciplines that could generate new knowledge for understanding environmental challenges and finding solutions to them;

- strengthen interdisciplinary bridges in this sense. For example, research in mathematics, economics or demography can support models developed by the climate sciences to better quantify the impact of future droughts; similarly, data produced by climate scientists should be used for agricultural research on plants that require little water, etc.;

- support the deliberations on the directions and impacts of research that are carried out within the framework of open groups (with diversified skills and knowledge, e.g. researchers, NGOs, farmers and other civil society stakeholders);

- diversify the transfer of innovations developed in the scientific community: by transferring more of these innovations to players proposing sustainable production or distribution models; by sharing with organisations

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[46] High Council on Climate, 3 Dec. 2019.

[47] In French law, this is the meaning of Article 9 of the Charter of the Environment, which states that: "Research and innovation must contribute to the preservation and enhancement of the environment."

[48] For a recent study that points to a "glaring imbalance" in Europe between science and technology policy on the one hand and the SDGs on the other, see "Changing Directions: Steering science, technology and innovation towards the Sustainable Development Goals" produced by the Steering Research and Innovation for Global Goals (STRINGS) project, 2022, https://strings.org.uk/

with limited means (associations, small businesses, etc.) innovations that facilitate control of the environmental footprint, etc.

3. Freedom of research and responsibility towards the environment

As a component of research ethics, consideration for the environment is necessarily in conflict with freedom of research. If scientists must be truly free to choose their research subjects and the ways to address them (including partnerships), is it conceivable that restrictions should be imposed on them because of the potential impacts of these subjects on the environment? COMETS considers this issue by stressing the need to strike a balance between these two imperatives[49].

First of all, it should be reiterated here that freedom of research is a crucial issue: it is a necessary condition for the acquisition of scientific knowledge as a common good. This means that in the interest of the development of knowledge, researchers must be able to conduct their research without being subject to pressure (whether political, religious or economic). As part of this freedom, **scientists remain free (within legal and ethical limits) to work on any research subject** without being ordered by their superiors to work on environmental issues—which in no way precludes a political decision to increase the number of researchers working on these topics while maintaining research diversity. Conversely, scientists **can freely choose, when possible[50]**, to **redirect their research subjects** towards environmental issues. They can also devote time, within their professional framework, to take environmental issues into consideration (for example, through participation in a particular group).

At the same time, as is the case with all freedoms, **freedom of research is not inherently boundless**[51]. Just as it is regularly restricted in the name of bioethical imperatives (reproductive cloning, human-animal chimeras), it can also be restricted in the name of environmental imperatives, as many of the examples mentioned above already demonstrate. Indeed, there is nothing illegal about preventing certain practices or research subjects from being regulated, limited or even prohibited, for reasons relating to their environmental impact.

In affirming the need for a fair balance between freedom of research and consideration for the environment, COMETS does not claim to have reached the end of its deliberations, as there are still many questions about what this means in practice. How can we assess, in terms of a 'fair balance', the benefit/necessity/risk of building a given telescope or particle accelerator? Or the decision whether or not to initiate archaeological digs? Or studies on plant genome editing? Should research on elementary particles or human spaceflight be stopped due to their environmental impacts or should it be continued in the name of anticipated knowledge, including insights for the environment? More generally, should all research that has or may have an environmental impact be prohibited? For what reasons? Because the environment contributes to human health and well-being? Because it determines our production capabilities? Because it is an end in its own right? How can preserving the environment be reconciled with other values such as human health? Should we prioritise the near future by prohibiting polluting research, or the distant future by banking on the potentially useful results of this research to preserve the biosphere?

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[49] COMETS has already stressed that freedom of research creates responsibilities towards society and the environment (Opinion no. 2018-35 "Freedoms and responsibilities in academic research".

[50] See below on the practical limits of this freedom of choice.

[51] M.-A. Hermitte, "La liberté de la recherche et ses limites. Approches juridiques" [The freedom and limits of research. Legal aspects], Romillat, 2001; M. Duclos and A. Fjeld (dir.), "La liberté de la recherche. Conflits, pratiques, horizons" [The freedom of research. Conflicts, practices, horizons], Kimé, 2019.

There are no standard or universal answers to these many questions, which involve different world views and often a complex hierarchy of priorities. The role of COMETS is not to decide on these issues itself, but simply to indicate some methodological tools to guide these deliberations 'in practical situations.

B. The environmental component of research ethics from a practical standpoint: methodological issues

COMETS believes that two methodological recommendations are necessary to address the complex issues surrounding the environmental impact of research. Firstly, it is calling for these issues to be widely discussed within the research community. Secondly, it believes that this debate and the decisions taken in the name of environmental research ethics should be supported as much as possible by tools, methodologies and, more generally, a scientifically sound, shared theoretical framework.

1. A wide-ranging debate to be held

For COMETS, the responsibility of the research community towards the environment is first and foremost an issue requiring discussion and debate among the research community, confronting viewpoints and identifying complementarities. Only in this way can community members really take these issues on board, ask the necessary questions, take everyone's viewpoint into account and adopt a course of action.

COMETS considers that this approach should take priority in the short term over the second method that would require each research project owner to submit their project to one or more *ad hoc* operational committees with responsibility for accrediting research (ethics committee, funding committee) with respect to the criterion of environmental impact, amongst other aspects. COMETS recognises the usefulness of this type of approach, which encourages the acculturation of researchers, as illustrated by the topic of research involving human subjects or animals, and the refusal of projects whose impact is considered 'too high' or projects that are conditioned on measures to reduce, offset or mitigate their impact. In this way, including the issue of environmental impact in the specifications for some research calls[52] undoubtedly contributes to spreading the idea of environmental protection to a number of research laboratories[53].

The aim is not therefore to minimise the importance of studying how best to match the actions of research programming and funding bodies with the needs of environmental protection. However, we must also be wary of taking a purely functional approach that could turn an issue requiring collective discussion into an administrative routine. It is important to avoid any hasty standardisation of environmental ethics, since this would impoverish the general debate. In addition to raising awareness among the research community at large, the objective is to establish the environmental impact of research as a collective issue. The aim here is share novel experiences between laboratories; to find the right balance between virtuous research practices and excessive administrative requirements; to start discussions between research communities

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[52] *The Quebec Research Funds (FRQ), for example, require applicants requesting funding to determine the level of environmental risk ("minimal", "greater than minimal") potentially raised by their project: Action plan on environmental responsibility in research, June 2020, p. 9. See also ANR (French national research agency), OneWater call for projects: "Water as a common good, Key programmes and equipment for Exploratory Research", 2022, which excludes projects that would cause significant harm to the environment (application of the 'do no significant harm' (DNSH) principle within the meaning of Article 17 of the EU regulation on Taxonomy for Sustainable Finance). See https://anr.fr/PEPR-Explo-OneWater-AAP-2022.*

[53] *See INRAE Ethics Committee, Ethical implications of major international agreements: Sustainable Development Goals and Paris Agreement on climate, Opinion No. 10, 2018.*

whose environmental impacts, needs and objectives are very different and between which it is advisable to prevent or overcome any risk of stigmatisation and division; to conduct broad deliberations on research directions and how they can meet a growing demand for justification by civil society; and in short, to adopt shared guidelines.

At what level should this discussion take place? The *laboratory* is clearly a level that is appropriate for this discussion. Some groups of researchers have made it their main forum of reflection, in order to 'reclaim' questions relating to the environmental impacts of research. The debate within laboratories and the responses developed locally are part of a logical and virtuous process. This process encourages broad and active involvement by research community members in studies relating to the environmental impact of their activities, whatever their status and taking account of their different roles. It enables laboratories to discuss, define and usefully implement a path of transition while reducing the negative impacts specific to each one (purchase of supplies, travel, waste reduction, energy savings), while also promoting a more general discussion on the choice of research topics. It is also at laboratory level that we sometimes see innovative approaches that can serve as examples to other colleagues. For example, some laboratories have taken advantage of their annual general meetings to introduce guidelines aimed at developing a research culture that respects the environment, e.g. by allocating a carbon quota to research staff for field trips, but making a difference between young and established researchers[54]. Others have set up initiatives to pool and consolidate purchases, in order to reduce the number of deliveries. Finally, and more generally, any studies on the environmental impact of research will find it both useful and fruitful to highlight the initiatives taken by staff. On this point, COMETS notes the efforts made by the CNRS to recognise and showcase the efforts of laboratories already on a low-carbon path[55].

However, the pursuit of studies, deliberations or initiatives on environmental responsibility cannot be limited to laboratories alone. The subject must be addressed at a wider level, by each individual **institute, between institutes, within the CNRS as a whole, across all research organisations and institutions and, more broadly, by the international scientific communities**.

Firstly, some issues and levers for action encompass but also extend beyond the limits of the laboratory: energy-efficient buildings, low-carbon campuses, negotiations on public contracts, but also and above all research governance and the definition of a research policy that takes account of environmental issues. The way in which research could, through its subjects of study, reduce its impact on the environment or contribute to the development of environmentally friendly solutions requires broad deliberation, encompassing research priorities at national and often international level.

The freedom of researchers to redirect their research, in whatever way, in their own laboratories, is often more theoretical rather than real, illustrating once again the limits of a deliberation taking place at individual level or confined to the laboratory alone. In many fields, research communities are made up of a large number of highly structured players (national or international consortia) sharing large instruments and sometimes demonstrating extreme inertia in the way they work. Neither individuals nor even their laboratory have any

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[54] For examples of this type, which go further than the current requirement for public-sector workers to take the train rather than to fly for short and medium distances, see the CNRS LOCEAN laboratory: https://www.locean.ipsl.fr/liens-science-societe/un-laboratoire-citoyen/,with details of the voting process https://climactions.ipsl.fr/vote-au-locean-2829-septembre-2020/, or at INRAE, the MaIAGE laboratory, https://maiage.inrae.fr/sites/default/files/document-maiage/internet/jobim2022-expe-1p5-A4.pdf. Also see the tool "Ma terre en 180'" developed by IRD researchers: N. Gratiot et al, A transition support system to build decarbonisation scenarios in the academic community, 2022 [https://hal.archives-ouvertes.fr/hal-03563246].

[55] See https://www.cnrs.fr/fr/cnrsinfo/transition-bas-carbone-un-plan-ambitieux-pour-le-cnrs.

real ability to determine their own research subject or to determine the best way to achieve their aims without external input. Any redirecting of research must therefore first be studied by research groups, be they research communities, companies, consortia or research organisations in general.

Secondly, if the debate on the environmental component of research ethics is to take place beyond the laboratory, it must reflect the diversity of the world of research. The impacts are not the same from one discipline to the next—see the impact of legal experts or mathematicians, often limited to thermal leakage in their buildings, travel, the use of databases, etc., and compare it with that of astronomy researchers using large instruments. The needs and objectives are not the same either. This can give rise to tensions requiring a broad interdisciplinary debate to avoid creating deep divisions in the world of research. One of the reasons why this debate needs to cast a wide net is because studies on how to overcome the environmental crisis include many scientific disciplines touching upon the environment, health, poverty, etc. With this in mind, COMETS notes the relevance of the "climate-research convention" project set up by the Labos 1point5 group. The idea behind the project is to select at random between 50 and 100 members of the research community representing the diversity of this community at large, and who are therefore likely to work together usefully[56].

As a final note, studies into the environmental impact of research should not be the preserve of the research community alone, simply for reasons relating to the independence of scientific research. It is a subject that calls for discussions on a wider scale than that of laboratories and research communities or organisations. Whether we are talking about synthetic biology, deep-sea research or geo-engineering, the question of whether to support or limit this type of research should be the subject of a national debate expanding beyond the boundaries of the research communities and their institutions. These communities and institutions clearly have a crucial role to play as experts with the capacity to inform decisions, as well as to explain the options available and the associated risks. Nevertheless, it is important for choices of this nature to be discussed on a wider platform, for example through public meetings of the type currently held every year in the field of bioethics, public conferences, public consultations, etc.

2. A theoretical framework to be built

The debate on the environmental impact of research, regardless of the scale at which it is conducted and whether it focuses on the footprint of everyday research practices or research subjects, should be supported with scientifically sound tools and methodologies. COMETS believes that at least two requirements should be met in this respect: environmental impacts need to be measured and a proportionate case-by-case approach applied. These are considered to be the two conditions needed to ensure that the deliberations and decisions taken in the name of environmental issues allow for the greatest possible synergy between taking the environment into account and maintaining excellent research that is relevant to society.

a) A proportionate case-by-case approach

Any debate on the responsibility of research players for the environmental impacts of their activities should be based on a proportionate, case-by-case approach. The need for a case-by-case approach

[56] *"The climate-research convention will therefore involve 50 to 100 members of the research community representative of the entire French scientific community at all levels. These people will be selected at random, as part of a transparent protocol in order to represent the diversity of practices and projects within the community as closely as possible. They will hold several meetings from winter 2023 onwards and will receive scientific training on climate and biodiversity issues, as well as on research and its environmental footprint. They will be given time for independent deliberation. The proposals will be submitted at the beginning of the 2023 academic year after the last session of the convention" (Labos 1point5, newsletter of 13 July 2022).*

has already been pointed out: it is impossible to compare literature research involving text corpora, archaeological research requiring travel to the field, or research in economics or climate sciences using power-greedy facilities such as supercomputers.

Furthermore, the principle of proportionality should be applied in each case. Indeed, COMETS considers that **environmental damage alone is not *in principle* an overwhelming obstacle to the initiation or conduct of research, and that, more generally, the environment does not, *by principle*, have to become the sole compass to guide research**. While the environment is a good in itself, it does not necessarily have to outweigh the other values that society holds dear. The 'environmental value' must be systematically taken into account and weighed up against all the other considerations: positive impacts on the environment, expected impacts in other areas and in the short or long term (improved health, training, sovereignty, etc.).

This proportionality approach should apply to all research practices. Its implementation could be inspired by the '3 Rs' principle applicable to animal experimentation (replacement, reduction and refinement)[57]. Whenever a journey is made, waste produced, or equipment to be replaced for a given research project, research staff should ask themselves what their objectives are, what the negative impacts on the environment are, and whether it is possible to reach the same objectives through practices with less environmental impact. In short, considerations must include justification of the impact[58]. What is the advantage of a flight over a video conference call? Is there a benefit in terms of scientific cooperation? Is it a trip to collect data or to conduct networked research based on the interfaces needed between French and foreign scientists? Or is it 'mere' passive participation in a conference? Is the production and massive storage of data by climatologists, economists and computer scientists justified in terms of the expected future benefit? Is it possible to achieve this same benefit by optimising the algorithms used or doing things differently? There are already many examples of researchers who intuitively apply an approach similar to the 3 Rs to make their decisions more environmentally friendly. For example, some researchers strive to design their numerical modelling projects in such a way as to limit their environmental cost, while still answering the scientific question at hand[59].

A similar weighing-up process should also be applied to the choice of research subjects and the ways to address them. Within a given field of research, what impact does the chosen subject have or potentially have on the environment? How might it help to perpetuate or, on the contrary, move beyond unsustainable modes of consumption or production? In what way and for whom do the negative impacts constitute a risk: for the environment itself? For its implications regarding our production capabilities? For our health, since the One Health perspective encourages an integrated approach to human, animal and environmental health issues? What extra insights or other benefits are expected from the proposed research? Do they justify choosing this subject? And what benefit outweighs the risk, if there is one?

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[57] The 3 Rs principle derives from the work of biologists W. Russel and R. Burch, "The Principles of Humane Experimental Technique", 1959.

[58] Thus, for example, the Quebec Research Funds (FRQ) "recognize that projects that raise serious concerns about the protection of human health or the environment may be necessary for society. Such projects may be acceptable when the expected benefits of the research outweigh the environmental impacts minimized by the planned mitigation measures. In particular, these projects can contribute essential knowledge for environmental protection or sustainable development on the long term. The fact that a research project raises serious concerns about the protection of human health or the environment does not disqualify the research from receiving funding from the FRQ. Assessing the level of environmental risk, identifying mitigation measures and planning measures to comply with legal requirements allow researchers to demonstrate a responsible environmental approach. " (FRQ, https://frq.gouv.qc.ca/en/environmental-responsibility/ p. 10).

[59] Y. Silvy et al., "A modeling framework to understand historical and projected ocean climate change in large coupled ensembles", Geosci. Model Dev., 15, 2022, pp. 7683-7713.

COMETS is well aware of the criticisms that this kind of trade-off may generate: risks and benefits will most often be uncertain and offset in time; the weight of short-term arguments may therefore always be greater than those of ecological considerations. However, COMETS recalls that the assessment of the degree of urgency, the seriousness of a situation and the political inertia all come into play in the proportionality analysis, which does not therefore systematically lead to a stalemate in which no decisions can be made, or to the choice of the lowest common denominator. On the contrary, when faced with situations deemed to be urgent or when in serious danger, the proportionality analysis requires strong decisions and measures commensurate with the challenges encountered.

b) Measuring environmental impacts

A second methodological challenge is to provide the debate with assessment tools.

Measuring GHG emissions is therefore essential in order to identify their causes, determinants and consequently, levers for action. Numerous ongoing studies aim to deepen or refine this assessment (e.g. with regard to air travel by research staff[60]), its methods (e.g. with regard to emissions attributable to purchases), the collection of data, and the understanding of uncertainties when quantifying the carbon footprint.

The same rationale should be applied to **measuring the impacts of research subjects**, at least in terms of knowledge about their environmental impacts (GHG emissions, pollution, loss of biodiversity, propensity to lead to the development of innovations with a potentially negative impact on the environment), so that this crucial subject can eventually be made objective.

COMETS is well aware of the considerable difficulties involved in such an assessment. There are few methods currently available to assess the impact. The interactions involved are also complex, with any action on one component affecting others. Examples abound of detrimental side effects from research whose primary purpose was to restore an ecosystem or protect a species[61]. Another difficulty in measuring impacts is the time lag between the research conducted and the impact to be assessed. As the findings of a research project, and the use that will be made of them by heterogeneous players, are not fully predictable, the impact on the environment is not fully predictable either[62]. This makes it difficult to take a position, for example, on research that has or could have a measurable negative impact on the environment in the short term, but which is expected (without being able to determine this with any certainty) to promote the development of knowledge that will benefit the environment in the long term. The decision taken 30 years ago to undertake the ITER[63] project is an outstanding example of such a long-term gamble. This vast international project, which has mobilised considerable resources since its inception, will have had a significant environmental

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[60] On this point, see O. Berné et al., "The carbon footprint of scientific visibility", Environ. Res. Lett. 17(12), 2022, 124008, which highlights a significant correlation between the number of flights made by researchers and their scientific visibility. The study does not reveal how this causality works, but it does highlight useful data, such as the number of flights taken by the most senior researchers, who travel by plane primarily for courses or recruitment committees.

[61] For example, based on scientific findings, the mongoose was introduced into the Hawaiian archipelago to limit the population of snakes imported as pets that had escaped and were destroying local fauna (especially endemic ground-nesting birds). A few decades later, once the snakes had been eliminated, it was directly responsible for the disappearance of the very endemic birds it was intended to protect.

[62] This is a very complex exercise in calculation, quite different from measuring the marginal productivity of knowledge per se. On this assessment of the economic impacts of research, see for example "Decisions on Assessing Research Impact", Research Excellence Framework, 2011.

[63] https://www.iter.org/proj/inafewlines

cost, with the long-term objective of demonstrating that fusion—the energy of the Sun and stars—can be used to produce electricity on a large scale, without emitting CO^2 and producing very little radioactive waste.

Faced with this difficulty in making a clear decision on the question of impacts, some fear that an overly cautious approach—stifling for science—will be adopted; others, that in the absence of evidence of negative impacts, an overly optimistic approach—potentially dangerous for the environment—will be preferred. COMETS is also aware that appraising the potential usefulness of research is always likely to be tainted by strategic uses, which draws attention to the integrity needed to carry out such an assessment.

This is why collective deliberation is so essential, and should draw on the research projects that have been under way for a decade to better understand and evaluate the mechanisms by which research contributes to negative or positive environmental impacts. In some organisations, major work has been conducted on the impacts of public agricultural research. At CIRAD, work on indicators to identify the extent to which research does or does not contribute to achieving the SDGs has been carried out. The aim is to increase the 'environmental impact culture' among research staff and to see whether a research outcome, like the adoption of a new technology, has an effect on the well-being of people or the preservation of the biosphere[64]. At INRAE, a standardised method known as ASIRPA has been set up to evaluate the societal impacts of agricultural research. While this study focuses primarily on applied research, it helps to characterise the impacts of research and the mechanisms through which they occur[65]. In order to better consider research in relation to the environmental crisis, to understand how it can minimise its negative impacts and increase its positive impacts in the medium and long term, this type of work should now be made systematic. COMETS acknowledges that the challenges are as great as the stakes. It believes that they need to be tackled, this being a prerequisite for research that is attentive to societal issues and relevant in the eyes of both civil society and research staff themselves.

[64] See Opinion 9 of the INRAE Ethics Committee, op. cit. On the call for such a 'new culture of environmental impact' at CIRAD, see S. Perret et al, "Agricultural research and responsible innovation: institutional, scientific and methodological challenges and responses", Technology and Innovation, vol. 7, 2022.

[65] See P.-B. Joly et al., ASIRPA: "A comprehensive theory-based approach to assessing the societal impacts of a research organization", Research Evaluation, 2015, pp. 1-14. The analysis proposes in particular to reason in terms of the 'contribution' of research to an environmental impact, rather than of 'attribution', because in most cases the impact depends on multiple interacting factors, the research findings being only one of them.

IV. RECOMMENDATIONS

Following its analysis, COMETS recommends:

1. Recognising that **consideration of the environment is an integral part of research ethics**; affirming in this respect the responsibility of research players to consider their activity in the light of environmental issues; this responsibility concerns not only the footprint of **research practices** but more generally the **negative or positive environmental impact** that the choice of a **particular research subject and a particular way of addressing it** (the research path) can have on the environment in the broadest sense, whether in the short, medium or long term.

2. Increasing the number of discussion forums enabling all research staff to debate the issues and scope of this responsibility.

Research laboratories appear to be the natural place to conduct this debate. In this respect, COMETS supports the request made by the CNRS President and the CPU (now "France Universités") to appoint one person in each research unit as the sustainable development officer.

The debate should also be conducted in wider forums than laboratories, at the level of local, national or international scientific communities (CNRS institutes and their Scientific Boards, other research organisations, university departments, research groups, academies and learned societies, scientific communities sharing the use of major research facilities, etc.) but also *between* these communities.

3. Providing the debate with a scientifically sound methodological framework that is shared within the research community. This framework should at the very least be based on two principles: the first is that of environmental impact measurement, itself supported by knowledge that has been built up on these impacts, and the second is of proportionality which, taking into account the peculiarities of each situation on a case-by-case basis, weighs up all the negative and positive impacts of research. With regard to measuring impacts, COMETS:

- supports initiatives taken to build up knowledge on the environmental impacts of research (GHG audits of laboratories, the CNRS and its institutes, in addition to research equipment);

- encourages pursuing such audits and recommends that the supervisory authorities facilitate matters, for example by simplifying the completion of an audit in the case of laboratories with multiple supervisory authorities;

- recommends that the CNRS and scientific foresight bodies support and undertake research to better measure the environmental impacts (greenhouse gases, pollution, damage to biodiversity, etc.) of new fields of research or the continuation of ongoing research;

- stresses the importance of developing an 'environmental impact culture' within the scientific community, by proposing, among other things, training courses[66] and interdisciplinary thematic schools on this subject.

4. More specifically addressing CNRS management, COMETS:

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[66] *On this point, COMETS notes the joint CNRS and IRD project—one of the ten winners of the government's call for "environmentally friendly innovation"—to raise staff awareness and offer appropriate training activities.*

- welcomes the fact that the CNRS intends to play a leading role in the world of higher education and research, and to ensure that it favourably influences sustainable development.

- recommends that the CNRS sustain and strengthen the means it uses to assess its impact on the environment in order to promote organisational learning and the acquisition of consolidated experience;

- stresses the importance of recognising and facilitating the ability of laboratories to provide innovative solutions for environmentally friendly research; calls for support of approaches based on local laboratory experience; recommends that the CNRS should create an open database of innovations of all kinds developed by laboratories and make it accessible, particularly to research organisations;

- encourages **training departments** to: raise awareness and train staff in the environmental dimension of research ethics; recruit staff to organise and run collaborative workshops and develop an 'interdisciplinary culture of environmental impact'; pursue their efforts to enable research staff, regardless of their status, to devote time to the issue of integrating environmental issues into research as part of their job;

- recommends supporting research community members wishing to redirect their activities towards practices and subjects likely to contribute to better environmental sustainability.

In its **relations with public and private decision-makers**, the CNRS should give greater support to and highlight research staff output (whether research, expert appraisals, warnings, etc.) that is likely to inform debates and stimulate action in favour of the environment.

5.- COMETS encourages:

- **the bodies responsible for programming and funding research**;

- the bodies responsible for assessing researchers;

- **the bodies of the National Committee for Scientific Research responsible for planning future research fields**

to reflect on how they can better factor the environmental impact of research into their work.

V. ANNEXES

Annex 1: Formal internal request

PRES.P.2021-115

Le Président-directeur général

Madame Christine Noiville
Présidente du Comité d'éthique du CNRS
3 rue Michel Ange
75016 Paris

Paris, le 20 décembre 2021

Objet: Saisine du COMETS par la présidence du CNRS sur l'impact environnemental de la recherche scientifique

Madame la Présidente du COMETS, chère Christine,

La mission du CNRS est de mener toutes les recherches présentant un intérêt pour la science ainsi que pour le progrès technologique, social et culturel du pays. Le CNRS développe également la connaissance, l'innovation et les partenariats en vue de contribuer aux objectifs du développement durable. Ce sont ces mêmes objectifs de transformation de nos sociétés, pour rendre ces dernières plus justes, paisibles, prospères et respectueuses de notre planète, qui ont conduit à la feuille de route nationale engageant la France à réduire de 30% les émissions de gaz à effet de serre (GES) en 2030, pour tendre vers la neutralité carbone en 2050.

L'impact environnemental de la recherche scientifique pose dès lors une question éthique cruciale. Si la recherche a pour vocation d'apporter des solutions pour répondre aux défis environnementaux, il s'avère qu'elle peut aussi contribuer au problème en menant des activités ou en développant des innovations coûteuses en termes énergétiques[1]. Il est donc nécessaire de mettre en cohérence les pratiques de recherche avec le développement durable. Dans cette optique, le CNRS a initié en 2019 une action auprès des chercheurs pour connaitre et maîtriser leur empreinte environnementale.

Or cette démarche, guidée par un souci d'éthique de participation individuelle à un effort nécessaire de réduction de l'émission de gaz à effet de serre (GES) par nos activités professionnelles et par la nécessité de répondre à la demande de nombreux chercheurs et chercheuses, en particulier les plus jeunes, soulève un certain nombre d'interrogations. Est-il possible de poursuivre simultanément les deux objectifs, d'une part se doter des moyens nécessaires à la conduite des recherches au meilleur niveau mondial et d'autre part réduire l'émission des GES de l'activité de recherche? Le CNRS doit-il se doter d'une feuille de route de réduction de son émission de GES au risque de peser sur l'efficacité des recherches ? Faut-il écarter certains sujets de recherche, parce que trop émetteurs de GES ou parce qu'ils conduiraient à développer des technologies hautement émettrices?

1 A titre d'exemple, INRAE a produit son bilan des émissions des GES qui donne 20% pour son cheptel d'animaux, 18% pour la fabrication des matériels scientifiques utilisés, 13% pour la consommation de gaz naturel et 13% pour les trajets domicile travail en voiture, et 9% pour les déplacements professionnels en avion...

CNRS
Campus Gérard Mégie
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Faut- il encourager des recherches qui visent à réduire les émissions de GES, ou à développer des connaissances qui permettraient de remplacer des technologiques très émettrices ?

La présidence du CNRS remercie le COMETS de formuler des recommandations sur ces questions.

Je vous prie d'agréer, Madame la Présidente du COMETS, l'expression de mes plus cordiales salutations.

Antoine Petit

Copie : Alain Schuhl, Directeur général délégué à la science

See page 7 for the English translation.

Annex 2: The CNRS's Carbon Footprint in 2022

Extract from "Transition bas-carbone : un plan ambitieux pour le CNRS" [Low-carbon transition: an ambitious plan for the CNRS], CNRS Hebdo, 24 November 2022: https://www.cnrs.fr/fr/cnrsinfo/transition-bas-carbone-un-plan-ambitieux-pour-le-cnrs.

“As part of the national low-carbon strategy, public institutions such as the CNRS are obliged to carry out a GHG audit every three years to establish its carbon footprint. Within the CNRS, this audit was conceived as a cross-cutting, multi-player project with the aim of estimating all the possible levers for reducing emissions. This work was based on the methodology recommended by ADEME and was carried out in collaboration with the research group Labos 1point5, which provides tools and research on emission factor calculations. The balance sheet resulting from this audit provides a snapshot at a given moment of the GHG emissions resulting from the organisation’s activities, such as staff commuting, scientific missions (i.e. work-related trips carried out by scientists as part of their research activities, including travelling to the field, taking part in conferences, etc.), and purchases required for research and laboratory life (including catering).

With nearly 2,000 items taken into account, purchases represent 73% of the CNRS’s GHG emissions. For this first audit, the CNRS decided to prioritise data over which it has control either as a host, employer or payer. Only the buildings managed by the CNRS – which host some 20,000 people, including 8,000 permanent CNRS staff – have been included, their emissions being by far and large due to the consumption of gas and electricity. Estimated through a national survey implemented in late 2021, all the commutes of all CNRS staff represent 5 million kilometres per week, i.e. 125 trips around the Earth; the use of cars is responsible for 87% of GHG emissions. Unsurprisingly, air travel accounts for the greatest emissions for scientific missions; the 300 million kilometres flown represent 91% of emissions, compared with 0.5% for the 60 million kilometres travelled by train.

The all-inclusive average for CNRS emissions comes to some 14 tonnes of carbon equivalent per year per employee. The goal of the Paris Agreement in order to reach carbon neutrality is 2 tonnes per person. One of the difficulties in GHG audits lies in data location and availability. This can lead to uncertainties, which are calculated and taken into account in the analysis; these uncertainties are linked to the extrapolation of data available or the emission factors themselves. The GHG audit is above all a tool with which to take certain measurements that can then be compared from one year to another. This approach will be optimised for the next audit in 2022 by refining the scope and correcting the blind spots identified this time.”

VI. QUALIFIED PERSONS CONSULTED

- Alice Agblekey, carbon footprint research officer, CNRS
- Nicolas Arnaud, director of INSU, the National Institute for Universe Sciences, CNRS
- Florence Bellivier, professor of private law and criminal sciences, University of Paris 1 Panthéon Sorbonne
- Tamara Ben Ari, INRAE, director of the Labos 1point5 research group
- Olivier Berné, CNRS, Labos 1point5 research group
- Léo Coutellec, lecturer in ethics and epistemology of contemporary sciences, University of Paris-Saclay
- Blandine de Geyer, national sustainable development officer, CNRS
- Pierre Guibentif, full professor at the University Institute of Lisbon (ISCTE-IUL), director of Maison des Sciences de l'Homme (MSH) – University of Paris-Saclay
- Patrick Hennebelle, CEA, Labos 1point5 group
- Marie-Angèle Hermitte, honorary research director, CNRS
- Pierre-Benoît Joly, president of INRAE Occitanie
- Catherine Larrère, professor emeritus of philosophy, University of Paris 1 Panthéon Sorbonne
- Lucile Schmid, vice-president of La Fabrique Écologique
- Alain Schuhl, director general for science, CNRS

VII. GLOSSARY: abbreviations or acronyms used

ADEME: *Agence de l'Environnement et de la Maîtrise de l'Energie* — French Agency for Ecological Transition
CIRAD: *Centre de Coopération Internationale en Recherche Agronomique pour le Développement* — French Agricultural Research Centre for International Development
CNRS: *Centre National de Recherche Scientifique* — French National Centre for Scientific Research
CoNRS: *Comité National de la Recherche Scientifique* — French National Committee for Scientific Research
CPU: Conference of University Presidents (now France Universités)
FRQ: *Fonds de Recherche du Québec* — Quebec Research Funds
GHG: Greenhouse gas
HLPE: High Level Panel of Experts on Food Security and Nutrition
IPBES: Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC: Intergovernmental Panel on Climate Change
OSR: Organisational Social Responsibility
SDGs: Sustainable Development Goals