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Scientist engagement and the knowledge–action gap

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The combined gravity of biodiversity loss and climate change keeps increasing. As the approaching catastrophe has never looked so alarming, the amount of scientific knowledge about the bioclimatic crisis is still rising exponentially. Here we reflect on how researchers in ecology or climate science behave amid this crisis. In face of the disproportionality between how much scientists know and how little they engage, we discuss four barriers that may underlie the decoupling of scientific awareness from concrete action. We then reflect on the potency of rational thinking to trigger engagement on its own, and question whether more scientific knowledge can be the tipping point towards radical changes within society. Our observations challenge the tenet that a better understanding of what surrounds us is necessary to protect it efficiently. With the environmental cost of scientific research itself as an additional factor that must be considered, we suggest there is an urgent need for researchers to collectively reflect on their situation and decide how to redirect their actions.

Aside from being the hottest ever recorded[1], 2023 looked like all previous years, with global CO_2 emissions increasing again by more than 1.1% compared to 2022[2–4]. It is 45 years since Charney's *Carbon Dioxide and Climate* report[5], 28 Conferences of the Parties (COP) have taken place, while one global report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and six from the Intergovernmental Panel on Climate Change (IPCC) have been published[6,7]. Yet, six of the nine planetary boundaries have been crossed[8], a sign that the Earth system has never been so unstable for durably supporting human life[9]. Exceeding the 1.5 °C warming mark could trigger a series of irreversible tipping points with grave consequences[10], and the odds of successfully staying below this threshold are quickly narrowing[11] and this goal now appears almost unachievable before 2030[3,12]. Climate is not the only source of worry however, as close to half of Earth's animal populations are declining[13], one of the latest indications of the ongoing mass extinction[14–16]. Each year, springtime is more silent still[17], as the buzz of insects[18,19] and birdsongs[20,21] have been smothered with anthropogenic disruptions.

Meanwhile, scientists (Box 1) have been taken up in a frenzied quest for more knowledge[22,23]. In particular, the number of research articles related to climate change has increased exponentially in the past decades[24,25], at a rate four to five times higher than in other scientific fields[26]. Justifying this trend often calls upon a key argument: that better protecting what surrounds us absolutely demands a better scientific understanding[24,25] (Fig. 1). This knowledge hypothesis is relayed at a diversity of scales, from the UNESCO[27] or the European Union in funding calls[28], to research institutes[29], publishers designing dedicated stickers (Fig. 1b), or scientists themselves in articles or grant proposals (for example, ref. 30). Likewise, we are told that raising scientific awareness is crucial to promote bioclimate action[31], as teachers or nongovernmental organizations have been busy popularizing knowledge and drawing biodiversity or climate frescoes (for example, refs. 32,33). The underlying postulate of these discourses is that a high scientific understanding of the crisis should translate into proportionally adequate behaviours[34] (for example, pro-environmental policies by decision-makers or sober lifestyle choices by citizens; Fig. 1a). As a consequence, some researchers have invested a lot of energy into the functioning of the IPCC or the IPBES in hope of transforming people through rational knowledge.

The relative failure of this endeavour[3] urges us to reconsider the principles underpinning the knowledge hypothesis and to question its validity[23]. To do so, looking at the behaviour of researchers in ecology and climate science may be informative. Most ecology researchers believe that nature is intrinsically valuable[35], appreciate its beauty and believe that we are morally obligated to preserve it[36]. Their scientific

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BOX 1

Glossary

Axiological neutrality. From the Greek *axios* (value). The epistemological aim of minimizing the impact of one's values onto one's scientific discourse and practices. How to achieve neutrality on a topic, or if it is achievable at all, has long been subject to debate.

Bioclimatic crisis. The combined crises of climate change and biodiversity loss. These two crises caused by human activities are intertwined with feedback loops (for example, climate change affecting ecosystem functioning, or land use and biodiversity loss leading to greenhouse-gas emissions), making them inseparable.

Climate scientists. Experts on the Earth's climate, studying its behaviour and the effect of climate changes on abiotic systems (atmosphere and hydrosphere).

Cognitive dissonance. Psychological discomfort caused by an internal conflict between one's representations (values, beliefs or knowledge) and behaviours (for example, knowing that taking the plane is a high emittor, yet still taking it). The subsequent response is a change of representations (for example, I have no choice but to fly to this congress) or actions (for example, I will not fly there) so to minimize dissonance.

Ecology scientists. Those studying ecosystems in the widest sense, from applied conservation science to more theoretical approaches looking at, for example, species interactions or the biodiversity–function relationship.

Engagement. In general, a trajectory of consistent behavioural choices committed towards one particular goal. In this case, we specifically refer to engagement to describe to a set of concrete, pro-environmental behaviours aimed at having a positive effect on the bioclimatic situation. This includes influencing policies (formal policy work, campaigning or activism), public advocacy and reducing one's environmental footprint in both personal and professional spheres.

Knowledge–action gap. The decoupling between research outputs and concrete actions taken by individuals. Explaining this gap may call on issues in the transfer of existing knowledge (for example, to the public or to policymakers) or on psychological and cognitive levers impeding behavioural changes.

Knowledge hypothesis. The prevailing hypothesis according to which an increased scientific understanding of a system should lead to an increase in its protection. Also relates to a belief in the 'goodness of more knowledge', implying that more scientific knowledge is always beneficial (and at worse, something neutral), but never detrimental. The underlying postulate of the knowledge hypothesis is that agents (for example, citizens and decision-makers) mostly have rational behaviours. As such, the hypothesis places the rational free will of agents at the core of bioclimate action and overshadows social norms, collective dynamics or power imbalances between individuals.

Naturalist ontology. An ontology is a formal, explicit specification of a shared representation of the world. According to Philippe Descola, the naturalist ontology is the belief that 'nature' is a separate set of entities that are not a product of human will, in contrast to 'culture'[35]. Hence, the naturalist ontology tends to place humans in a dominating position towards non-human entities. It constitutes some of the groundwork that allowed modern science.

Radical. From the Latin *radix* (root). Behaviours, stances or remarks targeted at the roots of a problem.

Situated. Takes into account the subjectivity of the agent by considering their social, cultural and material context (for example, situated knowledge or situated engagement).

Scientists. We refer to researchers in all fields of science, from non-human 'hard' sciences (for example, biology, geosciences, mathematics, physics and chemistry) to human sciences (for example, sociology, philosophy and psychology). However, our arguments regarding the knowledge hypothesis and the intimate relationship with facts describing the gravity of the bioclimatic crisis may be more specific to ecology and climate scientists.

education and occupation provide them with tools and figures to grasp the gravity of human-caused disruptions, which they often handle on a daily basis[37,38]. This awareness is reflected by how concerned they claim to be about the future[39,40], as six in ten climate experts expect at least a 3-°C warming by the end of the century[40]. Hence, researchers in ecology and climate science are at the apex of rational awareness regarding the gravity of the ongoing bioclimatic crisis. According to the knowledge hypothesis, one would expect them to display the highest level of pro-environmental behaviours: the increase in their engagement[41] should be proportional to how much more they know, thus be radical[42]. In other words, climate and ecology researchers comprise a cohort allowing us to question whether acute scientific knowledge ignites concrete behavioural changes. In recent years, a body of studies has looked at how scientists behave in this context, which we summarize in Box 2. Despite growing discussions regarding the societal position of researchers and more scientists speaking up, current evidence suggests that the engagement of ecology and climate researchers is not proportional to how much more aware they are of the gravity of the crisis (Box 2). From means of transport or lifestyle choices, climate protests to activism, the behaviour of most scientists seems to challenge the knowledge hypothesis.

Why, then, is the most scientifically aware social group not at the forefront of bioclimate action? More importantly, what does this remind us about the power of knowing? In this Perspective, we build upon existing literature in ecology, climate and human sciences to formulate an answer to these questions. We unfold our argument throughout three sections. First, we go beyond what scientists self-declare as obstacles to their engagement by detailing a series of levers that could impede more radical pro-environmental behaviours. Second, as the most acute awareness can be decoupled from behavioural changes, we dispute the capacity of rational facts to ignite engagement. We discuss what more knowledge may or may not allow on its own, which questions the meaning of current research. Finally, we bring forward a series of proposals to redirect energy towards efficient action. As ecology researchers ourselves, we must specify that our goal is not to condemn scientists for their (our) lack of engagement; rather, to encourage discussions and actions on this topic. Our references reflect the available literature and are biased towards climate-change engagement rather than biodiversity, but we believe that the mechanisms discussed below apply equally to both contexts.

Situated hurdles impeding the engagement of researchers

It has been a decade or so since psychology, social and behavioural sciences started looking at why inaction persists in spite of climate emergency[43,44]. For example, Gifford devised a taxonomy of barriers

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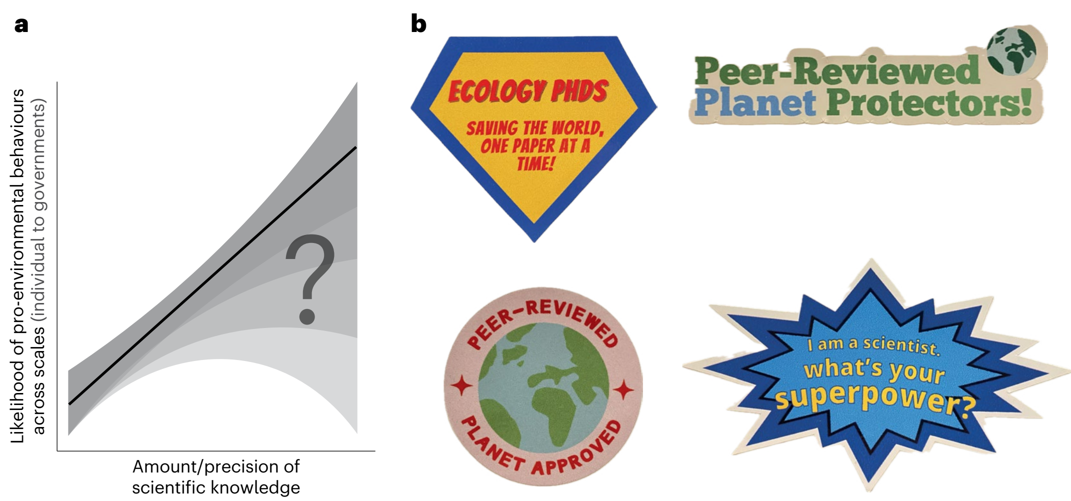

Fig. 1 | The knowledge hypothesis implies a correlation between scientific knowledge and the likelihood of pro-environmental behaviours. a, The knowledge hypothesis (black line): the expected positive correlation between the amount or precision of scientific knowledge and the likelihood of pro-environmental actions. Such a trend may be traced across scales, from citizens (scientifically aware versus unaware) to decision-makers within governments or nations. However, this hypothesis is rarely questioned in natural sciences (but see, for example, ref. 88), leaving substantial room for uncertainty (grey gradient). **b**, Set of stickers handed out by John Wiley & Sons at the 2023 British Ecological Society conference (Belfast, UK). These graphics are relatively explicit regarding the potency of a better scientific knowledge to trigger positive bioclimate action.

that impede climate change mitigation (table 1 in ref. 44). The specific question of scientists' engagement is a more recent topic, apart from a few mentions in the late 2000s (for example, refs. 45–47). Most studies discuss the ethics and implications of public engagement as scientists[48–52], debating whether and why scientists ought to engage or not[37,50,53–56]. Scientists have also been surveyed to assess what prevents aspects of their engagement in their view[39,45,57–60]. Yet, most of these approaches do not explicitly discuss the sociological and epistemological factors shaping academical researchers—although these could probably be classified in a more general framework such as Gifford's[44]. In this first part, we detail four barriers, some of which may be specific to ecology and climate scientists (Fig. 2). We illustrate how these situated hurdles may impede engagement and question their validity in hope of collectively debunking them.

Barrier 1: axiological neutrality

As polls show (for example, ref. 39), scientists are imprinted by an ideal of axiological neutrality (Box 1) preventing them from engaging. Aiming to be objective is an undisputable keystone of the scientific method. Yet, shared misconceptions can turn this ideal into a stranglehold and hinder action. Indeed, scientific objectivity is often taken or taught as a duty to produce results without ever going beyond a cold interpretation of what figures say[61], while being faithful to supposedly neutral facts[62]. As such, the quest for absolute objectivity may put scientists in a position of political apathy regarding their subject of study, which could favour inaction[63]. Yet, axiological neutrality as originally introduced by Max Weber acknowledged that scientific facts could never be entirely value free[64]. For many, objectivity as claimed by ecologists or climate scientists is thus elusive[65–67]. A nameworthy milestone is Donna Haraway's famous concept of 'situated knowledge' to emphasize the social construction of science[68]. Haraway showed how biases arising from a 'male gaze' in primatology had long overshadowed the role of female primates[69]. She downgraded what was claimed as neutral scientific facts to situated, partial male vision. In Haraway or Weber's mind, only by being conscious of our stance (see our 'Positionality statement'), by seeing from whence knowledge is created and by seeking diverging viewpoints can we achieve greater objectivity as scientists—yet without ever reaching it[64,68,70–72]. Unfortunately, we often lack these transdisciplinary debates and the divide between epistemology and natural sciences has kept growing. As a consequence, taking a public stance on scientific findings is often feared to come into conflict with the ability to 'remain neutral', or with scientific credibility in a social group (Fig. 2). However, several studies have addressed the credibility issue and sometimes showed that citizens were supporting climate advocacy by scientists[50,73–75]. Aiming for scientific objectivity should not be incompatible with acting according to one's values. We claim that engaging will not make scientists more impure than they are, for objectivity is learnt rather than innate.

Barrier 2: doing one's share of work

The second barrier impeding the engagement of scientists is their excessive belief in the goodness and power of knowledge (Fig. 1). Embracing the knowledge hypothesis may lead to the firm conviction that being a climate or ecology researcher constitutes a great share of the necessary fight. In a rebound effect, some scientists may explain that becoming activists or cycling to work is not their fight, for they already produce knowledge related to the bioclimatic crisis. Indisputably, climate science and ecology have had a pivotal role in explaining and asserting the links between human activities and the bioclimatic crisis (for example, refs. 19,76–81). Such history may fuel the desire to keep investing in more scientific knowledge at all costs. Yet, we argue that the gravity of the situation should incite scientists to adopt a more critical stance towards their activity. First, why should being ecology or climate researchers consume any other form of engagement? Second, should more scientific knowledge always prevail at all costs? Researchers flying thousands of kilometres to a congress may claim that the benefits of sharing their work will ultimately offset their environmental footprint[82,83] (Box 3). But these assertions can hardly be quantified and verified, making them more of a belief to withstand cognitive dissonance than a proven scientific fact. These concerns should weigh all the more in the face of the steady rise in habitat destruction (or species extinction, or CO_2 emissions[2,11]) despite the exponential increase in the number of research papers[24,37]. Incidentally, it has been proposed in some fields (for example, conservation biology) that more scientific knowledge could be a lesser priority than implementing the existing one[84–88], so to fill the knowledge–implementation gap[89]. Scientists could go as far as to question the increased need for complex research on trophic networks or species interactions[90]

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BOX 2

Acute rational knowledge does not translate into acute engagement for scientists

Accurately describing the bioclimate engagement of scientists is a tough task. Things have been slowly moving in the past few years, with more researchers speaking up in academical and political arenas (for example, ref. 142) or the rise of Scientist Rebellion[48,143]. In a recent large-scale poll, climate experts self-reported higher degrees of engagement than their non-expert scientist fellows[39,57]. However, what people report can differ substantially from what they actually do (for example, ref. 144). In particular, mismatches between what scientists feel they should do and what they actually take part in have previously been highlighted[45,58]. Transport-wise, cars are still the go-to option for commuting in French academia[145] and most scientists extensively rely on flights to travel worldwide[53,54,145–147]. Evidence was even brought for climate scientists taking the plane more often that non-climate expert researchers[82]. A recent study showed that discourses of climate delay are found within scientific communities[59], as in less-aware social groups[43]. At a more collective scale, only a minority of climate scientists join climate protests (25% of 200 top climate experts in 2021[40]), and even fewer partake in activism (for example, civil disobedience[37,48]). This all suggests that although experts of the bioclimatic crisis report a greater desire to engage, the actual process is slow and disproportionately low compared with their rational perception of the gravity and rapidity of the crisis. Graphically, the slope in Fig. 1a seems, at best, far shallower than what is ubiquitously claimed (or the response is non-linear). More qualitatively, ecology and climate researchers are not straightforwardly renowned as a radicalized faction in society. The mere fact that there is room for doubt around their engagement is sufficient to question it. This knowledge versus action paradox points at a 'double reality'[58,123] in the cognition of scientist, whereby they manage to isolate their sharp awareness of the gravity from their decision-making processes[148].

We must add that the engagement of individuals should not be presented as the single lever for pro-environmental actions, as the room for manoeuvre is not absolute[140,149]. Our collective fate strongly depends on structural changes in the hands of higher authorities (industries, governments and institutions)[150–154]. In addition, overfocusing on individual actions mimics the flaws of meritocratic discourses by overshadowing the social context: it implies that people are all equal in their capability to act[155,156]. Still, people with a higher social status (for example, academics) could be expected to engage more, as they encounter fewer economic hurdles to changing their behaviour[157] and are responsible for a greater share of CO_2 emissions (for example, ref. 158). Scientists should be all the more interested in being engaged as their credibility regarding climate policies was shown to be negatively correlated to their carbon footprint[129,159].

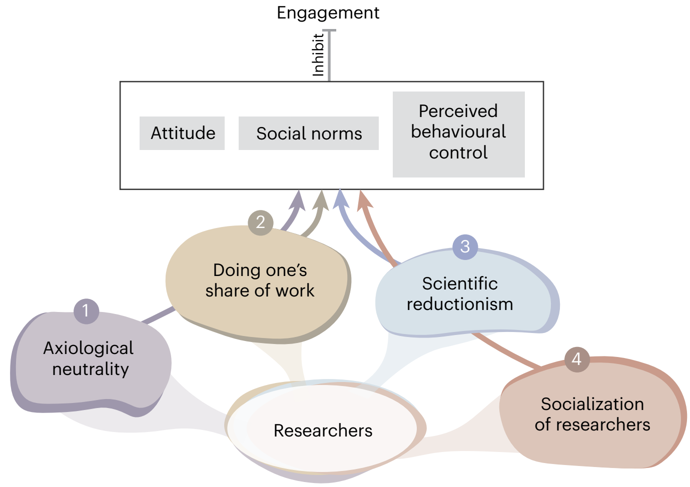

Fig. 2 | Four scientist-specific hurdles may impede engagement. The four hurdles add to those shared by all citizens, which are further developed in other studies[43,44]. To picture how these barriers may affect behaviour, we embed them within a simplified version of the theory of planned behaviour[45,113], as an example among other models. In this classical psychology theory, the effect of the barriers may occur through changes of one's attitude (the appreciation of the act of engaging more: is it believed good or bad, enjoyable or not, pointless or useful?), of the group's social norms (informal rules governing behaviour: do my colleagues engage, will they approve of my behaviour if I do?) and of perceived behavioural control (do I feel capable of engaging?). For instance, the myth of axiological neutrality reinforces fears of discredit and judgment from scientific peers (social norms). It also modifies attitude, as it would seem against scientific ethics to engage and go beyond fact reporting. Such analysis also implies that building a critical mass among researchers may act as a tipping point towards a new equilibrium, whereby engaged scientists would be socially valued instead of marginalized.

in face of successful conservation cases relying on more traditional knowledge, which had been sustained for centuries before being rejected in a neo-colonial fashion[91–94]. Finally, a more extreme belief in knowledge is the solving of the bioclimatic crisis through innovation and technology[3] (for example, CO_2 capture, or robotic bees for pollination). We must remember that most of these technologies do not exist yet and raise a number of environmental, ethical, legal and equity issues[95–97]. The Promethean belief[98] in the power of technique and scientific knowledge to master nature calls upon human hybris[99] and the naturalist ontology of occidental societies, which should be questioned so to favour engagement (Fig. 2).

Barrier 3: scientific reductionism

A third hurdle may be reductionism[100]: the fact that science segments systems into nested subparts (for example, species into populations, individuals, organs and cells) to study them independently and reassemble knowledge later on[101]. Despite the success of this method, the decomposition of complexity into isolated problems may complicate seeing the bigger picture or feeling legitimate (for example, working on mesoscale eddies under climate change scenarios does not make you aware of planetary boundaries), which relates to the issue of scientific overspecialization[102]. However, reductionism may impede action by other means. In ecology for instance, studying an organism, a population or an ecosystem requires to reduce its complexity. This may be achieved by studying one or two dimensions (for example, temperature or salt) within simplified and controlled environments (for example, microcosms or models), which pulls researchers away from natural settings. In addition, animals or cell cultures are seldom called by their vernacular or Latin name but often using alphanumerical codes. Quantitative measurements are increasingly done through wireless loggers, mass sequencing methods, automated video recording or cell counting. In other words, reductionist and quantitative natural sciences probably do not bring researchers closer to their 'objects' of study, to their 'model' organisms; rather, it turns these into abstract entities and fosters emotional detachment. Combined with the myth of neutrality and the amount of published results growing exponentially, scientific reductionism may increase emotional numbness[44] and thus change one's attitude towards engagement (Fig. 2).

BOX 3

The environmental and social costs of modern research

For researchers who did not choose climate science or ecology in the hope of positively impacting the crisis, the previous questions about how rational awareness affects behaviour may seem of secondary importance. Some may argue that 'pure research' is what should be defended; that wishing for a political impact as scientists was a mistake in the first place[160]. Aside from the epistemological questions raised by such discourses (for example, about neutrality), another broader issue relates to all scientists, regardless of their stance: the environmental footprint of research. The carbon footprint of academia has been extensively documented in recent years; yet strong action from scientists and institutions is still mostly lacking[53,107,161]. In France for instance, a 2019 survey estimated that members of the National Centre for Scientific Research (CNRS) emitted an average of 14 tCO_2 per year just through their research activity, in a country where electricity is decarbonized[145]. Despite the huge variance between fields (for example, average per capita emissions are much higher for astronomers[162]), such figures are unsettling. First, because they show once again that knowing and quantifying are insufficient to trigger change. Second, because this carbon footprint questions the sustainability of modern research and of its future developments. And yet, looking solely at carbon emissions does not even account for other dimensions of the problem, such as chemical pollutions, or the social and biodiversity cost of precious metals used in the devices upon which scientists rely to gather or analyse data[133]. If carbon emissions or environmental destruction cannot even be justified with the knowledge hypothesis anymore, the tension between the benefits and costs of knowing more is again emphasized. More concealed perhaps are costs relative to the societal dependencies of institutionalized science and full-time researchers. The fact that some may devote the entirety of their time to experimenting and searching is only possible through a highly partitioned society, with other social groups catering for scientists by producing their energy, base materials or everyday food. That is, the freedom to think claimed by scientists relies on overshadowed layers of necessity insured by non-academics. Added to the financial dependency of academia towards society, this aspect may have favoured the adoption of the knowledge hypothesis to justify a need for more research and create more purpose amid the crisis. All of these environmental and social considerations constitute a 'price for curiosity', exacerbated by the current crisis. Acknowledging this price increases the need for more collective discussions about the why, the how and the what scientists are doing day to day, whatever their stance towards the knowledge hypothesis[53,118,119].

Barrier 4: the socialization of researchers

A final lever decoupling acute rational knowledge from engagement may be the social trajectory of scientists in the academic system. Initially, researchers are mostly good students who succeed in academia following a long curriculum in higher education, which tends to positively correlate with a high socio-economic status[103]. Their curriculum is punctuated with rewards (grades, public recognition through symbolic ceremonies and citations) distributed by higher-authorities (teachers, supervisors and peers) on account of regular evaluations (examinations, article reviews, defence and activity reports). Academia trades self-esteem and acknowledgements of one's intellectual faculties in exchange for abnegation, obedience and performativity[104]. This positive reinforcement can be a source of powerful operant conditioning, as it moulds normalized people through 'disciplinary power'[105]. As such, questioning a system that granted you recognition at the expense of sacrifices is likely to be difficult. This social trajectory can thus be expected to hinder engagement in several ways (Fig. 2). First, by producing agents that lack political awareness: because of their chosen dedication to knowledge leaving little time in a hypercompetitive academic world; because some may have initially picked 'pure research' as a way to hopefully escape profit-oriented jobs (and politics, see barrier 1). Second, by selecting for individualistic and obedient personalities with large egos[106], who show high degrees of social conformism[37], whereas engagement rather calls upon anti-conformism and collective action against the standing system[39]. Last, because most senior scientists have a high socio-economic status and benefit from its associated prerogatives. Waiving one's right to take the plane, to live in a spacious place or drive to work—in short, living a more sober life—may be a difficult ask for those blessed with privileges.

The behaviour of scientists discredits the existence of a purely rational awakening

In the previous section, we detailed and questioned a series of hurdles that impede the engagement of climate and ecology researchers. In this second part, we draw conclusions regarding the capacity of rational knowledge to ignite radical change. We argue that debates about these questions have been oddly scarce in the scientific community due to overspecialization.

The fact that scientists do not display more radical forms of engagement results from a complex combination of factors (Fig. 2). We must now take a step back. Ecology and climate researchers, the cohort with the highest scientific awareness of the bioclimatic crisis, have not managed to overcome their social and psychological barriers[23,53,107]. If the most aware group within society has not taken drastic action to engage, if the individuals who can best say, read and grasp the gravity of the crisis have not been moved into action, then what? Then the acuteness of rational thinking will never overcome the social or psychological barriers of anyone. Climate and ecology researchers are the social group illustrating that knowing is not sufficient. If these experts have not felt the urge to act, should decision-makers skimming through IPBES or IPCC reports be expected to have a rational epiphany and suddenly become bioclimate activists? Should hopes be placed onto the next generation just because they now attend compulsory lectures dedicated to raising awareness about the sixth mass extinction? The empirical answer is: no, this is at least insufficient. This observation undermines the knowledge hypothesis (Fig. 1a). Such a statement debunks that producing more knowledge and sharing it downstream will be lifesaving on its own. Knowing, albeit perhaps necessary, is certainly not enough.

To some degree, this flagrant need to remind that rational knowledge is not enough for societal change illustrates how partitioned modern research is. Indeed, studies have recurrently shown that humans do not behave rationally and that a knowledge–action gap often remains (for example, refs. 34,44,108–114). Arguably, anyone in western societies knew it before Kant's *Sapere aude!* (Dare to know!) paved the way for a politics of reason[115]. It may hence be symptomatic of overspecialized scientists to think that raising awareness could be the tipping point[23] (Fig. 1a), or that ignorance is the prime cause for inaction[116]. Besides, embracing an unproven hypothesis to justify research could be seen as contrary to the scientific method. Beyond this knowledge–action gap, sociologist J. B. Comby has argued that the obstinate popularization of scientific facts about global change (the 'popularization doxa'[117]) could lead to a depoliticization of the climate problem. In his view, overconcentrating on the science of climate change may conceal its structural causes (for example, extractivism and capitalism) and focuses too much on individual actions[117] (Box 2). Journalists and researchers may sometimes prefer popularizing scientific facts

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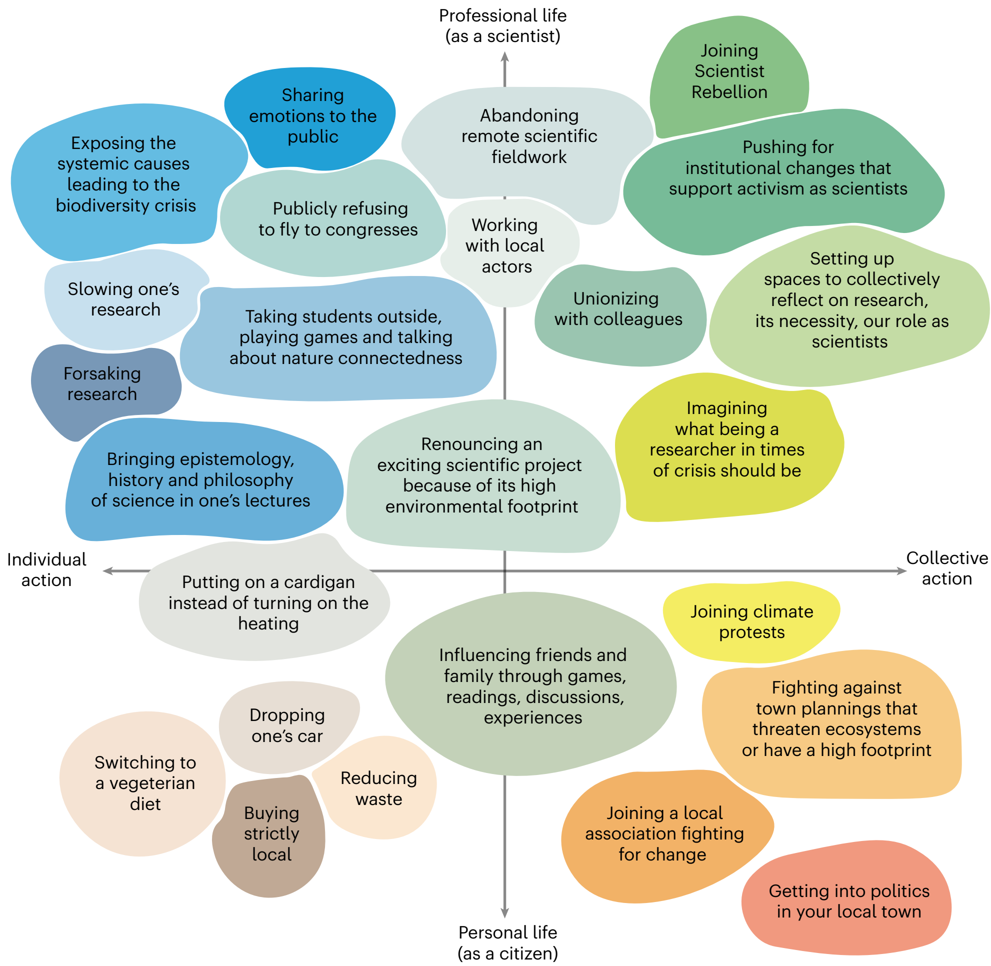

Fig. 3 | Leads for transformative engagement as scientists and citizens. This plane summarizes a series of examples to engage in accordance with one's knowledge of the gravity of the crisis. Some of these points were taken based on their estimated CO_2 mitigation potential, both for research (for example, refs. 138,139) and personal lives (for example, ref. 140). Others do not directly affect carbon emissions, but relate more to changes in how research is done, or why and what being a researcher could be in such times of crisis. Decoupling the citizen from the scientist self is not entirely possible, but we refer to the public stance taken by researchers in either of the two poles[141]. For example, mixing with other professions as citizens (for example, when getting into local politics) may favour more horizontal discussions by suppressing the verticality of the expert stance. These primers are not representative of all the existing strategies: many more ought to be devised collectively, adapted to the local context while maximizing social, gender or ethnic diversity so to increase objectivity. Individual actions may be easier to implement for academics with a position, but should not be presented as the core of anyone's engagement (Box 2). The option of 'forsaking research' deserves to be mentioned as a potential political path, rather than as individual failure.

without going any further: it could contribute to making themselves feel indispensable, yet without questioning the privileges of their social class which depend on the system's upholding[117]. Science has reached a state of such specialization that few researchers have debated or heard of these studies. As said above, rational knowledge may not be sufficient to ignite engagement. But just as challenging is that decoupling scientific results from politics may have impoverished their usefulness in the fight against the causes of the crisis. Added to the environmental costs of modern research that are incompatible with the Paris Agreement (Box 3), these observations are strong incentives to pause and ponder on where science is at. As stated by Longuet-Higgins in 1984: "(...) every scientist should ask him[/her]self, at every level from the most particular to the most general, exactly why he[/she] is doing what he[/she] is doing, and whether he[/she] would not be better advised to do it differently, or even something entirely different."[118]

From continuous knowledge accumulation towards reflexive action

We showed how the behaviour of ecology and climate researchers self-questions one of the claimed reasons to keep accumulating knowledge. Considering the costs associated to modern science (Box 3) and the gravity of the bioclimatic situation, it is high time to collectively rethink ecology and climate research before they become satirical. In this last section, we confront activism for more 'research as usual' by thinking about how ecology and climate science could follow a different path (Fig. 3), without excluding a degrowth of research activities[119].

Scientific research occupies an ambivalent position. On one hand, it has been a pivotal player to shed light on how grave both climate change and biodiversity loss are. Without it, we would not have gathered such robust descriptions of the impact humans have had on the Earth's climate and biosphere. On the other, modern science has largely contributed to providing the tools that our societies use to plunder the Earth's resources[120,121] and is a big CO_2 emitter by itself (Box 3). That is: the science that characterized the bioclimatic issue can hardly be decoupled from the trajectory of technical progress that itself lead to the crisis. This report can be painful for many of us, as it shakes a substantial part of our internal tales of life. After devoting an entire career to scientific research, reassessing and admitting to have kidded ourselves with preconceptions that do not hold can feel sore. Sore also, is the event that this dynamic may have partly been orchestrated by decision-makers. To some degree, could scientists have been beguiled with an insatiable need for more knowledge, more scenarios, more certainty before any political action could take place? Nowadays, is more research in ecology or climate science a sign of resistance, or obedient conformism[122]? We have had 50 years of intensive research on climate change and the biodiversity crisis. Never has humanity known so much about what is to come if it does not alter its course. We thus join colleagues claiming that time has come to change tactics[122] and redirect some, or even all of our energy towards other goals than a sheer increase in knowledge[37,52,123,124].

We anticipate that the previous sections may seem provocative. Cognitive dissonance[125] shall be more comfortable; rejecting these interrogations far less costly. To some extent, the fact that scientists have embraced the knowledge hypothesis may be an attempt to solve a crisis of meaning affecting academia amid the crisis. Unfortunately, there is little time left to act. For researchers to have a positive impact, they must use their energy to revise their mode of action and collectively question how to be efficient in their fight for societal change[38,48,122,123] (Fig. 3). How, then, to change tactics? We do not pretend to know what the single best thing to do is. Evolutionary studies have shown how there may be a multitude of answers to a single problem[126], and other authors have previously provided reflections upon the various ways to engage[122,123,127]. We propose that three interconnected goals be pursued: (1) reducing the environmental footprint of research[119], (2) engaging in actions that encourage or provoke systemic change and (3) considering a degrowth of research activities while aiming at more democratic, meaningful science. To do so, radical changes may be implemented both within professional and personal spheres[128,129] (Fig. 3). As trusted individuals[130] who know how grave the situation is, it may be the duty of ecology and climate researchers to embody change as citizens and scientists[15].

For professional aspects, concrete action plans will probably depend on institutions (for example, urban versus rural settings regarding mobility aspects) or career stage. A general, immediate small step could be to stop acquiring new datasets and focus on analysing the available ones, from previous experiments or within meta-analyses. In the short- to mid-term, scientists could re-anchor their research locally and involve non-scientific actors[87]. The first outcomes would be a decreased reliance on fossil fuels (for example, no remote field work, which would also limit colonial approaches in conservation biology[92,93]) and more tangible meaning surrounding the addressed scientific questions. In particular, movements such as action-research aimed at co-building knowledge with local actors around a circumscribed, practical problem may be a promising breach in the right direction[131,132]. Coupling this constraint with, for example, a minimum amount of digital technology to acquire simple data (population inventories or photographs) would also reduce the footprint of research[133]. This decrease in tool complexity could facilitate the involvement of non-scientists (for example, local schools) and compel researchers to reclaim skills lost through technique and specialization (for example, naturalist abilities). Another option could be to work on the knowledge–action gap issue[116,134]. Are nature connectedness[135], changes in social norms[108,110] or collective imaginaries of alternative worlds needed to ignite engagement? In this quest, building bridges with historians, psychologists, social scientists and non-academics will be pivotal[136]. Again, sketching the diversity of what research could be in times of crisis has yet to be done. Seeing it as an exciting endeavour more than renunciation will be key to succeed.

Concluding remarks

'Understanding better to protect better' is a recurrent verse in the scientific community and beyond (Fig. 1). Without further information, it suggests that a better knowledge is sufficient to increase the likelihood of pro-environmental behaviours. In this Perspective, we highlighted the lack of proportionality in the engagement of the most scientifically aware social group: ecology and climate researchers. Several levers may prevent the emergence of more radicality in their behaviours (Fig. 2). But blaming a minority of individuals is anything but interesting, even if the social impact of a mass radicalization of scientists would probably be great. The point of discussing these hurdles is only to free space for reflexivity upon how scientists are shaped. Rather, our main goal is to question the validity of the knowledge hypothesis and its ensuing arguments. At the very most, knowledge may be necessary, but not sufficient to provoke profound behavioural changes: there is no such thing as rational epiphany or purely rational free will. Instead, perhaps we should build upon Morel Darleux's words: "We only defend what we have learnt to love"[137]. Taking these statements into account is necessary if scientists want to have a positive impact. It entails deep, uneasy questionings about their profession, about internal tales regarding the costs (Box 3), the benefits and the need for more research. We barely touched upon these complex subjects, but hope that collectively discussing them more thoroughly and dedicating time to concrete action (Fig. 3) may help us to inhabit a liveable Earth for a little longer.

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Author contributions

Positionality statement: L.D. is a 27-year-old PhD student in ecology and evolution and intends to depart from academia afterwards. S.J. is a 36-year-old permanent CNRS researcher in ecology and evolution, specialized in phenotypic plasticity and dispersal. H.P. is a 59-year-old permanent CNRS researcher in the field of phylogenomics, but has been working on the topic of scientific degrowth for 15 years. Both Staffan and Hervé have children. All three of them identify as males, live in France and do not belong to a racialized minority. They regularly take part in activism, but do not feel sufficiently engaged. All three of them deem that tackling the bioclimatic crisis is of greater importance than accumulating more knowledge. Their research has been funded by public agencies for the past 10 years at least.

Competing interests

The authors declare no competing interests.

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