

Policy seduction and governance resistance? Examining public funding agencies and academic institutions on decarbonisation research

Abbas AbdulRafiu*

Science Policy Research Unit (SPRU), University of Sussex Business School, Falmer, Brighton BN1 9RH, UK

*Corresponding author. E-mail: a.abbas@sussex.ac.uk

Abstract

Public research funding is a critical instrument in technology and social innovation. This paper explores the emerging themes and topical trends that commonly influence interdisciplinary research within a sample of global research projects, including reviewing a recent study of 1,000 projects used in the selection of expert interview participants ($n = 15$). It examines the extent to which research funding agencies and academic institutions are shifting research priorities in the energy and climate change domain. It asks: What challenges does interdisciplinary research raise? The study reveals how cross-disciplinary research funding focuses on or fails to address the themes of sustainable development goals. In addition, it emphasises policy seduction and difficulty (resistance) in understanding cross-disciplinary methods in research and how research collaborations promote (or fail to promote) global South institutions and topics. Finally, the paper recommends that research funding needs involve a broader array of stakeholders in industrial decarbonisation research, including policymakers, industries, and citizens.

Key words: climate change; energy; global South; industrial decarbonisation; interdisciplinary; research priority; SDGs.

1. Introduction

The global effort in tackling the energy and climate change crises, alongside industrial decarbonisation, is essential to achieving sustainable development goals (SDGs), resilience across societies, sociotechnical systems, and infrastructures. Interdisciplinary research funding, academic institutions, and research councils are the essential components needed to realise these efforts and address the SDGs (Romero-Goyeneche et al. 2021). In addition, studies show a need for technology and social innovation in climate change and energy transitions research (Goodman and Marshall 2018b; Moriarty and Honnery 2018; Manni et al. 2020).

According to Pino and Ortega (2018), research institutions, funding bodies, and business enterprises are critical in helping to co-create technology and social innovation networks. The authors also emphasise the need to involve other key players that can drive through external engagement based on specific geographical needs (Pino and Ortega 2018). Since climate change threat is not regionally specific, it is then crucial to consider geographical knowledge capabilities, as various innovation activities require different types of logic, which can provide different results. Furthermore, we know that setting boundaries in policymaking are as important as the governance itself because policy tends to have different incremental impacts on citizens' welfare (Fawcett et al. 2018). This paper intends to advance the sustainability transition research scholarship. For instance, the role of research funding agencies in promoting energy and climate change innovation research

is mostly discussed, i.e. within research councils or educational institutions. However, it is hardly discussed frequently in the academic literature, even though they are a significant player in shaping and reshaping transformative innovation research.

The starting point of this paper is the assumption that there has been a clear shift in research priorities on climate change and energy research over the past three decades (Grubb et al. 2017; Fridahl et al. 2020; Neumann et al. 2020). However, the ongoing reforms in some funding agencies and academic institutions on interdisciplinary research are yielding or would yield better outcomes. However, there are questions about how interdisciplinary research contributes to the energy and climate change research debate and how funding agencies are rethinking grant calls that would complement achieving the SDGs. This includes questions about the research into energy systems (including fossil fuel and low-carbon sources), climate change (including adaptation, researching drought-resistant crops, and economic resilience), transport (including mixed modes such as passenger vehicles, rail, freight, and aviation), industrial decarbonisation (including distributed generation/co-generation, process emissions, industrial feedstocks, industrial carbon capture storage and utilisation, and energy storage (including distributed storage and batteries, fusion energy, and geothermal)). Since sustainability of public goods such as infrastructure, safe sea lanes, district heating, and renewable energy, storage capacity depends partly on the research outcomes. Therefore, path-dependent energy

research patterns need to be adopted, even as the world of energy systems changes (Goldthau and Sitter 2020).

Research funding agencies serve as a fulcrum between the principal (policymakers) and the agent (academic institutions). In other words, research councils are intermediaries between government and academics to serve societal research needs. So, shifts in research priorities could be essential for generating new knowledge and technological innovations capable of accelerating the sustainability transitions. Nevertheless, the extent of funding and categories of funded research is a crucial driver in delivering the expected outcomes (Irvine et al. 1990; Torugsa and O'Donohue 2016; AbdulRafiu et al. 2022). There are reasons to believe that current efforts in restructuring the research councils in some countries could be laudable. However, it is also essential to recognise that the transition so far has been driven by the convergence of both policies (seduction) and resistance to the implementation (governance) from critical stakeholders (such as energy-intensive industries and citizens), which could result in more environmental externalities (negative phenomenon), but the emergence of new innovative technology (positive) shift.

This paper examines policy seduction through the lens of cross-disciplinary research collaboration, which is commendable, even though this is happening with many challenges. Secondly, it also acknowledges that sometimes new legislation usually truncates the policy implementation processes, which in turn may hinder the research funding body, and in this regard, public management of research funds in such that it will steer research and development (R&D) in a way that addresses our societal challenges, while the study also felt that governance resistance identifies how policymakers and researchers want to maintain the status quo/business as usual (disciplinary boundaries), i.e. conducting energy and climate change research in silos, instead of adopting corporation, collaboration, and cross-disciplinary integration in conducting interdisciplinary research as a necessary means of ensuring that research projects are generating impactful outcomes needed for achieving sustainability transitions. It is also important to note that the transition progression is equally benefiting from divergent technology and social innovation as well as a shift in economic priorities (e.g. Roberts et al. 2018; Hahn et al. 2020).

In contribution to the debate on climate change and energy transitions research, this study critically assesses the role of research institutions and funding agencies on policy and governance in shifting the research agenda on climate change, energy, transport, and industrial decarbonisation (Nurdiawati and Urban 2021; Peñasco et al. 2021; Sovacool et al. 2022). It assesses the potential for 'policy seduction' (programme attraction, validation, and value) in grant proposal calls among the research community and then analyses governance systems that evoke consciousness in achieving just transitions (Filippakou et al. 2010). It recognises the relationship between academic institutions and research councils as essential in shifting research priorities needed to achieve a low-carbon transition. Meanwhile, the UNFCCC (2016) summary report on the roadmap for restructuring did not consider the issue of funding flows for climate change and energy research for managing climate risk (Jarraud and Steiner 2012; Santarius et al. 2018; Rhodes et al. 2022). The important lesson from this study is its ability to provide a deeper

understanding of the impact of interdisciplinary research funding and the dynamics of the prioritised topics needed for achieving low-carbon transitions. This paper also draws particular attention to how academics and research fund managers respond differently to the needs of conducting energy, climate change, and industrial decarbonisation research. It reveals an essential finding: most principal investigators (PIs) and other researchers do not necessarily link their work to SDGs and broader sustainability transition. For instance, the study shows that about 78 per cent of health research funding goes towards medicines, clinical trials, and vaccines, but there is a small share for prevention, which is the public health related to climate change and/or general environmental issues.

The rest of this article is in three parts; the next section presents the research methods and analytical protocol. Section 3 starts by distilling some crucial insights to answer the fundamental questions around the shift in research priorities for climate change and energy research over the past three decades (Section 3.1). Section 3.2 explores how to transform funding agencies and research institutions going forward. Section 3.3 examines how to increase the inclusiveness of global South/marginalised research groups in climate change and energy research. Section 3.4 discusses the challenges of conducting/managing interdisciplinary research. While Section 3.5 critically examines how funding agencies and researchers are implementing SDGs and other social factors, in addition to climate change and environmental issues in funding calls. Finally, Section 4 concludes with some policy recommendations that could better drive countries towards achieving transformative innovation.

2. Research methods and analytical protocol

The study recognises that interdisciplinary research embedded into SDGs can create transformative change. The methodology involved a review of the literature and primary data collection by semi-structured qualitative expert interviews with PIs from research institutions and grant managers in funding agencies (Research Councils). The interviews aimed to characterise strategies to integrate new interdisciplinary research agendas into SDGs. The participants are experts across twenty-nine countries that are among the largest funders of research or countries with high-carbon emissions, as revealed from a systematic assessment of 1,000 representative research projects (AbdulRafiu et al. 2022; Sovacool et al. 2022b), which documented the top twenty funded institutions and the top ten funding countries, in public research institutions and funding agencies (research councils). The data set helped to determine whether shifts in research priorities are happening and the challenges researchers and funders face in conducting interdisciplinary research. This approach is in line with other studies on funding patterns for climate change and energy research (see, e.g., Overland et al. 2021). Table A.1 presents the fifteen interviews ($n = 15$) that were conducted, showing the dates, countries (see also Fig. 1), and affiliations of interviewees, while Fig. 2 presents an institutional distribution of the interview participants.

The systematic review of a previous study by AbdulRafiu et al. (2022) reveals the data of the top twenty academic institutions that are most funded and the top ten coun-

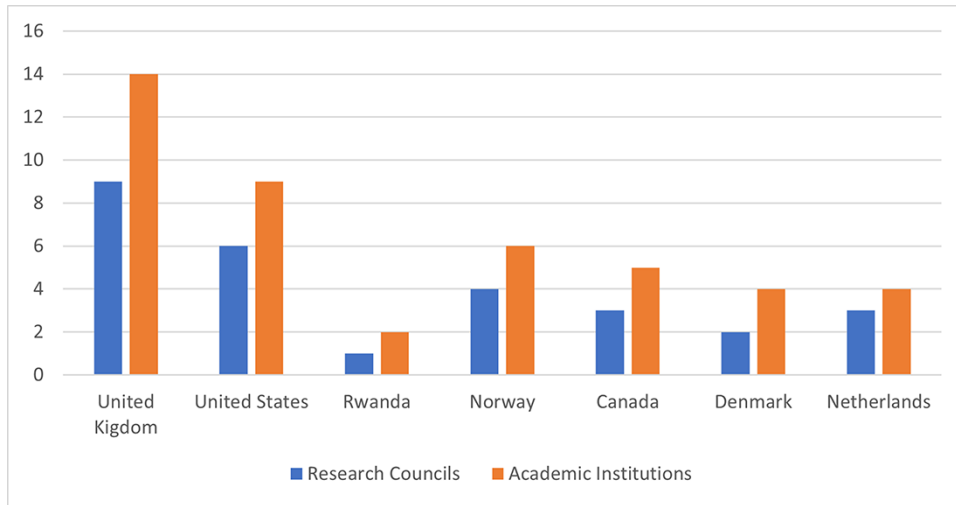


Figure 1. Research councils and academic institutions that participated in the expert interview.

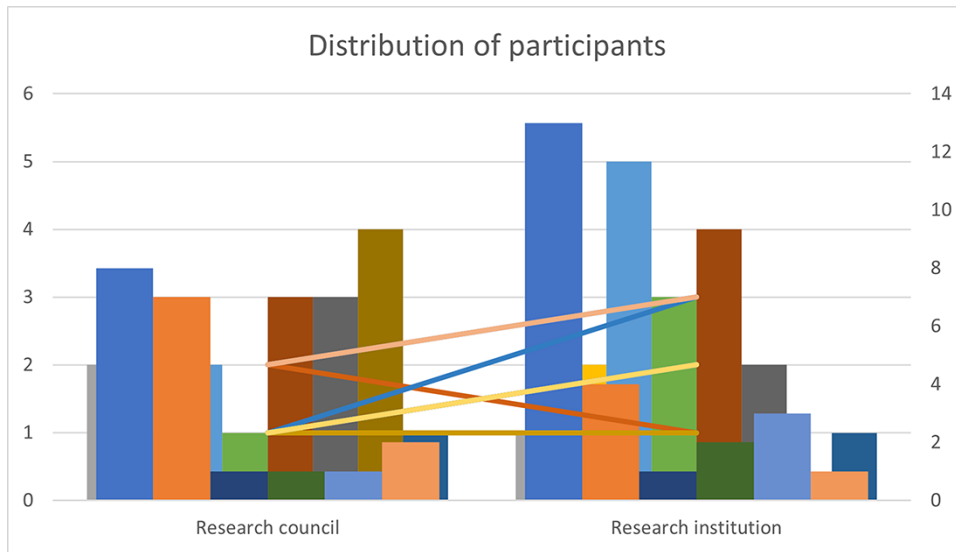


Figure 2. Streamgraph of participant's distribution across institutions.

tries that are funding research on climate change, energy, and industrial decarbonisation. The result from the data then informs the selection of the interview participants from research councils and academic institutions. Out of a pool of fifty invited experts, the representative fifteen interviewees showed appreciable interest in participating in this study. The interview results are then analysed and represent each data of the respondent number (e.g. R_01).

3. Results: analysing core themes from the transcribed data

Each theme in this section draws from the analysis of research data evidence provided by interviewees, who are grant managers with varying roles within the policy formation process in different research councils, researchers, and PIs in academic institutions. The interview participants provide important policy decisions that could reshape the sustainability transition research.

3.1 Examining shifts in priorities on climate change and energy research over three decades

In the past three decades, the social sciences discipline witnessed a noticeable increase in funding and publication of climate change-related research. In previous decades, natural science and physical science disciplines were the main focal point recognised by the scientific community (until the mid-1980s) for analysing and raising policy consciousness on climate change and other global environmental issues (Rykkja et al. 2014; Serran et al. 2019). However, even during the 1990s, when there was a shift in social sciences research publications, the focus was primarily on economic and social impacts, cost-benefit analyses, and feasible policy options, mostly from case studies. The increase in publications can be attributed to the intergovernmental panel on climate change report and stern review, both published in 2007 (Stern 2007; Solomon et al. 2007). It is evident that a significant advancement has been achieved over the years in climate change and energy research, but the socio-economic challenges posed by

Table 1. Interview responses on transforming funding agencies and research institutions.

R_01	'Citizen's engagement is key, because these funding calls topic are written down by these European policy officers and they're not entirely expert on citizen engagement. So, we need transformation in this direction.'
R_02	'Well, they have transformed themselves, one umbrella UKRI that was a bold important step. Though I don't think it's fully implemented yet if I'm being honest, I think sometimes too often research Councils fall back into their own silos. I think it's going to take longer for the culture to shift and it's difficult, I mean it's really difficult.'
R_03	'One of the key issues is funding pattern of proper interdisciplinary research need to change, you know, because these are complex issues. So, a better understanding of mechanisms interdisciplinary funding is really important.'
R_04	'Grant calls on mission-oriented innovation policies, say applied research that would serve new industrial development. So, we have tried to connect with different organisations, which is how I expected the Research Council to tailor their funding.'
R_05	'Transition is already happening in research councils, they have learned how to come together over time, and now we have the UKRI, which brings them all together. However, there is tension between them, the disciplines wanting to pull back their control and say no, we must have funding for my discipline. I think that tension is still there.'
R_06	'From the UK perspective, the introduction of the global challenge research fund is somewhat neo-colonial because they are not thinking about sustainability and the equality of those partnerships. They need to find ways to avoid replication and duplication of projects in different countries.'
R_07	'One recent bid I applied for was on interdisciplinary settlement centre, where there was a strong remix to social scientists. However, when we got the reviews, they were reviewed by engineers and economists, and the social sciences have never been at the forefront.'
R_08	'I still think there is much to be done structurally and institutionally in the funding bids. I do not think that universities are set up to be able to respond to interdisciplinary calls that well. It is generally hard to do cross-faculty, cross-discipline research funding proposal calls. However, we can start, for example, with joint PhDs between faculties, there is a real need for the university's practising cross faculty research.'
R_09	'I think it is essential that they keep the balance between the bottom-up research and mission-oriented research, and deal with approved working method, I mean all the internal mechanisms on how they work with evaluations and review of funding applications.'
R_10	'We need to go deeper in some ways, and we need our universities to encourage young people coming into science to be educated to do science differently, instead of very reductionist approaches. We need cross-faculty PhD.'
R_11	'I think if we need to solve what is fundamentally challenging the world, there is a significant need to coordinate research initiatives, and a certain number of countries or organisations should be the leader of such global research direction.'
R_12	'From a research council point of view, it is very much building interdisciplinary community and research network which kind of understand the challenges, that is the way to approach the future challenges.'
R_13	'We need transformative investment bundles; we need more coordination or collective action across the funding systems, but it is still fragmented. This also applies to universities. There is a need for a global body for research coordination in universities.'
R_14	'Perhaps, regarding other areas where things have changed quickly, I mean COVID-19 pandemic and vaccines research might be an interesting scenario to try to draw some lessons from within two years in a way that energy research has not.'
R_15	'Clearly, research frameworks are influenced by the incumbent players in the energy system research. But, to some extent that is inevitable, because more need to be done to accelerate it.'

climate change require some shift in research on behaviour and technological innovation (Weaver and Miller 2019).

The literature reveals that research funding on sociotechnical transitions is gaining attention from research councils and academic institutions. Some experts presented Table 1 said that most researchers and funding bodies presently acknowledge the importance of shifting research priorities and interdisciplinary research that considers societal needs. For example, a respondent from a funding agency (R_01) said, 'Our research projects now involve research institutions and a mix of innovation ecosystem actors and stakeholders that are nearer to the citizens.' This shift in attention reflects a significant increase in behavioural changes by stakeholders that is commensurate with the level of investments in research activities over the longer term (Rietig and Laing 2017). Another view from a PI was that there is a shift in research focus, implying that researchers are now taking an interdisciplinary approach. For instance, R_02 as with others mentioned that the ongoing initiatives like interdisciplinary grants could fundamentally change research funding. 'I think we have seen a significant shift towards interdisciplinary funding. Recently a lot of the more significant initiatives that (our programmes) are promoted are about crossing disciplinary boundaries, especially on digital technology.'

Digital systems drive the current innovation processes, and therefore transforming research activities that would promote

collaboration to accelerate transformative change in energy systems research interdisciplinarity is critical for transitions to occur (OECD 2021). Shifts in research priority by funders were echoed by the R_03 as with others that, 'There has been a massive shift by research funders. Although much funds are being put into clinical research, whereas climate change impact is primarily on population health. Nevertheless, the health funding for environmental exposures is still fairly limited as we speak.' According to Hoffman et al. (2020), there is a need for research funding to focus on more global health challenges to fill essential gaps identified in the future. Funding calls should address real problems, i.e. certain diseases and circumstances that asymmetrically influence disadvantaged populations left behind (Hoffman et al. 2020). The relationships between transformational responses (a system of addressing socio-economic and ecological challenges) and transformational impacts (the process of making a positive impact) are seen as fundamental in limiting the long-term challenges of climate change and energy transitions (Weaver and Miller 2019).

Although shifts in research focus and priorities began in the 1990s, evidence of the needed shift in setting research priorities towards social sciences is only starting to emerge. For instance, during the interviews, R_04 noted this about the shift, 'There is a big shift towards clean energy research away from fossil fuel, though that as now happened a long

time ago. So, there is a current shift in how clean energy technology or clean energy research is carried out interdisciplinarily and collaboration with industries. I guess there has been a trend towards conducting more social science-based climate change research.' This finding corroborates Spanos (2021) on partnership arrangement that there could be more opportunities for businesses with meagre innovative experience and resource constraints to learn how to conduct climate and energy research through collaboration with research institutions. Such knowledge may be unavailable to them where collaboration does not exist (Spanos 2021). Relatedly, the need for new technology assessment seems to be a variable option for determining whether a technology transfer influences global research funding (Bulli and Somogyi 2011).

Aside from the varying technologies needed in achieving transition, this paper also reveals that the transfer of appropriate technology requires a change in lifestyles. The R_05 as with others mentioned that the initial approach was towards developing technology that would tackle climate challenges; however, studies reveal that socio-economic research is equally important, which is now shaping the research direction. 'Absolutely, this is the big change I have noticed since the 1990s. Then, a tiny community of energy researchers did not pay much attention to climate change; rather, research mainly focused on developing technology. At that time, some economists were active in the market reform debate. However, there was not any interdisciplinary research community. We now have an interdisciplinary research community, although still quite fragmented.' Thus, the study observed that there is some level of absence in interdisciplinary research collaboration in energy and climate change research, especially among socio-economic disciplines, because some current energy research topics focus on engineering, while other fields of research collaboration mainly involve studies on techno-economic modelling of markets, with an interest in the intensity of the energy supply side (Schmidt and Weigt 2015).

However, it is clear that integrating sociotechnical (which is understanding technological and social change) and socio-economic point of view is a requisite for identifying socially equitable, technically feasible, and financially viable transition scenarios (Schot and Steinmueller 2018; Delafield et al. 2021). R_06 supported this position, stating that achieving transitions on low-carbon energy needs to reflect the trade-offs and multiple interactions highlighted by the energy quadrilemma (cost, environment, security, and job opportunities) (Olabi 2016). 'I guess some of the shifts are conceptual. So, for me, the resource nexus was a useful starting point for the research and led to some interesting findings, but there are these critical things that we need to keep asking about how these conceptual shifts in research are impacting the environment. This is a critical question about those shifts adding value to the research agenda.'

Ultimately, the views of R_07 were that there are shifts, as health research funding agencies are now beginning to fund climate change and health issues. 'Well, there has been a massive shift by research funders towards climate change impact on population health; previously, they were not particularly interested in the impact of climate change. Talking about health research funders, they were not particularly interested in Climate change before now.' In addition, R_08 as with others affirms that research councils are working to balance the

environment, e.g. research on energy security, energy cost, change in societal norms, and job opportunities, not just energy and climate technology. 'I would say, there has been a shift towards not just a technology focus on energy and climate change, but also more thinking about the social implications. I do not think we are fully there yet, but I would say there is a switch to recognise more societal impacts and understandings of the energy system.'

This suggests that respondents are aware of the shift in research agenda, from technology development to innovation that addresses social challenges, alongside the need for behavioural change. However, a study by Williams et al. (2020) reveals that human-induced adaptations are often constrained by the inadequate understanding of the impacts of current efforts around the issues aimed at tackling global challenges to make informed decisions. This presents problems in management across research, policymakers, and societies. There is an urgent need to pay particular attention to where limited resources should be channelled to provide needed research and knowledge and build skills/capacity for societal needs that would drive transitions (Williams et al. 2020). Recent studies also recognise the potential impact of coronavirus disease 2019 (COVID-19) on climate research and energy politics, which assumes that if the response to climate emergency has been approached the same way as the pandemic, then more could have been achieved in low-carbon transitions (Kuzemko et al. 2020).

A recent study by Hao and Shao (2021) contributed significantly to our understanding of how population, in addition to political, social, and economic factors, drives low-carbon energy research, development, and deployment (Hao and Shao 2021). Respondent R_09 stated that funders in countries like Denmark now use different models to encourage collaborative research through funding calls. 'Presently, in Danish research funding, especially my research council, it encourages synergies between research areas and linking different disciplines on funding energy and climate research. This is on the front burner, from what I do it is all about climate, basically. Research proposals of high quality that have to do with energy and climate research are mostly funded.' There are often debates around the mechanisms of allocating funding for performance-based research funding systems and the peer review-based research assessment (PRBRA). The implementation of the three models in funding allocation varies across countries, which includes the Metric-Based Assessment. There are indications that historical allocation and input indicators still dominate research funding methods. However, in some countries, performance-based measurement has possibly been implemented in funding allocation. According to Geuna and Piolatto (2016), the UK and Italy are the only two countries possibly implementing PRBRA systems to evaluate research grant allocation (Geuna and Piolatto 2016).

For instance, respondent R_10 mentioned that it is probably taking too long to arrive at solutions for our current climate crisis. 'I think there has been a real step change, but it frightens me a bit that we were doing it 25 years ago, and we did not make many changes. For example, we now use the peer review-based research assessment method, reshaping research direction interdisciplinarity.' However, the view from R_11 is that government investments are shifting from energy security and economic cost to research and innovation on cleaner technology. 'First of all, 30 years ago, research was

only driven by energy security, but last five years, our government is even reporting on what they need to do to reduce carbon emissions, and so the government have been increasing its investments in research, innovation and development of climate technology and climate innovation to reduce carbon emissions.'

Mazzucato and Li (2021) suggest that the state should take part in financing research based on the belief that recent scientific research would go a long way in enhancing the R&D of the firm. They then acknowledge that in the decarbonisation of industry, scientific research contributes substantially and restores activities that promote the intensification of scientific knowledge (Mazzucato and Li 2021). Chen et al. (2018) argue that advanced economies have adopted innovation as a driver of growth and development. Meanwhile, developed economies, such as China and South Korea, continuously push towards a low-carbon industry through innovation to achieve their comparative advantage (Chen et al. 2018). However, the potential shift in the argument is vital in response to the broader challenges of validating sustainability transitions. The current conversation can instead centre on how best the world climate dialogue is accepted; Rudiak-Gould called this 'reception' studies (Goodman 2018a). This study further reveals a compelling shift in research priority; respondent R_12 noted the fundamental shift that no single approach or a single research council can own an area; it is only through collaboration that we must solve real-world problems. 'So, to me, I have got traditional understanding now that to reach this planetary, societal goals and targets, scientists cannot sit in a room and then come up with the answers. Collaboration is needed among disciplines, industry, and citizens', presumed to be the fundamental shift.

In another instance, R_13 noted that the real challenge now is the lack of linkage of the systems—e.g. the connection between the energy and mobility systems and the food systems. 'Well, there is a clear shift, if you look at investment in renewable energy. I think because in the deep transition research we talked about surges – the first deep transition, connected to industrialisation and fossil fuels, and the second deep transition is connected to renewables, low carbon mobility and food system.' Goodman et al. (2018) argue that increasing the understanding of science and socio-economic implications of climate change 'complications' on energy production threatens the assumption that new investment in fossil fuel extraction for growth and prosperity and the consequent emissions growth is worrisome. These challenges have surged the negative externality into broader social and economic fields that need long-term solutions, continually requiring a wider collection of social research fields, and raise new questions onto the research agenda (Goodman and Marshall 2018).

Oppositely, Sovacool et al. (2020) argue that understanding the relationship between science, technology, society (STS), and the natural environment is a fragment in science and technology studies. Meanwhile, the process that informed scientific knowledge and technological design derived and conjoined with networks of social institutions from science and technology studies (Sovacool et al. 2020). Responding to these, the R_14 pointed to similar views that systemic changes, about how the research community will achieve complete system change away from current structure standards. 'I think we have moved from discussing how we do incremental change in the energy system to how we do systemic

change. For example, how do we get a completely different energy system based on zero carbon sources within the standards of infrastructure change within a quite short period.' It was an exciting view by R_15 who said that shifts in research priorities are happening, but what is required now is the connections of all the systems, i.e. energy, mobility, food, water, and health. 'For me, we have achieved shift, but the real challenge now is the connection with all the systems, so the connection between energy system and mobility system connection with the food system is what we should look at going forward.'

Ultimately, the implication of this is the need to emphasise the importance of innovation frameworks and the need to influence the direction of public policy towards the integration of vulnerable groups into innovation processes (Daniels et al. 2017). Relatedly, other scholars too recognised that actors often neglect the incorporation of broader societal objectives in academic research, or they tend to leave it to the projects. For example, technology actors usually focus on developing, testing, and optimising technology but neglect embedding wider societal goals in STS research or leave it to a later stage (Schot and Geels 2008). Carbajo and Cabeza further observe that the disparity between fields of research and research ecosystems can stimulate responsible research and societal impact (Carbajo and Cabeza 2018). Utilising the three analytical scales—micro, meso, and macro—is considered a factor for operationalising energy research and policy (Sovacool et al. 2019).

3.2 Transforming funding agencies and research institutions

With so much on the line, taking urgent action against climate change is essential, with actionable steps informed by scientific and social sciences evidence. Studies suggest that research and innovative technologies that will catalyse energy transitions and influence change in societal norms, which will create behavioural changes, are critical in achieving sustainability transitions. Therefore, climate change stands apart from other social challenges not only in its scale and urgency but also in its complexity (Fankhauser et al. 2019).

In achieving our research needs, the literature dealt with how governments worldwide, especially developed countries and countries with the most significant carbon emission, have invested significantly in research through their funding bodies. However, these investments in scientific and social science research look like drops in the ocean compared with needed actions to accelerate low-carbon transitions. For example, through its publicly-funded Research Councils, the UK Research and Innovation (UKRI) has invested around £3 billion in supporting R&D and innovation per annum (pa) from 2016 and an additional £2 billion by 2020. However, analysis of the impact of UKRI research funding is said to be partial to a large extent, and some are case-based, which makes it challenging to create the needed impact. Furthermore, even though, in the past, attempts have been made for measurable assessments of the impact of UKRI funding, available information is limited in the evaluation of the impact of innovation (Vanino et al. 2019). Therefore, low measurable tools for research impact evaluation raise some salient questions about whether the current focus on innovation, R&D, and policy by research funding bodies is commensurate with current challenges that climate change poses (Cohen et al. 2019; Coilin et al. 2020).

Table 2. Interview responses on the inclusiveness of the global South in climate change and energy research.

R_01	‘Yes, many of the consortiums applying for a horizon 2020 grants are from western countries, even though some of the money goes to global South, some countries in African and Asia. I can tell you that about 90% of the projects are led by PIs from so-called Western countries, this is because the consortia leader has to be from a European country or organisation.’
R_02	‘If I was from the global South, I would be really angry, to be honest about the many dimensions. Researchers from Europe and the US or Europe and UK doing research in the global South, by just involving academics from there as merely research assistants. I agree that there is the issue of capability in the global South, but there are many who are also excellent in research design and methods. I have worked with some of them.’
R_03	‘Well, obviously, the funders make stipulations around their funding, but also it has to do with capacity building. So, you know, supporting institutions like the African Academy of Sciences, identifying more fellowships for early career researchers to get the training they need could bridge that gap.’
R_04	‘Ok, a good starting point is that. PIs can be international or nationally in Norway, but it has to be that a PI is connected to a Norwegian institution because the institution has to be the project’s product owner.’
R_05	‘Yeah, the high-level answer is building capacity, which is easier to say than to do. It is just that the capacity tends to be relatively small compared to the scale of the challenge. So that is one thing I think about regarding what can be done. I also think it is partly about funding rules.’
R_06	‘It’s really a good question. How do we ensure that the funding is there within the global South, especially in African countries so that academics there can lead, rather than them being led from the UK or other western countries, and that goes into the research funding landscape. Although I think this idea of capacity building is problematic.’
R_07	‘I think it is imperative to extend more research funding to the global South, especially Africa because that is getting to the heart of the problem unless you tackle the attitudes which go back to the days of colonies. Unless we tackle these power structures, the problems will not change. There should be equal partners and equally funded.’
R_08	‘I started to think about how we might do it at this stage, and there is probably more work to be done on ensuring that the way research is done, and the wheels, is all-inclusive and potentially the framing of the research.’
R_09	‘That can be challenging because, if you look at the EU programme, it focuses on the EU, and other parts of the world. The US, you will see they are at the centre of gravity. I have been there, I do not know if there could be co-funded programmes or something like that could be an idea.’
R_10	‘This is very interesting question and a horrific to see very few researchers especially from Africa involve in climate change and energy research, compare to their population. So, really, I support a complete reversal of the funding system, so that we wouldn’t be able to get involved in research that has to do with global South, unless it was being led by somebody from the global South who understood and knew the problem but felt that we maybe had something to offer from our own experience.’
R_11	‘What happens in case some skilled people in South moved to North, which I call brain drain because of instability in some of those countries. Maybe at the high level, we can co-create better possibilities for them, so global South, especially Africa, can be encouraged to promote research funding within their continent.’
R_12	‘Creating equitable status with no restrictions with partners, but also one of the benefits, for now, is working with some of the partners that were having specific fund so obviously the IDA fund which kind of drives the capacity building, so it is builds like intellectual capacity but also sort of class in terms of building an infrastructure.’
R_13	‘So, I think researchers from the global South need to build more self-confidence, equal knowledge infrastructure, and more available resources. So, in the end, we need to transfer skills and knowledge.’
R_14	‘We would need a considerable proportion of funding to be devoted to capacity building in the research institutions of the global South for that to make an enormous difference. The larger and industrialising countries should involve the global South in setting their research priorities and having their research programmes fund them.’
R_15	‘I think there should be a balance between mitigation and adaptation research. There should be more of a focus on the global South in adaptation research.’

However, the views by experts in Table 2 was that despite the ongoing reforms in some research councils encouraging working together, their engagement is still low. Notably, R_01 said that there is still a low rate of engaging critical stakeholders in the research agenda. The needed research stream is beyond scientists, funding bodies, and their research institutions; instead, there is a clear need to involve the citizens, industries, and civil societies, where funding calls should be impact-based, rather than competitive (Kythreotis et al. 2019). ‘Citizen’s engagement is key because in this funding calls topics, these European policy officers write down the topic, and they are not entirely experts on citizen engagement and climate change. So, we need transformation in this direction.’ Meanwhile, R_02, when responding to this question, said that there is still not enough air for amalgamated research councils to make current reform work. Further said, ‘Well, they have transformed themselves, one umbrella UKRI that was a bold important step. Though I do not think it is fully implemented yet, if I am being honest, I sometimes think too often that research councils fall back into their silos. I think it will take longer for the culture to shift and it is difficult

to work together.’ However, R_03 responded differently to this question because issues around low-carbon transitions are complex, and individual research councils cannot address them. Therefore, there is a need to commission a study on the mechanism of interdisciplinary research that forms a new framework for sustainability transitions research. ‘One of the critical issues is funding pattern of proper interdisciplinary research need to change, you know because these are complex issues. So, a better understanding of the mechanisms of interdisciplinary funding is fundamental.’ Experts suggest that more policy intervention is needed to achieve interdisciplinary research collaboration.

Perhaps unsurprisingly, some studies argue that funding agencies should be biased absent and should be keen to provide funding to teams with definite attributes (teamwork and innovative collaboration) because there are possibilities for such a team to generate research with high impact (Winkel 2018). More so, other literature suggests that funding organisations should be flexible to research groups with the considerable distinction of knowledge because there is a likelihood of higher success for such teams (Banal-Estañol et al. 2019).

In support of this, [Viner et al. \(2004\)](#) reveal three models in an attempt to describe the process of funding distribution: a 'political' model, in this case, the best scientists bring into play their supremacy over the distribution of resources; the second is an accumulative advantage model, and the third a merit model ([Viner et al. 2004](#)). However, the biases and supremacy sometimes exhibited in funding allocation could also pose some element of risk to innovation and R&D. Since the public sector is significant in funding high-risk research, empirical evidence exists which shows that effective strategies for managing risk within research councils are lacking ([Goldstein and Kearney 2020](#)).

Prominent scholars continue to argue that policy independence could be difficult to perceive in funding agencies, and seduction in policy to perform their functions in this context under government accountability procedure could also be challenging. Perhaps universities must also hold on to the maximum autonomy constant with that accountability framework ([Filippakou et al. 2010](#)). Other academics show concern about sincerity or non-sincere reviewers who do not have a strategic concern about the research outcomes when reviewing grant proposals ([Bayindir et al. 2019](#)). Interviewees noted below in [Table 1](#) that research councils should be more concerned about the research results through interdisciplinary funding instead of focusing on their silo funding bodies. Fundamentally, there is a need for research network building, cross universities, cross-faculty PhD training, and research coordination across countries.

Notwithstanding this dearth of evidence owing to the research coverage, some interview participants in [Table 1](#) underscore the vital role that cross-disciplinary collaboration can play in addressing our current challenges of climate change and the decarbonisation of our lifestyles. It is evident that research processes are linked to the research environment, favourable or not. Some grant applications are critical for the advancement of specific disciplines, but it is challenging to get funded, possibly because of the standardisation and predominance of grant funding ([Laudel and Gläser 2014](#)). For example, [Hopkins and Rudmik \(2016\)](#) reveal that there has been disproportionate underfunding of chronic rhinosinusitis for consecutive ten years in the study carried out in the USA, UK, and Canada despite the health challenge it posed ([Hopkins and Rudmik 2016](#)). In another instance, several studies in Germany, the UK, and the USA equally show that funding based on specific projects has gained the interest of funders in the past decades. This shift is part of a broader reform in funding agencies and research institutions, which reflects the increase in trust from policymakers and other stakeholders in the management of scientific research. The extent of project impacts can also inform policymakers for further design of funding instruments. More so, using project properties is also another dimension that could be used by funders ([Buenstorf and Koenig 2020](#); [Bloch 2020](#); [Thomas and Nedeva 2012](#)).

A critique from the interview responded that a specific funding process tends to favour and support some particular concepts, especially health and medicine ([van Bekkum et al. 2016](#); [Reale 2017](#)). However, this does not impact public health research on air pollution because research in these areas has received less attention, despite its impact on population health. In addition, there are questions about how research streams, and relationships between funders and universities,

can be consequential to interdisciplinary research initiatives, and evaluating the successes and impacts of the grant is difficult. There is also a phobia that the early career researchers rarely attract one or two grants or no grant at all ([Lyll et al. 2013](#); [Baczkiewicz et al. 2020](#); [van den Besselaar and Sandström 2015](#); [Overland and Sovacool 2020](#)). An increasing number of actors from industries and foundations also show concerns in university research. This growing number of academic captains is resulting in a 'winners take all' trend in research funding. So, the possible consequence of this trend is the centralisation of funds in large projects and centres to the detriment of smaller or/and individual earlier career researchers and issues around the valorisation process of funded research proposed from studies ([Munari and Toschi 2021](#); [Bloch and Sørensen 2015](#); [Hoffman et al. 2020](#)).

3.3 Inclusion of global South and marginalised groups in climate change and energy research

Despite the global urgency for research, development and deployment of renewable energies, electrification of transport, and decarbonisation of industry from the global North. There is a need to equally consider and exploit the comparative advantage of the global South for research into adaptation and adaptive crops, however, recent evidence has shown that the needed climate change and energy research landscape in that region are still sparse. Overall, this study argues that there is a need to remove barriers between researchers globally through even distribution of transitions research funding—if the world must solve the current challenges posed by climate change. Furthermore, this suggests that disregarding the research potentials between countries in Africa, South America, and many South East Asian countries amounts to a loss of opportunities that the world could derive from their diversity ([Apfel et al. 2021](#); [Fekete et al. 2021](#); [Galvin 2020](#)).

The views of some respondents, see [Table 2](#), when asked about how to create more inclusiveness for global South researchers during the interview said that the global South needs to be more involved in climate change, energy, and transitions research, even if it requires that the developed economies also donate research funding in the form of aid. There is a general agreement by the interviewees that there is an existing capacity in the global South; about 89 per cent of interview participants suggest that the global North needs to invest more in building the capability of researchers and research infrastructure that can translate research outcomes into innovative technology and socio-economic development in the global South region.

A study suggests that in some instances, developing nations are moderately more worried about the condition of their environment than developed countries ([Adugu 2020](#)), even though there are arguments about the capacity and scientific capability for handling challenging environmental issues that require research findings to inform policy. A recent study on Africa's science, technology, and innovation (STI) argues that the capacity needs for policymaking are still inadequate. The findings recognise that, despite the insufficient funding from the African government for STI research, there are some research capacity and analytical capabilities that could provide African science granting councils and research institutions with information for evidence-based policymaking ([Chataway et al. 2019](#)).

It is notable that research outputs in South America and Latin America are anticipated to be per global best practices in terms of quality, relevance, rigour, convincing, and application. Notwithstanding, sparse R&D resources, compounded by socio-economic problems, constitute a considerable barrier to accomplishing research objectives in that region (Tijssen and Kraemer-Mbula 2018; Bautista-Puig et al. 2019). There is more emphasis on the capability and capacity of researchers in the global South, which need to be built. Some studies also suggest that research infrastructures are inadequate, especially in Africa, for academics in this region to carry out cutting-edge research.

The normalisation of parameters is essential to reveal the research focus. For example, a study on Africa's research outputs finds that there are publications by African and Asian universities that are highly-cited worldwide. Surprisingly, to a large extent, the share of highly-cited publications with 'no cooperation' implies the presence of niches of local excellence independent of external research partnerships (Ellis et al. 2015). Meanwhile, there are assumptions that research councils are now reviewing their funding patterns and approaches to a large extent in a format that better increases their coverage and impacts from funded research (TETROE et al. 2008). Other studies allude that innovation research is happening in the global South. However, there is a lack of persistent inflows and outflows of research outputs with measurable impacts to accelerate and expand local innovation and the markets (Vallejo et al. 2019).

3.4 The challenges of conducting/managing interdisciplinary research

There are growing discussions about 'entangled stakeholders' involvement in scientific research, comprising businesses, policymakers, academic and civil society collectively driving innovation R&D management. Recent literature such as Katoh et al. (2021) shows a greater possibility of producing high-impact scientific research involving diverse teams (Katoh et al. 2021). Remarkably, a study by Lanier et al. (2018) reveals that the processes involved in organising a research team and comprehending the expected changes that may occur in team size due to diversity in the core and the expanded teams could be difficult (Lanier et al. 2018). However, at the beginning of interdisciplinary research, it usually takes time for teams to become productive, as members need first to invest some time to establish trust, shared identity, and effective relations before they become efficient and productive. Perhaps, some teams tend to be more efficient than others; for example, there is a need to develop a routine collaboration, which may appear to elongate the membership of such a research team. It is established that interdisciplinary work is incrementally necessary if we must find solutions to present global problems, and co-creation of practicable knowledge can be challenging, even though there is an urgency to adopt an approach that is interdisciplinary even in ensuring workable policy (Katoh et al. 2021; Lanier et al. 2018; Karunasagar and Karunasagar 2016).

Findings from interviewees in Table 3 support these views from the literature as they identified understanding disciplinary language to be a major challenge faced, while others point to how short-term funding does not optimally support interdisciplinary research. The experts emphasised the need to break barriers among disciplines and allow more time to

understand different approaches before research teams meet necessary expectations.

The last decade witnessed researchers turning to different disciplines from those they specialised in. However, increasingly, they begin to allude that dissimilarity in how the interdisciplinary community can understand, access, process, and communicate insight from scientific fields different from their background is challenging (Rodela and Alašević 2017). Some studies categorise these challenges as (1) the research institutions that specialised in core areas might find it difficult to deviate and (2) the process of publication of interdisciplinary research and funding policies are cumbersome (Schuitema and Sintov 2017). Others recognise that current societal complexity requires social and natural sciences to provide solutions, involving collaboration between various stakeholders, e.g. policymakers, researchers, engineers, and firms (Ignaciuk et al. 2012). However, tension exists between these various stakeholders (funding agencies and research institutions). Regardless, the interviewed experts in Table 3 mentioned that long-term funding, capacity to listen to each other, and learning new research approaches are essential for generating new knowledge needed to address the fundamental challenges the world over that we are currently facing imposed by climate change. Some said a fundamental tension between disciplines makes it difficult to achieve success in interdisciplinary work.

Typically, researchers face challenges that are conceptual or structural. The conceptual challenges involve perspectives held by natural and social scientists, which results in high expectations from natural scientists to solve problems. Meanwhile, the structural problems are inadequate institutional incentives for interdisciplinary work, temporal and spatial disagreement of social scientific data, and, lastly, friction in communication among disciplines, as well as how to overcome paradigmatic differences (Sievanen et al. 2012; Gardner 2013).

3.5 Examining how funding agencies are actualising SDGs in the climate change research agenda

The SDGs adopted in 2015 by world leaders highlight how intertwined our societal challenges are, with the breakthrough in one SDG affecting others. These SDG fundamentals invite a deep consideration regarding the options and directions for public investments in scientific research and knowledge generation. Accordingly, to achieve the SDG targets, it is paramount to shift the value of knowledge and use it to promote fairness, flexibility, impartiality, and transparency in research and innovation development. With this fundamental principle, this article further argues that interdisciplinary research funding would be a driver of achieving SDGs, and there is a need for a paradigm shift to break both conceptual and structural barriers that may hinder it. Therefore, there should be a significant shift in funding structure that strengthens interdisciplinary research and the research funding agencies. Citizens and leaders have an opportunity to harness this window of interdisciplinary research to resource the implementation of SDGs and achieve the target (Herzig Van Wees et al. 2019; Nhamo et al. 2020). However, during the interview, some participants, Table 4, expressed frustration over the inability to include non-academic stakeholders in grant proposals because

Table 3. Interview responses to challenges of conducting an interdisciplinary research project.

R_01	'In my research council, I have been involved in some horizon 2020 projects with water institution in the Netherlands. It was quite challenging to be honest, because first of all, you have many different countries in this project, and cultural things were sometimes difficult, and I think it is more difficult sometimes if there are many different disciplines within the project.'
R_02	'One big challenge I can talk about is the time taken to understand each other's language and methods. Moreover, by the time the interdisciplinary team comprehends themselves, it is probably one year already, and most of the fundings are for three years. So, more funding time is required to administer cross-disciplinary work.'
R_03	'Yes, it takes much time to communicate, you know there is a different language, and there are different approaches to producing evidence. So, that is challenging. We are a relative success, but there is much bad interdisciplinary work. So, like climatologists will do a health study without including people from social science, which will not be very good.'
R_04	'Well, I think managing is not a problem; things work out pretty well but evaluating is a challenge. The present situation is figuring out what type of experts will evaluate proposals. Evidence shows that projects come off worse. Where grant's proposal evaluations when they are interdisciplinary do not quite necessarily meet the expectations very well.'
R_05	'I think one of the big challenges is requiring or allowing enough time so people of diverse disciplines can be brought together to understand each other and come up with a common understanding of how we are going to address a particular question. I have tried working with the wrong people, and you end up having the same conversation again, working in parallel.'
R_06	'There are many challenges, you know, when we compare engineering with human geography, we not only have different methods and concepts, but we sometimes fundamentally see the world differently. However, when we come to the interdisciplinary publication, there come challenges, but we begin to learn daily.'
R_07	'Because everything takes a lot longer than straightforward, you know hypothesis-driven natural science. Therefore, you need to be patient, in terms of academic production.'
R_08	'I think there is a real tension between disciplines that creates problems I also find these endless debates of those tensions, and if you look through one theory, for example, there is sometimes not a willingness to look beyond that feeling.'
R_09	'In my research council, I have not managed interdisciplinary myself, but what I hear from our research institutions is that it can be challenging because you researchers with different perspectives and sort of, to put it on edge, you can say that everybody has their perspective and they want to do it their way.'
R_10	'I think, everything on interdisciplinary need time to understand by team, therefore, you need to be patient, in terms of academic production. So, longer research funding may help.'
R_11	'I think, some of the main challenges, we have is to build is team spirit needed or team understanding needed, let us say to bring the disciplines together without taking a long time to understand each other's language.'
R_12	'The challenge can be around learning new approaches or what I have had certain privy to conversations where someone says, well you cannot do that because that fundamentally disagrees with everything we are doing. Essentially, the other party is saying, well, no, you have to do it. So it is about, I suppose, shared goals and trying to understand the framework in advance.'
R_13	'Yeah, I think the incumbent funding strategies of 2-3 years of project funding are not helping interdisciplinary research because you need more time and more platforms to get going with different individuals from various disciplines.'
R_14	'So, there is a definite tension there, the main one it is about getting people to work together and, frankly, some people will never do that they want they are happier stuck to their discipline, they are happier doing materials research.'
R_15	'The main challenge is to get people to listen to each other and to understand each other, not simply to revert to their disciplinary way of thinking. Because when understanding the difference between energy and power or energy and work in that sense, they are thinking like a physicist; that is not the only way to think of it. So, interdisciplinary research is harder.'

they believe that could change the narratives about research impact.

Recent studies found fragmentation and decentralisation in response to the COVID-19 pandemic. As a result, there are calls for a review of SDG-governance approaches and identifying four priorities that could usher in a new research approach (Meuleman 2021). The goals are central to human development, and a new approach to knowledge management is equally central to this agenda; thus, funding institutions and universities could play a significant role in contributing to achieving these goals (Romero-Goyeneche et al. 2021). This was the view of Maksymiv et al. (2021) on how interdisciplinary research on bioeconomy contributes to the achievement of some pillars of SDGs (Maksymiv et al. 2021). There is also a clear emphasis on the need for science evidence-based approaches to implementing SDGs, which policymakers now see in implementations as coherent, integrated, and simultaneously challenging (Allen et al. 2018). The views presented by participants in this study in Table 4 was that if countries must achieve the SDGs, then research funding calls should begin to integrate it into their programmes because the open competitive calls do not work when addressing the SDGs.

The various views expressed by experts and policy leaders in the interviews assume that research institutions with their hybrid knowledge, collective goal, and research are critical factors in tackling these current challenges, which can further enhance the achievement of targets and ambitious goals (Gratzer et al. 2019). Although solving these critical issues is beyond the scope of this paper, however, it suggests that the embodiment of SDGs implementation in research funding calls could also assist in achieving the goals.

4. Policy recommendations and conclusions

Governance demands strong public policies that holistically address the fundamental problems in the world today. In a modern context of accelerating sociotechnical, socio-economical, and socio-ecological transitions, and to remedy these tripartite limitations, there is a need for consistent institutional policy (Tzankova 2020). Innovation scholars often argue that the impacts of policy do not hang on instrument alone but also on policy design (Polzin et al. 2019). Table 5 reveals the views of experts in this study about the need for global research directionality, breaking barriers, and more citizen engagement in policies and programmes.

Table 4. Some interview comments on how funding agencies are actualising SDGs.

R_01	'I think funding agencies should have their topic calls clear in front of the project and tell the applicants that your project needs to answer to these impacts on SDGs, and that is how you will get funded.'
R_02	'There are boundaries between that research councils have to dissolve because huge boundaries still exist. They may want to deny it, but it exists in research councils. Working together is the only way to address SDG issues, and that will also create the smooth running of interdisciplinary.'
R_03	'If research councils can ensure proper interdisciplinary processes by ensuring they have the right disciplines together and then suitably funded. Making sure research call embedded SDGs implementation.'
R_04	'We have integrated the SDGs hugely into our evaluation processes and applications. So, proposals to the Research Council explain how they tie into SDGs.'
R_05	'I think perhaps to align SDGs is quite big and recognising that they are interdisciplinary. Therefore, it does not require the funders to design their proposals accordingly.'
R_06	'I guess the first thing would be a consideration of what extent the SDGs feature in the decision-making of funding bodies.'
R_07	'I suppose the question of the relationship between funders and they also need to understand what the priorities of SDGs to policymakers they seek to serve are.'
R_08	'Making sure funding mechanisms are set up that includes partnerships with policymakers whose responsibility is achieving SDGs.'
R_09	'The focus should be about the funding call and linking it to the SDGs.'
R_10	'SDGs implementation? I would just suggest that funders should be open to slightly different ways of looking at things and that trans- and interdisciplinary approaches are ideal.'
R_11	'Our fundamental problems in the world today cannot just be solved only with technology and fundamental research. So, funding that promotes SDGs will not only make research outcomes implementable, but it will also make them sustainable.'
R_12	'Important aspect is to train and build PIs that are activity leaders in the nations and in regions which are also leading SDGs.'
R_13	'The current funding system does not work anymore because it is based on a kind of open competitive grant, and many good projects centred around SDGs do not get funded.'
R_14	'To help us deliver on SDGs, we need to set our social and political priorities and construct the broader research programme accordingly.'
R_15	'Design interdisciplinary, socially, politically focused research on helping take forward the SDGs. Not to think that transition can just be delivered by having better technology alone.'

Table 5. Expert interview policy recommendations for achieving transformative innovation.

R_01	'We are seeing an increasing emphasis on citizen engagement. To improve transformative innovation, you need to understand what motivates the citizens to change their behaviour.'
R_02	'There is a need to cut and break barriers between disciplines, policymakers, industries and research institutions.'
R_03	'Longer term funding mechanisms or renewing funding are essential, and then you can support these interdisciplinary networks that will produce transformative outcomes.'
R_04	'We need to build competence on global economic directionality. So, research innovation policy in a broader sense that it is not relegated to a passive role, but to have strong directionality.'
R_05	'Probably about making sure the government system can conceive and design these transformational changes, then the finance which will often mean international finance, as well as national.'
R_06	'Cooperation around action rather than just setting goals. Therefore, attentiveness to how they are going to impact upon different groups, I think that is vital.'
R_07	'I wanted to see one day when the distribution of research funding encourages more diverse perspectives to be heard and more transparent without boundaries.'
R_08	'Prioritising what universities value not just the most amount of funding they get, but the quality of that funding, whether it is truly inclusive, whether it is truly impactful.'
R_09	'To pick those goals is steering everything, and that is being done and where the funding is going, so that is also very important.'
R_10	'We think technological innovation will change things, and I do not think it is. However, social innovation is going to give us things we need.'
R_11	'More mission and implementable research and innovation, so keeping in mind that there are also people at the end who will use it.'
R_12	'Countries can get a framework for how to produce climate science and design a framework to approach the fundamental challenges that we faced.'
R_13	'I would certainly support any policy that is looking at the local empowerment, and that would build up local knowledge infrastructures.'
R_14	'We need a policy that balances short-term research projects and longer-term institutions that seek to understand the relationship between research, technology and society and direct it with the transition.'
R_15	'I think we need an interdisciplinary approach to understanding sort of the regional requirements for achieving transitions.'

Although some literature encourages policy engagement with academics without setting boundaries, which promotes cross-disciplinary research engagement with policymakers (Fawcett et al. 2018), the need for institutions to interact and promote knowledge and innovation flow among researchers and policymakers is necessary to get a better understanding of accelerating funding streams and impactful innovation

at the national and regional level (Pino and Ortega 2018). There is also a debate about what policy framework is recommended for ensuring that media are part of the research stream in funding climate change and energy research. There is a contending argument that interdisciplinary research is often under-reported, and even when reported, it is fragmented (Karlssoon-Vinkhuyzen et al. 2017; Goldthau and Sitter 2020).

Notably, the interviewed experts in Table 5 recommend that regional research empowerment and social innovation that would complement technology development and policy on long-term research projects would be groundbreaking for future research outcomes.

A new international research coordination regime is needed to harness multi-, cross-, and interdisciplinary research opportunities to solve our present global challenges. Moreover, funding interdisciplinary research is essential for generating new knowledge as it continues to gain momentum in solving our complex real-world problems. A principal conclusion is that there has been a shift in research priorities since 1990 when the climate change agenda began to be at the fore of global debate, and the shift in the funding of interdisciplinary research related to the SDGs also continues to snowball in the last 5 years.

The study shows that the interaction among disciplines is proliferating among the research communities, influenced by the ongoing reforms in funding agencies in many countries which encourage funding of interdisciplinary research, even though there are still tensions among the disciplines where this is happening. These findings also extend this notion among stakeholders, researchers, and fund managers to acknowledge the importance of interdisciplinary work and its integration into SDGs. However, they do not identify a strong relationship between their research programmes or activities and the SDG agenda, even when their work addresses issues around SDG topics. This finding provides evidence of how knowledge generation contributes to achieving the SDGs, which can be used in STI policy, especially in transformative innovation policy.

The paper suggests that there is a need for more profound inclusiveness and engagement of global South topics and researchers in the new interdisciplinary funding framework since every country and every region have peculiarity on how the climate change crisis is impacted, which is also critical for the assessment and policy interventions. Even though many countries have developed robust policies, there is governance resistance resulting in policy somersault, while there are other situations, resistance from important stakeholders hinders the implementation of coherent public research funding policy. The potential of transformative scientific research in generating knowledge for addressing the SDGs is critical. The paper answer this ‘how’ question through a specific method, which involves not only individual research goals but also ensuring that most scientific research and knowledge generation goes beyond its goals and directly or indirectly links with the SDGs. Finally, the article proposes the need to establish a global institution for academic research coordination in the convergence of climate change, energy, transport, and industrial decarbonisation research if we must address our real-world challenges.

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- This article systematically explores how research funding is shaping climate and energy innovation.
- This article examines the research councils’ reforms and interdisciplinary funding.
- This article evaluates the funding pattern and SDGs agenda.
- This article explores how public research funding are generating new knowledge on energy and climate change.
- This article analyses disciplinary politics and shifting research priorities.

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Appendix

Table A.1. List of respondents and affiliations.

Respondent	Date (2021)	Institution	Type of institution
R01	3 November	Netherlands	Research council
R02	4 November	UK	University
R03	4 November	Canada	University
R04	18 November	Norway	Research council
R05	18 November	UK	University
R06	26 November	UK	University
R07	14 December	USA	University
R08	26 November	UK	University
R09	10 November	Denmark	Research council
R10	9 November	UK	University
R11	5 November	Denmark	Research council
R12	17 November	UK	Research council
R13	13 December	Netherlands	University
R14	13 December	Rwanda	University
R15	16 December	Norway	Research council