Thirty years of climate research funding has overlooked the potential of experimental transformative technologies

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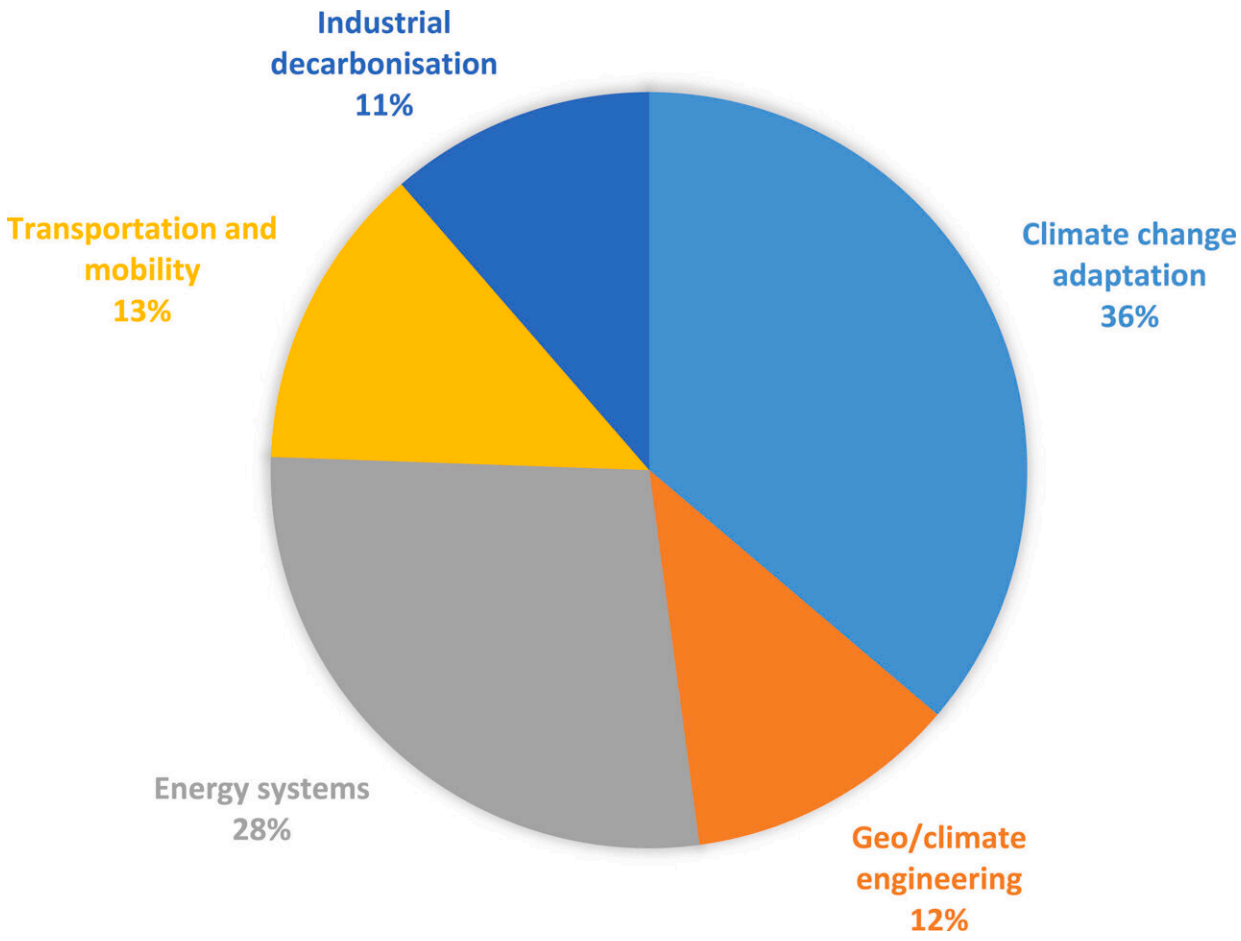

The general technological areas or systems funded by energy and climate research, 1990 to 2020 (N = 1000 projects). Credit: *Renewable and Sustainable Energy Reviews* (2022). DOI: 10.1016/j.rser.2022.112420

A new study from the University of Sussex Business School reveals the technologies and academic disciplines that are being overlooked by research funders in the global fight against climate change.

Potentially transformative technologies such as stratospheric aerosol injection or albedo management have received less than £1 in £500 of climate research funding over the past 30 years while even established climate change responses such as industrial decarbonization have received just a third of the research funding that climate change adaption projects have received.

Based on a sample of 1,000 projects totaling more than $2.2 billion in research funding granted between 1990 and 2020, climate change adaptation projects received the highest proportion (36%), followed by climate mitigation via energy systems (28%), transport and mobility (13%), geoengineering (12%) and industrial decarbonization (11%), reveals the study newly published in the journal *Renewable and Sustainable Energy Reviews*.

Academics in the Science Policy Research Unit (SPRU) at the University of Sussex Business School reveal that climate research funding over the past three decades has been asymmetrically distributed with the United Kingdom (40%), European Union (27%) and United States (11%) receiving almost four-fifths of all funding disbursed for a sample of 1,000 projects analyzed by the researchers. Countries such as China, India, Israel or Japan received very low amounts of funding; while developing countries, especially in Latin America and Africa hardly feature.

The dominance of the Global North, and the U.K. in particular, is even more prevalent in the academics' analysis of institutions most successful at attracting funding with 20 institutions, 18 of which U.K.-based, sharing 96% of funding worth more than $800m spent on the social

sciences, showing a clear concentration among top universities.

Benjamin Sovacool, Professor of Energy Policy in the Science Policy Research Unit (SPRU) at the University of Sussex Business School, said:

"As a positive sign, our tracking of recent research trends reveals a much stronger role of the social sciences, arts and humanities than we would have predicted. These collective disciplines received about 45% of the funding from our sampled projects over the 30-year period.

"As a negative sign, the hugely disproportionate funding awarded to the U.K., U.S. and EU raises important questions around issues of justice and equity in funding for Research & Development especially on technology and innovation that could help address climate-related challenges, which are expected to adversely affect low-income countries disproportionately in achieving just-transitions. Even accounting for the fact that our dataset overrepresents research projects in the Anglo-Saxon world, that can afford to publish research data in English, it is clear this is a significant failing to support a truly global response to the world's greatest challenge."

Dr. Chux Daniels, Research Fellow in Science, Technology and Innovation Policy in the Science Policy Research Unit (SPRU) at the University of Sussex Business School, said:

"Policies on research funding shape the dynamics on knowledge, innovation and technology; while technology, innovation and knowledge may in turn, influence research funding, shifts in research priorities and policies on climate change and sustainability. Therefore, deepening understanding on the role of policies in achieving equitable, just and inclusive transition to sustainability is vital for realizing climate change and decarbonizations goals. The transformative innovation policy approach offers useful ideas on technology and innovation-driven

development strategies for addressing climate change and decarbonization."

The researchers identify a number of technologies that could have a significant role in limiting climate change but are hugely underfunded in terms of research. These technologies include:

Stratospheric aerosol injection (SAI) (0.2% of all climate funding)—Although it may sound like science fiction, the study authors say SAI techniques are technically feasible today and could enable near-term reduction of global warming if given more careful consideration within the community.

Marine cloud brightening (0.15%) and Cloud thinning (0%)—The academics argue marine cloud brightening could be deployed relatively quickly, using fleets of ships to spray sea water into the air below marine clouds, thereby increasing the clouds' reflectivity and longevity.

Ocean mirrors (0.15%) and Space sunshades (0.1%)—Both technologies work using the same principle, of placing scatterers, reflectors, or mirrors either across the ocean (terrestrially based) or into the high atmosphere or outer space (above the atmosphere) to reduce the amount of sunlight entering the Earth, thereby reducing warming.

High-albedo crops and buildings (0.1%)—Albedo modification proposes that if less energy is absorbed by the Earth system, the surface of the Earth will cool on average. The authors explain that technology could replicate the impact of huge volcanic explosions which inject huge amounts of sulfur dioxide into the stratosphere, increasing the Earth's reflectivity (albedo) and decreasing the amount of sunlight absorbed which can lead to temperature drops of around 0.3C for three years. Possible strategies include albedo modification either via buildings (painting them white) or landscapes (managing cropland or marginal

land) to better reflect sunlight, particularly in the Arctic but also in areas of high latitude, where sea ice and ice sheets can be protected.

The study also reveals areas of research which receive tiny proportions of the funding available and whose significance and role to play in the fight against climate change, the researchers believe has been overlooked. These include:

Food science and technology (0.036% of climate funding)—The researchers describe this as a troubling funding gap given that the journey from farming activities to food processing and transportation of finished goods to consumption can have significant negative impacts on water consumption, energy consumption, climate change, and other environmental externalities. They note that the food sector via agriculture has a higher national energy demand greater than either China or the United States.

Neuroscience (0.022%)—Social neuroscience, psychology and cognitive neuroscience all have a valuable role to play in informing social interventions that may hamper or facilitate behavioral change, the study authors suggest. They add the specialisms can inform the neural activity behind the behavioral responses to climate change and extreme weather including fear and emotional trauma.

Theology, divinity and religious studies (0.046% and 0.037% respectively)—The study authors argue these disciplines can help researchers better understand deeper spiritual implications of low-carbon transitions including how they may reshape connections to the environment, or promote a new set of values geared towards sustainability (e.g. altruism or frugality).

Sports studies (0.012%)—An important topic the researchers argue given that climate change and extreme weather events are already

impacting major events like the Olympics or impacting major sporting leagues. They add that climate change impacts include significant negative effect on human health and account for behavioral change in physical activity.

Classics (0.00009%)—Understanding the lessons from history and the collapse of empires precipitated by environmental calamities and how archaeology and related areas of cultural heritage can inform discussions of global climate response are some of the overlooked value of Classical Studies in the global response to climate change.

Abdulrafiu Abbas, Doctoral Researcher in the Science Policy Research Unit (SPRU) at the University of Sussex Business School, said:

"The significant funding gaps our study has revealed in research topics identify a tendency of research funders to pursue hot topics by going along with the crowd or groupthink, and also highlights under-researched topics that, perhaps, are even more worthy of exploration.

"Our study also indicates that there is need for research community and funding agencies to promote more transparency and accountability in their funding patterns. In doing so, this would facilitate a deeper understanding of spiritual and historical implications of low-carbon transitions, and connections between the extreme weather events and mother nature that could help set new drivers and dynamics geared towards low-carbon sustainability."

The study also reveals how priority areas for climate research funding have shifted over the years with almost no topic remaining as the top of the funding list for a given period or a given general area of technology.

For example the top funded energy and climate mitigation technology in 1990 was nuclear power but in 2020 it was energy efficiency. The top

geoengineering topic was ocean fertilization in 1990 but direct air capture in 2020. The top mobility option was passenger (conventional) transport in 1990, but electric vehicles in 2020.

The study also reveals the impact that major climate conventions have had in shaping the level of funding and also the areas where funding is focussed. Over the 30-year period, the academics identified funding peaks in the early 1990s which coincide with the Rio Convention and the launch of the United Nations Framework Convention on Climate Change. A similar jump in funding occurs around 2000, coinciding with the signing of the Kyoto Protocol having its signing period end in 1999, and then a massive surge in funding post 2008 to 2020, which the academics attribute to shifts in policy and technology debates towards net-zero and decarbonisation and the influence of the Paris Accords.

The analysis also reveals that engineering and technology dominated funding patterns from 1998 to 2002, again potentially linked to the Kyoto Protocol, before a surge in support for social science and humanities projects from 2005 onwards.

The paper analyzed the role of public research funding patterns between 1990 and 2020, examining 153, 202 projects funded by 154 research councils across 17 countries including the EU. A deeper analysis was undertaken of 1000 representative projects with a total budget of $2.268 billion.

More information: Abbas AbdulRafiu et al, The dynamics of global public research funding on climate change, energy, transport, and industrial decarbonisation, *Renewable and Sustainable Energy Reviews* (2022). DOI: 10.1016/j.rser.2022.112420