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A mission-driven approach for converting research into climate action

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With each IPCC report, the science basis around climate change increases extensively in terms of scope, depth, and complexity. In converting this knowledge into societal climate action, research organisations face the challenge of reforming the ways they structure themselves, generate solutions, and communicate scientific findings to stakeholders. Here we present a mission-driven approach to guide those efforts.

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INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report[1] is a reflection and summary of published knowledge and findings related to climate-change from the global academic and research community. This assessment includes dedicated focus on mitigation approaches such as technology development and transfer, demand-side options, and socio-cultural and behavioural aspects, while also recognising the close linkages between mitigation pathways and development outcomes and the potential to target mitigation action to achieve sustainable development objectives. The scientific findings from the research community provide the building blocks for a wide range of solutions. However, research organisations should effectively position themselves to address the gap between scientific-knowledge generation and its implementation into climate policies and programmes (the 'knowledge-action gap'). We propose that research-intensive organisations strengthen their 'mission-driven' focus, enabling diverse fields of research to leverage complementarities, align with appropriate stakeholders and end-users, and streamline into policy action.

CHALLENGES AND OPPORTUNITIES FOR TRANSFORMING RESEARCH INTO CLIMATE ACTION

The concept of the knowledge-action gap is well-established, not least with regard to climate-change research. Overcoming this gap requires that research is perceived as relevant, of high technical quality, and objective[2] it must balance the production of science with societal needs in order to be usable[3] and can enhance its communication beyond academic audiences through narrative-driven techniques[4]. Given the rapid proliferation of scientific publications, evidenced by the IPCC report complexity, climate science needs to adopt a multidimensional approach that connects concepts, dimensions, methodologies, and worldviews beyond a single discipline[5]. At a practical level, increasing practitioner and end-user participation in the IPCC process can enhance its accessibility to decision-makers[6].

Dedicated academic fields have emerged aiming to resolve this gap. They address, among other things, educational implications of climate change for policy and practice, emphasising approaches such as pedagogical techniques[7], curriculum development[8], and the training of staff[9]. Across the broader sustainable development field, there is the recognition that an upgraded 'operating system' in higher education institutes is needed, involving co-creative collaboration and inter-organisational network participation[10]. There is broad agreement that collaboration and partnerships between societal actors and the academic research community, facilitated by a growing scene of think tanks, NGOs, and applied research organisations, are considered crucial for successful climate action—in some places, these are mandated by policy[11].

Universities should therefore build on this strategic role both as a catalyst for new, multi-disciplinary, ideas and solutions and as a link between climate science and societal action. Regular turnover among researchers and students makes universities a unique venue with potential to rapidly proliferate this knowledge to society. Yet challenges in achieving climate action have been linked to a variety of structural and institutional factors shaping current academic research[12–14]. We suggest a roadmap for researchers and universities to reformulate their identities around ambitious but achievable 'missions' within the academic setting, which can help them leverage and promote knowledge transfer on climate action.

A MISSION-DRIVEN FRAMEWORK FOR CLIMATE-CHANGE RESEARCH

While most traditional, mission-based scientific and engineering achievements have been centrally controlled and defined by small groups of experts, the context of global environmental and climate change lends itself to much more complex missions that must be co-defined by many levels of stakeholders[15]. This approach has taken root in innovation theory with particular focus on creating the structures needed to achieve sustainability outcomes[16]; to focus on activities supporting societal

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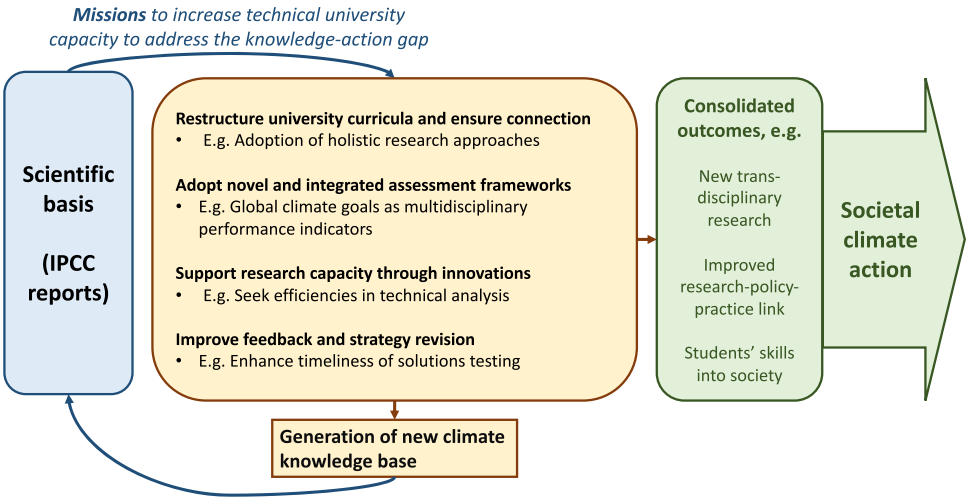

Fig. 1 A 'missions-driven' roadmap for converting research into climate action. A scientific-knowledge base generated for and resulting from global climate assessments provides a basis for understanding current gaps and limitations in the research process. Transdisciplinary 'missions' shaping new climate research are designed to address these limitations and provide solutions for policy streamlining while redefining the structure of existing research approaches.

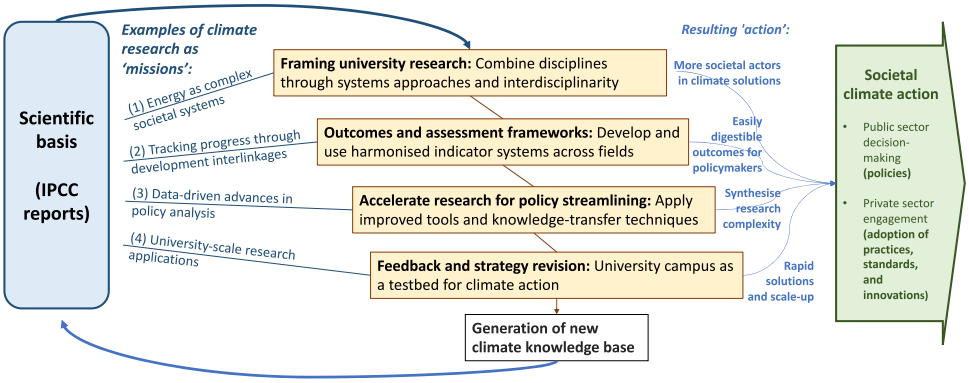

Fig. 2 Missions of a technical research university in practice. Examples of research missions designed to consolidate climate research at KTH Royal Institute of Technology.

transformation instead of sectoral priorities[17]; and to provide the directionality needed to nurture new industrial landscapes, embracing co-creation practices and the management of complex systems, among others[18]. These principles align with a need for complementarity of action by all societal actors in major sustainability transformations[19] and transnational innovation programmes[20]. The OECD assesses mission-oriented innovation policy in the context of achieving net-zero emissions, given its characteristics of strategic orientation, policy coordination, and policy implementation[21].

The use of mission-based approaches has thus far largely focused on innovation policy. We propose that academic research should adopt the principles of this approach to break out of established research silos and university structures toward a whole-of-society approach. Making rigorous climate research accessible and actionable can also contribute toward reaching new segments of society, which are not aligned with current scientific thinking, a challenge familiar to policymakers. While the integration of disciplines and subject areas is increasingly common in a university setting, the core structures of the research model should be more effectively aligned with the end goal of climate action. Figure 1 presents a roadmap for universities to internalise the scientific basis on climate action in their operations, by identifying university-wide missions directed at climate action as well as structures to implement those missions. In the next section, we discuss in more detail how certain elements of this approach are being integrated in climate research at a leading technical university.

LESSONS FROM A MISSION-DRIVEN RESEARCH FRAMEWORK IN A TECHNICAL UNIVERSITY SETTING

A typical university has a curriculum structured around core topical elements. However, many universities are striving to develop new climate change and other research that transcends these disciplines. In our experience this can be facilitated through a shift toward dedicated transdisciplinary research structures incorporating cross-discipline research and societal partners to address the climate challenge. These are exemplified, for example, by new cross-disciplinary institutes and centres being set up at leading universities like Stanford, Harvard, KTH Royal Institute of Technology, and many others. However, these research structures face a continuous challenge of identifying appropriate 'missions' to consolidate and implement climate-related research in society. By bringing together an interdisciplinary team of researchers to analyse and respond to IPCC report findings, missions can be identified which can more effectively transmit transdisciplinary research expertise toward societal outcomes through transformations of the existing academic or university structures. Applying the approach proposed in Fig. 1, we exemplify in Fig. 2, specific missions centred on research at KTH Royal Institute of Technology

are defined within the remit of the university's Climate Action Centre, and described in the following paragraphs.

(1) A systems approach to energy and climate mitigation

Mission: *Reformulate climate mitigation research in terms of complex systems and across multi-disciplinary solutions rather than advances in the energy sector that only focus on technical or behavioural aspects*.

Technical universities are at the forefront of research into renewable energy and electricity efficiencies. Technical sub-systems to solving the mitigation challenge are well-covered in existing research foci such as electrification of transport, district heating, and so on, while research into behavioural aspects of energy use is also well-established. However, energy usage is shaped not only by technologies and individuals, but by social relations, regulations, traditions, and networks. Redefining the mitigation challenge in this way can address the transformations required to decreased resource and energy use and to adjust to our planetary boundaries. Transdisciplinary research should increasingly be defined around elements that more accurately reflect the energy system, incorporating social science, political science, psychology, humanities, and others. For instance, system approaches to climate mitigation should integrate economic aspects for the transition, technology data from laboratories and field testing, and consider behavioural and other aspects as well. All of these skills may sit in different departments in a research organisation. Upgraded curricula that generate new skill sets fusing technical research with societal change and governance aspects will challenge current energy paradigms and patterns and embed this systems-based thinking into new projects and solutions.

(2) Integrating climate mitigation action and development through interlinkages and indicators

Mission: *Create a connected research structure across the university based on interlinkages across disciplines to address climate change. Use climate goals and objectives developed collaboratively by the global community as common assessment frameworks for disciplines across a variety of topics and themes*.

Linkages are increasingly understood between sectoral actions and global climate outcomes[22]. While a plethora of tools have emerged to consider such linkages at the policy level, the use of such approaches within research organisations are less explored. Connecting research across natural and social sciences using the Sustainable Development Goals (SDGs) and their assessment criteria as a basis for holistic climate action provides a harmonised structure to operationalise this knowledge, track indicators, and assess solutions. Such assessment frameworks, based on common climate and development targets, help to streamline climate objectives into policy and accelerate climate action in an equitable way through the understanding of synergies and trade-offs between potential solutions. Engaging politicians and decision-makers through the digestible lens of the SDG targets and indicators makes diverse academic research easier to understand and act upon in integrated policy as well as by thematic topic area. The creation of tools that simplify access to information can be used to justify project impact within the development agendas.

(3) Supporting climate-mitigation solutions through data-driven methods

Mission: *Align methods involving automation, big data, and computational statistics to support new climate-solution discoveries by synthesising complex knowledge and interlinkages across fields and systems*.

Recent advances in the field of artificial intelligence (AI) have resulted in a wide variety of data-driven methods for quantitative analysis of textually described information. Climate-policy analysis has in the past relied on document review, expert elicitation, and other manual and time-consuming processes. However, new techniques such as analysing interactions between AI methods and the SDGs[23] provide a new frontier for this type of research, synthesising large amounts of information with potential to transform how research is translated into climate action.

The length and technical jargon that characterise academic papers and aggregated summaries by organisations such as the IPCC make this research difficult to translate into actionable policy guidance. Methods such as data-driven natural-language processing are becoming more widespread in the scientific community[24] and can scale such analyses by drawing from vast documentation databases curated at research institutions and identifying synergies and trade-offs with the SDGs through automated semantic analysis. Finally, deep reinforcement learning[25] can be used to inform optimal policy actions in conjunction with the SDG targets. The resulting framework is a generalised resource for decision-making by policymakers, enterprises, and citizens (Fig. 3).

(4) Utilising the university campus as a testbed for achieving net-zero emission goals

Mission: *Use the university setting to test solutions to achieve net-zero carbon emissions in ambitious timeframes*.

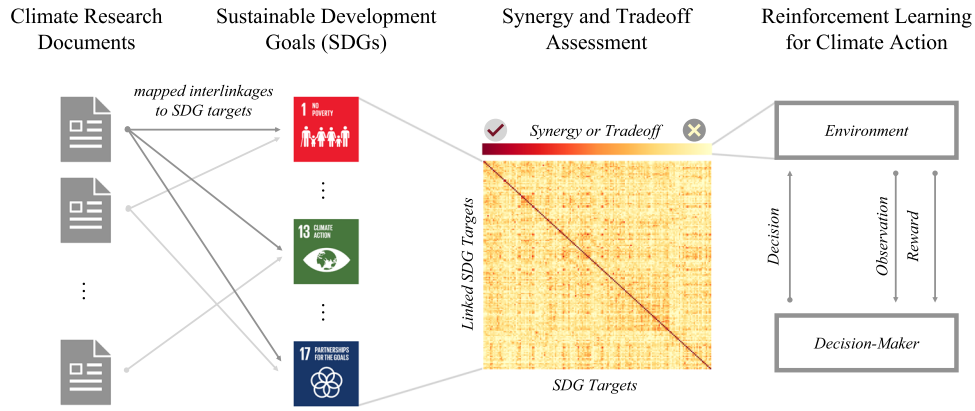

Fig. 3 Data-driven framework for translating climate-related research into actionable policy recommendations. This approach relies on natural-language processing (NLP) to automatically identify interlinkages between documented research and SDGs, including relevant synergies and trade-offs. The resulting knowledge base of SDG and climate interactions can inform optimal policy actions through data-driven optimisation.

Universities comprise a complex mix of buildings, research infrastructures and people. Greenhouse gas emissions from universities include electricity, heat and cooling in buildings, employee travel, use of information and communication technology (ICT), as well as computing power, among others. This mission encourages interactions between research teams and institutional structures within the university setting to develop solutions that can then be scaled up. The university may serve as a testbed for technical innovations to reduce emissions and energy use in buildings and research infrastructures, while social science research may support goals that require behavioural changes, such as travel or the increased adoption of plant-based foods in academia. More broadly, a large array of interconnected methods and disciplines can be designed and tested to achieve mitigation goals, generating important information to replicate and adopt at a broader scale to achieve the net-zero goals in cities, countries and globally.

REFLECTION AND SUMMARY

These examples of integrated climate action initiatives reflect some of the potential areas in which a technical university may consolidate scientific knowledge, tools, and innovations within an updated academic structure to address the knowledge-action gap. Beyond the context outlined here and focusing on internal coordination in large research universities, common structures and transdisciplinary centres can also help collaboration across research institutions and the private and public sector. Among other things, we encourage universities struggling to connect research within their structures to share experiences and best practices to do so.

Nevertheless, the 'missions-driven' approach risks certain pitfalls, such as leading university research to path dependencies led by pre-determined objectives rather than the evolving context, demand, and innovation requirements[26]. Bottom-up research has an advantage of driving science in unexpected directions leading to technological breakthroughs for climate action that may be missed by too much focus on a mission-driven approach. A broader stakeholder base also risks looser coordination and more difficult coordination in implementation of solutions. Acknowledging these cautions, a mission-driven approach balanced by bottom-up research can ultimately lead to real climate action emerging from the vast web of knowledge generated by the world's leading scientists and contained in what are perceived as difficult-to-access formats such as the IPCC reports.

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ADDITIONAL INFORMATION

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