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Fostering interdisciplinarity and collaboration: the role of challenge-driven research in European University Alliances through the CHARM-EU experience

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This paper explores the innovative dynamics established through the European Universities Initiative (EUI) and their role in steering collaborative, challenge-driven research with societal impact. The EUI fosters the creation of university alliances aimed at aligning education and research with societal needs within the European Research Area. These alliances are designed to enhance transnational cooperation, particularly via developing common science agendas that serve as joint research strategies designed to deepen scientific collaboration among alliance partners. These agendas are structured around key priorities such as sustainability, inter- and transdisciplinary research, and adherence to Responsible Research and Innovation principles. Our study focuses on the CHARM-EU Alliance as a case study, presenting a participatory process for building multidisciplinary academic teams to define scientific priorities aligned with sustainable development goals. The process provides a practical tool for fostering new scientific networks to identify and tackle complex global issues, being replicable, inclusive, and adaptable for other alliances. Additionally, the paper discusses the main barriers encountered in developing and implementing a procedure to set up a common science agenda, including the challenges of inter-institutional collaboration and the integration of diverse institutional policies and priorities. Our findings offer insight into the successes and limitations of such initiatives, contributing to a collective learning experience that can inform policy and academic communities on fostering transformative research strategies within university alliances.

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Introduction

In this paper we explore the innovative dynamics set up through the European Universities Initiative (EUI), by which a number of university alliances have been created following an ambitious strategy of the European Commission (EC). We particularly focus on their role in steering collaborative challenge-driven research with a societal impact, since these alliances have been conceived as testbeds for novel approaches within the European higher education landscape.

The EU aims to strengthen European integration by aligning education and science with societal needs and establishing a European Research Area (ERA) to enhance competitiveness and innovation (EC, 2007a). Initiatives like Erasmus+ and the EUI foster student and staff mobility and institutional cooperation, creating alliances to develop joint education and research strategies. These efforts are aimed not only at enhancing the quality of European higher education but also at emphasising the importance of a robust research dimension, driving innovation, and addressing grand societal challenges through collaborative research endeavours. In this line, one of the key elements for the alliances is the development of a common science agenda, which would ideally work as a joint research strategy to deepen scientific collaboration among the alliance partners, and would integrate a number of priority areas predefined by the EC to link different ecosystems

Universities have been singled out as occupying a privileged position from which to guide society toward a sustainable, more peaceful, and inclusive future (Klofsten et al. 2019), not only by creating knowledge, but also through collaboration, civil engagement, and dissemination of knowledge (Findler et al. 2019). The framework for such advancement, as suggested by institutions like the UN, is constituted by the sustainable development goals (SDGs) (Lim et al. 2018; Cottafava et al. 2022). Furthermore, it has been recognised that inter- and transdisciplinarity are essential for SDG research (Moallemi et al. 2020; Keynejad et al. 2021). The concept of "grand challenges" serves as an ideal framework for transnational institution building processes (Marqués and Graf, 2024)[1]. It aims to connect universities with business, regional, policy, and civil society actors. This approach, assumed by the EU in its research policy orientations since 2007 (EC, 2007b), addresses societal and other challenges with a multidisciplinary, cross-sectoral mindset, integrating education and research to prompt joint research strategic planning by creating learning networks that enable universities to share knowledge, align strategies, and engage in moral reflection (Macq et al. 2020).

In light of this, in this paper, we reflect on the feasibility of creating an inter-university common science agenda, developed under the EUI and hence following an institutional mandate, that integrates the EC priority areas and sets up a shared framework to deepen joint collaborative research. We aim to address the question of how to mobilise, integrate and bring together researchers from diverse institutions under a multidisciplinary and challenge-based approach. To that end, we present a procedure devised and implemented within the CHARM-EU Alliance[2], which involves a participatory process used to build multidisciplinary academic teams tasked with defining scientific priorities. The process is designed to be simple, replicable, inclusive, and adaptable for other alliances or consortia, thereby providing a practical tool for fostering new scientific networks aimed at addressing complex global issues.

Our goal is to explore how an SDG-driven approach, combined with four principal aspects identified as key components of the alliances' common science agendas, can be utilised to define unified strategies. Additionally, we examine the actual barriers encountered along the way and assess how these were dealt with, as well as consider what can be seen as the main achievements of the process. The successes and failures we describe are understood as a collective learning experience, which we intend to share with the whole policy and academic communities through this text. While other works, such as Fuchs et al. (2023), focused on the overall case of the EuroTeQ Alliance, or Stensaker et al. (2023), showed the formation and initial development of up to ten alliances, to our knowledge no scientific papers have been published to date on the detailed construction of a transformative research strategy of a university alliance under the EUI.

The remainder of the text is structured as follows. Section 2 briefly describes the origin, evolution, and current state of the EUI. Next, we review the main aspects of developing a challenge-driven common science agenda for alliances within the EUI, along with the main barriers that can be expected to arise (Section 3). In Section 4, we describe the method we propose to define shared SDG-driven research challenges and summarise the results and most important aspects of its practical implementation. Finally, in Section 5, we discuss our main findings and draw some conclusions, together with offering policy recommendations that arise from them.

The European Universities Initiative

One of the overriding aims of the EU is to strengthen European integration and work towards a future in which the Union is populated by genuinely European citizens who embody European values. In this vein, the EC aims to build a cohesive European society, particularly through a commitment to progressively aligning education and science with societal needs. In a move to unify and concentrate innovative efforts, by 2000, the EC issued a Communication that laid out "the foundations for an ERA, a border-free zone for research in which scientific resources will be better deployed to create more jobs and improve Europe's competitiveness" (EC, 2007a). As a result, the 15 science ministers of the (then) EU member states agreed on "a schedule for changes intended to increase the efficiency and competitiveness of basic science in Europe" (Schiermeier, 2000). Meanwhile, to encourage transnational integration of students and young people generally, a key objective of the original Erasmus and now the Erasmus+ Programme is the promotion of human mobility and European identity (EC, 2017). This integrative goal is shared by the Framework Programmes for Research and Technological Development (FPs) which foster R&I excellence and international collaboration (e.g., van Mol, 2018; Polluveer, 2024). As stressed by Conceição et al. (2020), successive FPs have raised public awareness of the importance of connecting society with science and technology developments, culminating in the "Science with and for Society Programme" (SwafS) within Horizon 2020 (FP8, 2014–2020) "to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility" (EC, 2014). This is part of the shift towards Responsible Research and Innovation (RRI), emphasising the intertwined relationship between science, society, and ethical considerations and reflecting progress toward total integration of European values within education, science, and innovation.

In line with these developments, the ERA has continued to progress since its inception in 2000, as laid out in "A new ERA for Research and Innovation" (EC, 2020a), and other texts (e.g., EC, 2020b, 2021a, 2021b). In the ERA Policy Agenda 2022–2024 (EC, 2021c), of the 20 planned actions and within the Priority Area "Taking up together the challenges posed by the twin green and digital transition, and increasing society's participation in the ERA", the EC includes: "Empower higher education institutions

to develop in line with the ERA, and in synergy with the European Education Area". This sets out the key and leading role universities are to play in the development of the EU science agenda. Two main pillars of this action are the European Excellence Initiative[3] (EEI) and EUI (EC, 2022a), which congregates European universities into strategic alliances. These international coalitions are crafted to foster enduring structural, strategic and sustainable collaboration among European higher education institutions (HEIs). The initiative proposes transnational collaborations that come together and engage with each other via various programmatic funding tools (ERASMUS+, Horizon Europe, Digital Europe, and other EU and national instruments) (EC, 2022b, 2022c). The EU is currently employing some of these mechanisms as novel instruments for policy experimentation within the EUI framework (i.e., a joint European degree[4]; institutionalised EU cooperation instruments to explore the feasibility of a specific European legal status for alliances[5]).

With its launch in 2018, the EUI aimed to trigger systemic, structural, and sustainable institutionalised cooperation between HEIs (Arnaldo Valdés and Gómez Comendador, 2022). As expressed by Marqués and Graf (2024), the initiative represents a case of a transnational institution-building process, based on new institutionalism, devised to potentially prompt structural reforms in the European higher education landscape. The Council Recommendation of 5 April 2022 "on building bridges for effective European higher education cooperation" encourages deeper cooperation and sharing of knowledge and resources between HEIs, while inviting member states to remove obstacles to more compatible higher education systems. It thereby claims to offer an opportunity for HEIs to explore "the necessity, benefits, risks and feasibility of setting up institutionalised cooperation instruments, such as a possible legal status for alliances" (EC, 2022b: 3). As Gunn (2020) stresses, successful alliances are expected to focus on three aspects: (i) a unified and long-term strategy for education that is closely linked with research, innovation, and societal needs; (ii) the establishment of a European higher education inter-university campus that allows for seamless mobility for students and staff; and (iii) the formation of European teams dedicated to tackling societal challenges through a multidisciplinary approach.

The first Erasmus+ call for the EUI, focused mainly on education, encouraged the formation of alliances with five to eight partners. The initiative aimed to prompt the bottom-up inception of networks of universities that would improve mobility (Cino Pagliarello, 2022) and allow students to obtain joint degrees in several countries (Marqués and Graf, 2024). The initial call for proposals closed in February 2019, attracting 54 applications. These were reviewed by experts and an evaluative committee, which selected the top proposals based on available funding and criteria such as relevance, geographical balance, quality, cooperation arrangements, and sustainability. As a result, 17 European University Alliances comprising 114 institutions from 24 countries were established in June 2019. Subsequent calls expanded the number of alliances and institutions involved. In 2020, 24 further alliances were funded, involving 165 HEIs, and thanks to the 2020 call, three new alliances were created. In addition, the previously created alliances were encouraged to expand their respective number of members in order to renew their projects, resulting in a total of 44 alliances, involving 340 HEIs. In 2023, the rollout of the EUI yielded a total of 50 alliances across Europe, with more than 430 HEIs involved. Finally, the EC established the goal of the EUI expanding the number of alliances to 60, a figure that was reached by mid-2024, with a total of 64 alliances funded at the time of writing and more than 560 universities involved[6].

Since the Erasmus+ call focused on the alliances' joint teaching dimension, and considering all the missions of universities (education, but also research, innovation, and knowledge transfer), a number of alliances were selected by the EC to develop their R&I dimension through the aforementioned SwafS call: 17 in a first-round (2020), 22 more in the second round (2021). The objective was to use the EUI as a testbed to explore the promotion of institutional transformations in HEIs within a number of priority areas (Ethics and Integrity, Science Education, Open Science, Public Engagement in RRI, and promoting Gender Equality in R&I), and to support the advancement of the ERA Policy Agenda 2022–2024 (its Action 13, in particular; EC, 2021c) and the EEI (O'Neill and Acheson, 2023).

Alliances' common science agendas: main pillars and potential barriers for design and implementation

Through the aforementioned SwafS call, alliances were requested to focus on a series of priority topics to develop their R&I joint strategies, namely, seven transformational modules (TF), TF1: Develop a common R&I agenda; TF2: Strengthen human capital; TF3: Share research infrastructures; TF4: Engage non-academic actors; TF5: Mainstream Open Science; TF6: Engage citizens and society; TF7: Explore joint university structures. Besides conceiving shared strategies to foster institutional changes within TF2-7, a key element, and probably the most challenging one, was the inception of joint plans to develop a critical mass to define and implement common R&I agendas (TF1). As expressed by O'Neill and Acheson (2023), a common agenda "serves to strategically focus the institutions on specific research and innovation topics and foster collaboration among researchers on those topics", they "typically cover areas of expertise as well as new priority areas for the institutions", and "should ideally be collaboratively developed with input from researchers, research managers, and leaders". These agendas, hence, would ideally work as a joint research strategy to deepen scientific collaboration among the alliance partners and would integrate all the priority areas predefined by the EC. A wide range of approaches has been implemented by alliances in their respective efforts to develop their common agendas (see examples in O'Neill and Acheson, 2023, 2024; Reus et al. 2023; TORCH Consortium, 2023a, 2023b). These usually focus on identifying specific research topics and promoting the creation of new networks among member universities. Many explore knowledge creation through challenge-driven, multidisciplinary research approaches, fostering innovative solutions to real-world problems and promoting civic engagement and adaptability across Europe (Reus et al. 2023; TORCH Consortium, 2023a, 2023b).

The route set out along by the EUI is, however, not free from obstacles and barriers. Some of these are specifically a result of multilateral transnational efforts at cooperation, mainly related to the diversity of institutional policies and priorities, practices, and organisational models inherent to the partner institutions; some derive from the practical implementation of transdisciplinary methods; others stem from restrictive regulatory or funding frameworks at the level of HEIs (European University Association, 2022; TORCH Consortium, 2022a).

Assuming the SDGs as a valid framework around which a research strategy can be structured, and bearing in mind the alliances' TFs and diverse approaches, we consider four aspects that are widely shared and appear to be essential to build up a common science agenda: (1) research driven by the quest for solutions to the challenges facing society; (2) interinstitutional and international collaboration; (3) inter- and transdisciplinary research; and (4) adherence to the RRI principles.

Challenge-driven research. An EU priority is to tackle and resolve the intrinsically complex issues facing humanity and our

planet, often referred to as "wicked problems" (Churchman, 1967). In this regard, the EU Treaty of Amsterdam of 1997 explicitly mentions the principles of sustainable development in the context of EU objectives. As an indication of its increasing importance, Kastrinos and Weber (2020) report that in FP5 the adjective "sustainable" is mentioned 47 times, while in the Horizon 2020 programme it is mentioned 117 times. Implementation of the European Green Deal and the EU Missions in Horizon Europe (EC, 2023) are ways in which the EU is moving towards greater sustainability. More broadly, the EU, through its member states, has confirmed its commitment to the UN's Agenda 2030 and accepted the challenge of achieving the corresponding SDGs in FP9, Horizon Europe (2021–2027) (European Council, 2017; EC, 2019). To this end, it has reiterated the need for an agenda centred on sustainability and a revamped governance approach aligned with transition management principles, all of which set meeting this challenge as the goal of research and innovation. Some work has emphasised the significance of such policies in shaping the emergence of "socio-technical regimes" explicitly focused on environmental sustainability and social inclusion (Mazzucato and Perez, 2014; Mazzucato, 2018).

Sustainable development, though, either as an objective or as a criterion, cannot fully define a research agenda. Apart from having to decide how to integrate sustainability within a research strategy plan or a common science agenda, there are also difficulties associated with working in a transnational framework and with adopting a multidisciplinary team approach (the variation across scientific fields in terms of practical ways to approach research).

There is a need to mainstream the different concepts that constitute sustainability throughout the entire higher education and research ecosystem in order to avoid the pitfalls of "inconsistencies, inaccuracies and a lack of detail regarding the processes and strategies to fully integrate the SDGs into the curricula, research and partnerships" (Avelar et al. 2023). The same authors go on to emphasise the need to prioritise specific SDGs, identifying "an exaggeration in the number of SDGs being addressed at the same time, which does not seem desirable [… and so] there is a need to define priorities on what can be useful" (Avelar et al. 2023) in terms of integrating SDGs into HEIs. Other authors have also tackled "the need for a framework which caters to a more systematic introduction of the SDGs in university programmes [… that] includes institutional, thematic, structural and personal/individual aspects" (Leal Filho et al. 2021). Despite such efforts, a literature review concludes that there is "no consensus on where to begin implementing the SDGs in HEIs" (Gonçalves Serafini et al. 2022). We are left instead with a list of possible initiatives and good practices that may help effective incorporation of the SDGs into HEIs, including institutional support, shifts in organisational culture, and guidelines on SDG awareness.

International collaboration between European universities. Considering the future of international research efforts towards sustainability, particularly for the actions proposed by the ERA Policy Agenda (EC, 2021c), it is clear that collaborative endeavours are essential. Okamura (2023), in an evaluation of the past five decades of global scientific cooperation, points out that international research collaboration is not only vital for executing large-scale academic R&D projects but is equally critical for addressing global challenges, including the SDGs, and responding to worldwide crises. Similarly, Lees et al. (2023) highlight the benefits of multinational collaboration in researcher development, noting that it improves the learning environment for researchers, which in turn enhances capacity building and the quality of education, as supported by Marinoni (2019), who reinforces the idea that the presence of policy or a strategy for internationalisation is becoming the norm, with the research dimension being particularly relevant.

Internationalisation is, hence, a requirement for grand research projects (Parikh, 2021), and also a must in the future of alliances, according to the EUI. However, it is not exempt from potential pitfalls. It faces, for instance, language barriers (mainly at the level of administrative and teaching staff), as well as internal resistance (Deca, 2020). Maassen et al. (2023) outline as main barriers aspects such as coordination, conflict resolution, commitment, and cultural characteristics. According to those authors, in many European University Alliances, decisions are made by consensus across all levels, which can lead to decisions being misaligned with overall goals. While this consensus approach minimises internal conflicts, it can slow down decision-making, risking missed opportunities and failure to meet project objectives. Intensifying R&I cooperation involves developing aligned policies and transformative actions in strategic areas (research assessment; equality, diversity, and inclusivity; Open Science; inter- and transdisciplinary challenge-driven research). In addition to this, it is also necessary to establish mutually beneficial partnerships that allow knowledge and competencies to be shared effectively and efficiently. This requires the exploration of alternative or novel governance models, the streamlining of administrative processes to support and foster research activities, the creation of joint structures with input from all the parties involved, and the establishment of agreements for mutual recognition.

Multidisciplinarity of challenge-driven research. Addressing efforts such as the EUI (though prior to the inception of this particular programme), Belcher et al. (2016) underscored the necessity of integrating new knowledge and innovation, action, and engagement to tackle the complexity of contemporary social and environmental problems. They argue for the importance of crossing disciplinary and academic boundaries as a means of enhancing the relevance and effectiveness of research. Pineo et al. (2021) also emphasise the critical role of transdisciplinarity in addressing global challenges, as it is essential to achieve a holistic understanding and develop solutions, since it enables integration of diverse knowledge and transcends traditional disciplinary limits. This perspective is further supported by a policy paper from the OECD (2020), which detailed how transdisciplinary research is instrumental in confronting complex societal issues and creating sustainable, long-term solutions. It seems there is a consensus that trans- and multidisciplinary teams are needed. Fortunately, as Twyman and Contractor (2019) comment when introducing their work on team assembly, "there is currently a convergence of social science theory, readily available digital data traces, and web-based technologies that leverage theories and insights from multiple domains to better understand and enable team assembly […] providing researchers with insights into the assembly of effective teams [which] will aid them in maximising their chances for scientific success and innovation".

However, the literature acknowledges the challenges associated with these novel, multidimensional, and complex approaches, particularly noting the difficulty in determining their efficacy (Belcher et al. 2016). Along the same lines, Arnold et al. (2021) identify the principal obstacles to successful multidisciplinary research as "structuring large projects to produce tangible outcomes in a timely manner, providing support for individual contributions on large research teams, or demonstrating the significance of outcomes". To overcome these difficulties, Pineo et al. (2021) suggest a six-stage model that includes initial active development "to establish a shared mission and ways of working"

together with (constant or recurrent) "conceptualisation to develop goals and the study approach by combining diverse knowledge". Ideally, this occurs "early in the project timeline and involves foundation-setting activities such as agreeing research governance processes [overlapping with '(pre-)development'] and developing the research approach".

Multidisciplinary (or transdisciplinary) teams may be driven by the SDGs, but we currently lack a clear pathway for integrating these goals as a framework into the policies and programmes (educational or research) of HEIs (Gonçalves Serafini et al. 2022; Hong et al. 2023). Although the output of scientific production linked to the SDGs is steadily increasing (Bautista-Puig et al. 2021), the need to be selective when considering the 17 SDGs, incorporating 169 specific targets, certainly rings true (Romero Goyeneche et al. 2022). The conclusions of Leal Filho et al. (2021) still seem to be the norm: "Many HEIs struggle today on how best to incorporate the SDGs in their operations. Efforts in this field are hindered by many barriers […] there are still many research gaps […] for instance, the need to define reliable indicators, […] a system to monitor and document progress [… and] how to prioritise the achievement of specific goals, without endangering others".

Schneider et al. (2019) consider there is a need to find common ground among the scientific community on what sustainability is and what the implementation of the SDG agenda means in practical terms. While inter- and transdisciplinary research is recognised as a valid approach, researchers and institutions must reflect on how to handle its normative dimension. In a later paper, Schneider et al. (2023) investigate how science funders can promote transdisciplinary research to improve science–policy–society interactions as a way to advance sustainable development in the Global South. Arnold et al. (2021) point to seed funding opportunities and targeted training for researchers, among others, as relevant avenues for HEIs to incentivise multidisciplinarity. In relation to this, Twyman and Contractor (2019) identify so-called staffed or top-down aspects where organisational input is required to ensure the multidisciplinary nature of research teams and projects, together with a convergence of interests. Relevant ideas need to be elicited, but they must come from (potential) participants to lead to a shared science agenda. Ultimately, it is these bottom-up or self-assembly aspects, centred on the personal commitment and contributions of researchers working in harmony, that will determine whether an incipient research project bears fruit.

Responsible research and innovation. The RRI framework, in its original vision, concentrates on five main areas: gender, open access, science communication, ethics, and public engagement (Owen et al. 2021). The specific brand of responsibility evoked by RRI, as set out within Horizon Europe (FP9), is precisely towards the environment and society in terms of social impact and inclusiveness, as reflected most clearly through the myriad equality, diversity and inclusion (EDI) missions. By working towards the UN SDGs, challenge-driven research is clearly taking bold strides along the path of responsibility; indeed, the two concepts (RRI and SDGs) could almost be seen as a chicken-and-egg situation. When addressing RRI, Smith et al. (2022) open their paper by proclaiming: "it is vital for researchers to actively engage with EDI which, if not attended to, may detrimentally affect both potential research participants and the research itself". Nevertheless, Cuthbert et al. (2023) highlight "the persistence of gender inequality in STEMM workplaces, despite many initiatives to redress it as well as the ostensible commitment of many leaders. STEMM leaders' efforts to promote gender equality appear hampered by various misconceptions, particularly inadequate understanding of the complexity of the problem".

The CHARM-EU common science agenda: piloting a researcher-based participatory process to conceive research challenges

The CHARM-EU alliance. Initially formed by five universities (University of Barcelona, Trinity College Dublin, Utrecht University, Eötvös Loránd University, and University of Montpellier), CHARM-EU was one of the first 17 European University Alliances selected from the inaugural call in 2019. Since then, it has expanded to include nine members, with the addition of Åbo Akademi University, Julius-Maximilians-University Würzburg, Ruhr West University of Applied Sciences, and University of Bergen in 2022. It embodies a challenge-driven, accessible, and mobile model aligned with European values and the SDGs. The Alliance establishes long-term institutional, structural, and strategic transnational cooperation among its members, putting the spotlight on sustainability (in a broad academic sense) both in its teaching and research initiatives. Its model envisions an interconnected European higher education campus, with mobility, inclusivity, and transdisciplinarity as core values, to implement a transformative approach to programme and curriculum design, as well as to prompt deeper collaboration in R&I initiatives among its partners, some of which are research-intensive universities and members of LERU.

The research arm of the Alliance was developed through the TORCH project, which set out to enable and encourage transdisciplinary SDG-driven RRI impacting at three levels: alliance, institutional, and societal. In line with the needs that have been identified in the literature, the priorities include accelerating and catalysing processes of institutional change, championing gender equality in R&I policy, as well as supporting Open and Citizen Science practices. A key aspect is the inception of a common science agenda based on research challenges that would rely on the scientific strengths and complementarities of its member universities, along with their research priorities and available infrastructures, alignment with the Alliance common educational project, and orientation towards EU funding priorities.

Method and data. The process to build up a common science agenda was designed and handled by a Working Group (WG) composed of representatives of the five universities, with different profiles (Vice Rector and Vice Dean for Research, Vice-Rector for Internationalisation Policy, Head of Doctorate School, Head of Research Support Office and Research Development Office, researchers with specific expertise in interdisciplinarity and complex networks, research support staff, and data analysts). The purpose was two-fold: ensure proper alignment with institutional strategies when defining priorities, and maximise researcher engagement in the process. It was developed through a combined top-down and bottom-up four-step participatory process.

For this study, we applied a qualitative research methodology focused on textual analysis and case study description. We gathered all relevant documents from the WG, including meeting minutes, project reports, internal communications, and official publications, in order to present a methodology carried out by the CHARM-EU Alliance to pilot the creation of its common science agenda. All data were collected and analysed (quantitatively or qualitatively) by and within the WG.

Case study results. This section presents the combined top-down and bottom-up four-step participatory process, along with the results of putting this process into practice as experiential learning, and as an attempt to arrive at feasible transnational multidisciplinary responsible SDG-driven research projects the

Table 1 CHARM-EU research thematic lines: correspondence with UN SDGs.

Thematic line	UN SDGs
1. Food, water, life & health	SDG2 - Zero Hunger SDG3 - Good Health & Well-Being SDG6 - Clean Water & Sanitation
2. Biodiversity, environment, climate change	SDG13 - Climate Action SDG14 - Life Below Water SDG15 - Life on Land
3. Inequality, economic growth, governance, migration	SDG1 - No Poverty SDG5 - Gender Equality SDG8 - Decent Work & Economic Growth SDG10 - Reduced Inequalities SDG16 - Peace, Justice & Strong Institutions
4. Big data, artificial intelligence	Transversal

Alliance would be in a position to propose in response to future international calls offering funding.

The starting point consisted of the four key lines of research that the CHARM-EU Alliance focuses on: (1) food, water, life & health; (2) biodiversity, environment, and climate change; (3) inequality, economic growth, governance, migration; and (4) big data, artificial intelligence. These four lines were defined upon the creation of the Alliance, based on: an in-depth study of the five founding universities' strengths and complementarities in research (based on bibliometrics analysis of their scientific production and specialisation, and on alignment with their respective research strategy plans); market analysis to design the Alliance's inter-institutional master's programme in Global Challenges for Sustainability[7].

In a preliminary phase, the WG identified which of the SDGs is most directly connected to the four TORCH Thematic Lines, as shown in Table 1. By framing the TORCH Thematic Lines in terms of these specific objectives, we ensured that the bottom-up process of research challenge formulation, and also the particular outcomes arrived at, were guided by and organised around SDGs.

The process then consisted of four steps, culminating in the formulation of six research challenges, which showcase this collective approach. The emphasis is always on leveraging the diversity and complementarity of the Alliance's strengths, focusing specifically on transdisciplinarity and societal impact.

Step 1: Establishing areas of interest and expertise using the research areas questionnaire. To begin the participatory process, each partner university identified a number of researchers that could potentially be involved, according to their own internal criteria. Trinity College chose to contact their whole academic staff; the other four partners nominated researchers, taking into consideration: the pre-established thematic lines (Table 1), the widest representation of scientific disciplines, and gender balance. The selected researchers were invited to respond to the research areas questionnaire (Q1) via Microsoft Forms, to establish their preferred areas of interest and expertise. The resulting dataset, besides personal and professional details, includes areas of expertise categorised using the Fields of Science Classification (OECD, 2007), and research interests and keywords aligned with the CHARM-EU thematic lines and SDGs. Responses to these questions were restricted to a number of predefined options, in order to facilitate clustering of the results. At this step, the dataset was processed via Microsoft Power BI, and simple statistics were produced to facilitate the reading of the data (see Q1 in Supplementary Materials).

Q1 yielded 389 individual responses from the five universities. The numbers of researchers invited together with response rates are presented in Table 2 below.

Figure 1 provides an overview of the results in terms of participation, background diversity, and multidisciplinarity. From a gender perspective, the respondent pool was reasonably balanced. Notably, all TORCH Thematic Lines were well-represented, with significant participation also in the transversal areas. Across the five broad academic fields (OECD, 2007), Natural and Social Sciences were most strongly represented, followed by Medical and Health Sciences. Humanities, Engineering and Technology, and Agricultural Sciences were less well-represented (Fig. 1). SDG3 (Good Health & Well-Being), SDG13 (Climate Action), and SDG10 (Reduced Inequalities) were the preferred options. The resulting dataset served a dual purpose: to identify common interests among the pool of researchers based on their responses and to enable initial grouping of researchers based on SDGs and Thematic Lines.

Step 2: Institutional analysis and prioritisation. While the participatory process leading to the formulation of research challenges adopted a bottom-up approach, a top–down component was introduced in Step 2. This was to ensure identification of priority SDGs (within individual responses that had potential for further development) was aligned with the five institutions' interests (as defined in their respective research strategy plans).

To this end, first, each partner university analysed the data collected via Q1 from its own researchers, considering the following aspects (that comprise both quantitative and qualitative focusing):

- How many researchers received Q1 and what was the institution's response rate?
- What priorities were set in the respective university's Research Strategy Plan (or similar) and which of these were well or poorly represented among the responses received from researchers?
- Were the fields of expertise of the respondents evenly distributed among the different scientific disciplines; which were underrepresented?
- Taking into account only their own institutional strategy and researchers' responses, which thematic lines and SDGs should the research challenges be focused on and prioritise?

The establishment and number of research priorities varied: while the University of Barcelona did not, at that moment, detail such priorities in its research strategy plan, the other four universities did. Trinity College identified five: climate change, along with the environment and related issues; cancer; infectious diseases; law; and policy studies. Utrecht University defined four: dynamics of youth, institutions for Open Science, life sciences, and pathways to sustainability. Eötvös Loránd University, seven: applications of IT solutions; astrophysics and particle physics; culture and family; diagnostics and therapeutics; material science; problem-solving systems; and chemistry and biochemistry. Finally, the University of Montpellier established three broad areas: Feed–Protect–Care.

Second, each institution's responses to the questions were discussed among the WG. The collective goal was to reach an alliance consensus on at least three SDGs, to which the emerging research challenges would be intricately linked and which would be pursued further in accordance with the research strategies and plans of the five universities. So, the results of this analysis by each participating university were pooled.

This validation process was also supported by bibliometric analysis of the strengths and complementarities of the five

Table 2 Research areas questionnaire (Q1): number of researchers per institution invited to participate and respondents.

No. of researchers from each university invited to participate and respondents

	UB	TCD	UU	ELTE	UM	TOTAL
Researchers invited to answer Q1	160	1860	64	117	50	2251
Q1 respondents (rate)	118 (74%)	123 (7%)	41 (64%)	73 (62%)	34 (68%)	389 (17%)

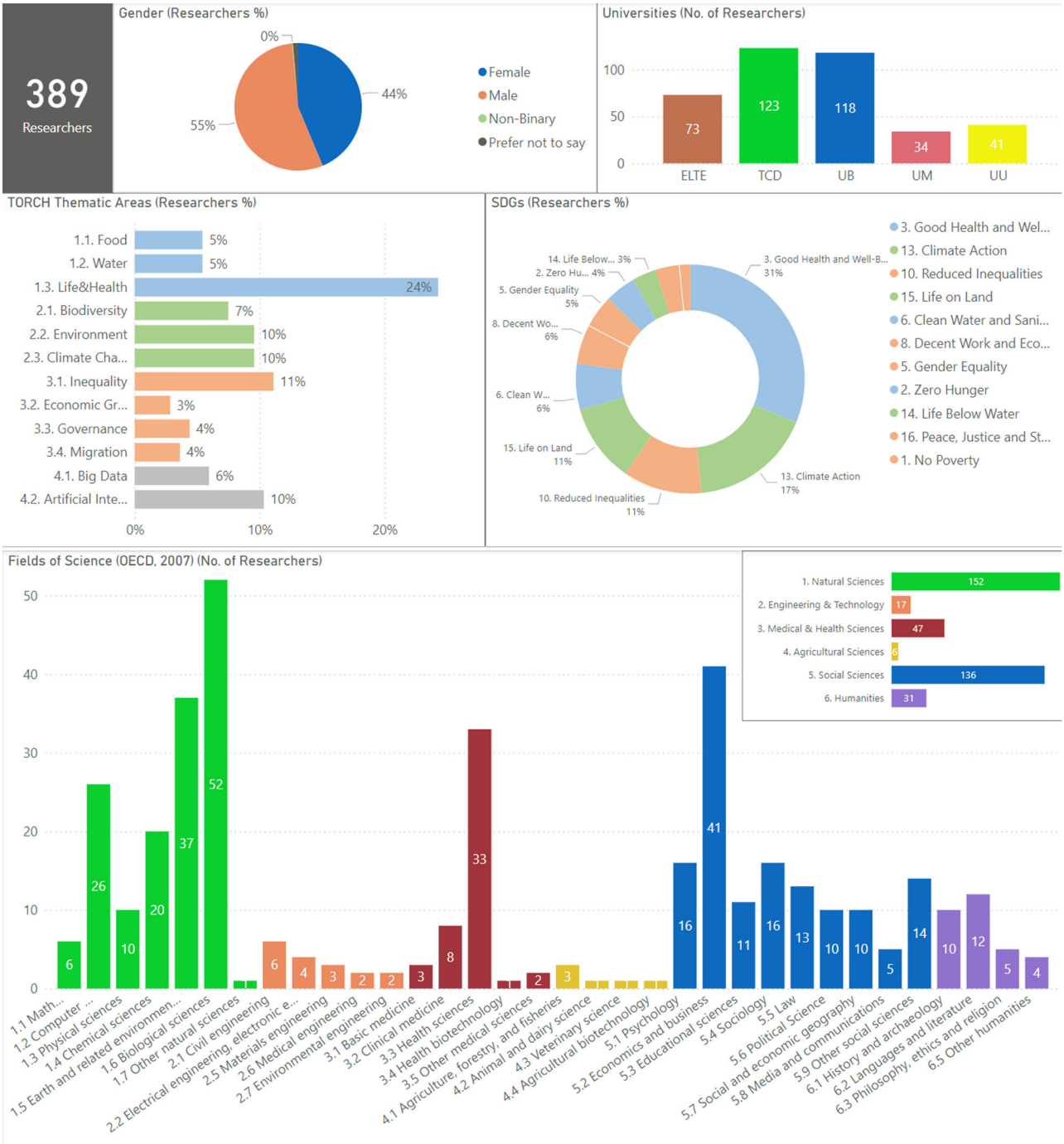

Fig. 1 Researcher profiles from questionnaire responses. Panels show (1) gender distribution (%); (2) number of researchers per university; (3) TORCH thematic preferences; (4) associated SDGs; (5) OECD Fields of Science; and (6) broader scientific domains. Colours represent categories consistently across panels.

Table 3 Preparation for expert focus groups (Q2): number of researchers per institution invited to participate and respondents who provided an individual research challenge.

	No. of researchers/experts from each university					
	UB	TCD	UU	ELTE	UM	TOTAL (average rate)
Invited to form part of an expert focus group (who received Q2)	26	16	28	47	14	131
Submitted proposal (returned Q2) and joined a focus group (rate)	14 (54%)	12 (75%)	12 (43%)	31 (66%)	12 (86%)	81 (65%)

universities, as well as by a breakdown of scientific networks that already existed within the Alliance via a custom-designed online interactive application. The application permits intricate visualisation of co-authorship and institution networks along with mapping the co-occurrence of research concepts (described in detail in Díaz-Guilera, 2024)[8].

The strategic alignment ensured a targeted approach, capitalising on the strengths of the Alliance in addressing key global challenges and maximising societal impact. The final selection identified one SDG per non-transversal Thematic Line, as follows:

- SDG3 - Good Health & Well-Being
- SDG10 - Reduced Inequalities
- SDG13 - Climate Action

Step 3: Expert focus groups: clustering researchers around SDGs. With the three priority SDGs defined, Step 3 was again principally bottom-up, generating research challenges from a narrower perspective; these could potentially result in a research opportunity and finally be developed further under funding from competitive calls. This required three expert focus groups, one for each SDG selected. To set this up, each university nominated a number of researchers (from those who responded to Q1 and identified the priority SDG within their scientific interests) as potential focus group participants. Researchers were selected according to criteria of each university, but considering the lists should be multidisciplinary and gender balanced.

A total of 131 researchers were selected and invited to complete a second questionnaire (Q2: Research Challenges Focus Groups Questionnaire) via Microsoft Forms. Q2 enabled a bottom-up approach again, as it represented a means of eliciting relevant research challenges each expert would potentially be interested in pursuing. To that end, it included, as its main feature, an open question for each respondent to describe the key scientific challenge/topic to be tackled in relation to the SDG of their choice. It also requested details of how to develop the challenge, such as relevant bibliographic references, and considerations on how transdisciplinarity, a gender perspective, and the involvement of non-academic actors could be integrated into its implementation (see Q2 in Supplementary Materials).

The resulting dataset, processed via Microsoft Power BI, was used to categorise researchers into three distinct focus groups aligned with their chosen SDGs. Figures on these researchers, their distribution across universities, and the final number of respondents to Q2 are detailed in Table 3.

In preparing the focus groups, the individual proposals provided by each researcher via Q2 were categorised under broad topics (the task was performed by one expert per group, identified by the WG from the respondent pool) to facilitate focused exchange and guide discussions within the three focus groups. The primary aim of these discussions was for the researchers to reach consensus on a topic (or topics) for further development as research challenges. Efforts were made to form multidisciplinary, multi-university, gender-balanced focus groups. The sessions were facilitated by the WG, but decisions on which topics should be pursued further (or not) as challenges, and how to advance them, were solely made by the groups of experts. The results are summarised below and in Fig. 2 and Table 4.

Focus Group on SDG3 - good health & well-being: A total of 34 researchers with diverse backgrounds selected SDG3, submitting 25 individual research challenges. They were grouped into three broad proposal areas. Proposals P1 (Promotion of Healthy Lifestyles) and P2 (Prevention and Preparedness for Diseases) were selected for further development as research challenges, following agreement within the focus group. Proposal P3 (Inequalities and Health) was abandoned at this stage, as it was considered the potential team was not multidisciplinary enough (Table 4).

Focus Group on SDG10 - reduced inequalities: 33 researchers opted for SDG10, providing 26 specific challenges grouped under four broad preliminary proposals. Proposals P2 (Coping with Digitalisation and the Transformation of the World of Work as a New Source of Inequalities) and P4 (Designing Better Institutions to Fight Against Inequalities) were selected for advancement within the focus group. The other proposals were abandoned at that point due to insufficient interest in pursuing them (P1), and agreement that a proposal dealing with climate change issues was better suited for the group working on SDG13 (P3) (Table 4).

Focus Group on SDG13 - climate action: The SDG13 focus group centred on 34 specific challenges (from 38 respondents) categorised into five broad proposals. Proposals P2 (Sustainable Management of Freshwater Resources within the Global Change Frameset) and P3 (Strengthening Resilience to Climate-Related Hazards and Fostering Disaster Risk Reduction Policies) were accepted as challenges to be developed further. Three other proposals were abandoned due to insufficient diversity in terms of scientific fields or lack of sufficient interest in them (Table 4).

Finally, six multi-university, multidisciplinary and gender-balanced teams of researchers were formed as a result of researcher initiative following the focus groups, in order to develop the selected topics into research challenges.

Producing the research challenges. Once the six topics were identified and the corresponding teams formed, the researchers (42 in total) were requested to compose a brief document outlining their respective research challenges, following this model:

1. Research challenge
   1.1 Title
   1.2 Objectives & societal impact
2. Research tasks
3. Contribution beyond current state-of-the-art
4. Methodology
5. Gendered innovation
6. Transdisciplinarity
   6.1 Transdisciplinary approach

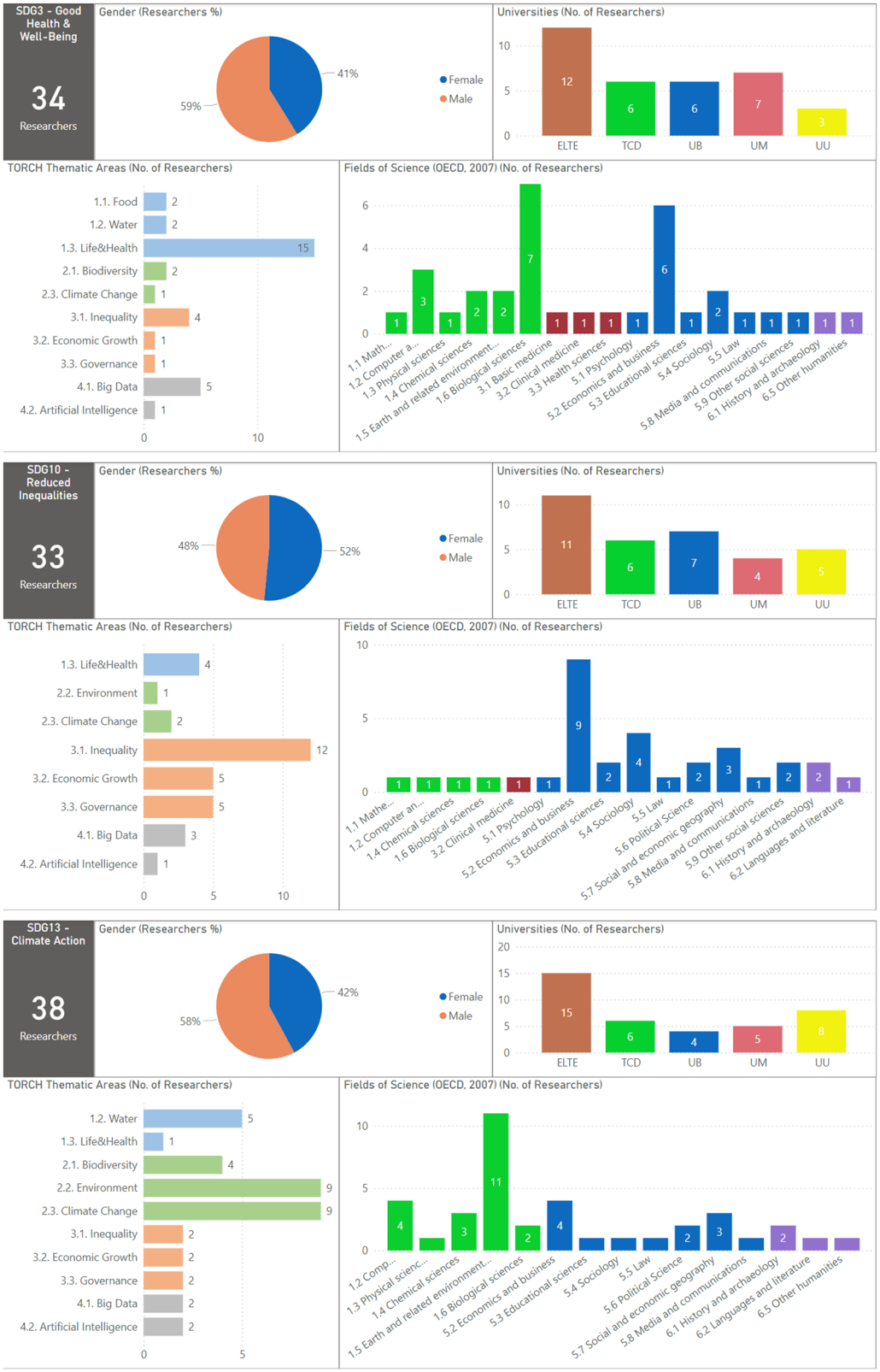

Fig. 2 Focus group preparation for SDG3, SDG10 and SDG13. Each SDG panel includes (1) gender distribution; (2) researchers per university; (3) TORCH thematic areas; and (4) OECD Fields of Science. Colours represent categories consistently across panels and bar heights indicate the number of researchers.

6.2 Scientific disciplines to involve (other than those already present in this group)

7. Non-academic actors' involvement
8. List of references
9. Team of researchers
10. Additional comments

Table 4 Focus group results (SDG3, SDG10, SDG13): participation, specific (individual) research proposals received, and topics selected for further development as research challenges.

Focus group	No. of respondents (Q2)	No. of participants	No. of specific (individual) research challenges received	Broad topics under which the individual proposals were grouped	Topic selected (S) or discarded (D)
SDG3 - good health & well-being	34	25	25	SDG3-P1. Promotion of healthy lifestyles	S
				SDG3-P2. Prevention and preparedness for diseases (including mental health)	S
				SDG3-P3. Inequalities and health	D
SDG10 - reduced inequalities	33	28	26	SDG10-P1. Improving education in order to reduce inequalities	D
				SDG10-P2. Coping with digitalisation and the transformation of the world of work as a new source of inequalities	S
				SDG10-P3. How can policies reduce between and within countries inequalities associated to climate change	D
				SDG10-P4. Designing better institutions to fight against inequalities	S
SDG13 - climate action	38	25	34	SDG13-P1. Enhancing deeper knowledge of the climate system components	D
				SDG13-P2. Sustainable management of freshwater resources within the global change frameset	S
				SDG13-P3. Strengthening resilience to climate-related hazards and fostering disaster risk reduction policies	S
				SDG13-P4. Integrating climate change measures into European policies, strategies, and planning	D
				SDG13-P5. Improving education and awareness-raising on climate change	D

This structure ensured the formulation of the challenges was aligned with the guiding principles overviewed in previous sections, i.e., novelty and societal impact-based research, RRI and gender equality, multidisciplinary, and transdisciplinarity. In parallel, it also allowed for the research challenges to be expanded into full research proposals targeting competitive funding, as it comprised the main aspects usually found in European and national calls. The detailed formulation of the six research challenges can be found in TORCH Consortium (2022b), the titles of which are:

- SDG3-C1: Adult, child, and teenager participation in physical activity across Europe.
- SDG3-C2: Prevention of and preparedness for negative effects of climate change on vector-borne infectious diseases.
- SDG10-C1: Coping with digitalisation and the transformation of the world of work as a new source of inequalities.
- SDG10-C2: Designing better universities to fight against inequalities.
- SDG13-C1: Preventive water sustainable management of freshwater resources within a global change frameset.
- SDG13-C2: Mapping risks, joining funds, taking actions: fostering nature-based solutions to mitigate climate-related hazards.

Participatory process timeline. The ideation phase, conducted by the WG, to design the joint work plan and methodology was carried out in April–May 2021 (2 months). The participatory process, the subsequent steps of which are described above, then spanned from June 2021 to December 2021 (7 months), as described in detail below:

- Step 1. Identification of researchers and design of Q1: from June to mid-July 2021 (1.5 months). Q1 collection of responses: from mid-July 2021 to mid-September 2021 (2 months). Responding to Q1 took ≈15 min.
- Step 2: Q1 results analysis and institutional validation process: second half of September (0.5 months). Selection of researchers and design of Q2: first half of October 2021 (0.5 months). Q2 collection of responses: second half of October 2021 (0.5 months). Responding to Q2 took ≈25 min.
- Step 3: Q2 results analysis and design of focus groups: first half of November (0.5 months). Focus groups were held by mid-November 2021 (each one consisted of two sessions: first, preparatory, 1 h; second, expert discussion, 3 h).
- Step 4: Researchers draughting research challenges: from mid-November to December 2021 (1.5 months).

Further development of the research challenges. A completely successful strategy would result in the formation of researcher teams with the capacity to submit project proposals for competitive funding calls. Once the six challenges were produced, the WG encouraged the respective teams to develop their challenges further into full research proposals, for which the partner institutions provided support (administrative and organisational, matchmaking and identification of potential external partners, overseeing coordination of writing). This outcome was achieved for three of the six challenges, which were submitted to different European calls, with one being funded (Water4All call), one unsuccessful (Horizon Europe), one pending evaluation (MSCA-Doctoral Networks).

The method piloted here will feed into the development of the Alliance's future research strategy, since it proved to be an excellent foundation for assembling multidisciplinary teams, which could be replicated or scaled up to address other societal issues. CHARM-EU also gained valuable knowledge about the specific needs of researchers in terms of support for team and project proposal development, as described in the following section.

Conclusions and recommendations

This paper summarises the experiences of CHARM-EU, an inaugural member of the European University Alliances, in testing a procedure for conceptualising a unified research agenda to address societal challenges. The procedure is contextualised within the broader scope of the EUI, highlighting four critical dimensions: (1) research motivated by the pursuit of solutions to societal issues; (2) collaboration across institutions and borders; (3) interdisciplinary and transdisciplinary research; and (4) commitment to the principles of RRI.

We detail a strategy that merges top-down and bottom-up approaches, unfolding through four stages. The identification of societal challenges was conducted from the top down, with university leadership defining the primary directions and research area goals where institutions could leverage their competitive edge and expertise to deliver outstanding contributions. The resulting research networks were inherently international and spanned disciplines, yet their development was influenced by individual researchers indicating their research interests, thus ensuring bottom-up input into the process. RRI principles were integrated both from the top and from the bottom, guiding the formation of networks in a manner that was both comprehensive and balanced. The resultant R&I agenda relies on the complementarities of the Alliance to focus on SDG-driven challenges. Additionally, the challenges were strategically aligned with the CHARM-EU priority research areas, demonstrating a clear synergy with Horizon calls, as well as educational focus, thus further enhancing the initiative's relevance and impact. However, it is important to note that the priorities and specific topics resulting from this process are not a fixed list of items on which the Alliance partners should focus their research strategy, but illustrate a method that facilitates the definition of such a list. The challenges and problems societies face, following Kaldewey's (2018) terminology, are constantly evolving. Therefore, universities (and alliances) must develop structures and strategies capable of providing timely and robust responses. This idea reflects this paper's main aim: presenting a simple and replicable process that could be applied in other alliances, as well as in the future of CHARM-EU. This work thus fills a gap in the existing academic literature by offering a practical framework for interdisciplinary, transdisciplinary, and collaborative research in alignment with European Commission priorities and SDGs that have not been extensively documented before.

In our view, the process successfully contributed to defining a common science agenda for the Alliance, as it contemplates all four aspects identified as essential within EUI R&I endeavours: research driven by the quest for solutions to societal challenges; interinstitutional and international collaboration; inter- and transdisciplinary research; and adherence to RRI principles. Therefore, considering the increasing importance of the SDGs (Kastrinos and Weber, 2020), and the need for frameworks that facilitate their systematic introduction into curricula, research and partnerships, as noted by Leal Filho et al. (2021) and Avelar et al. (2023), the procedure presented here as a case study constitutes a practical tool for integrating them into institutional research strategies. Through the identification of a limited number of priorities, it also ponders the risk of exaggerating the number of SDGs being addressed at the same time when including them in HEI research plans (Avelar et al. 2023). Moreover, one of the method's primarily goals is to foster the creation of international and interinstitutional networks, as a key aspect for executing large-scale academic research projects and addressing global challenges, including the SDGs (Parikh, 2021; Lees et al. 2023; Okamura, 2023). Such scientific networks are, by nature, multidisciplinary, following the four-step methodology carried out to build them up, reflecting the critical role of transdisciplinary research in addressing global challenges and confronting complex societal issues (OECD, 2020; Pineo et al. 2021). In this sense, this simple procedure could contribute to establishing pathways that combine these two aspects (SDG-driven research and multidisciplinarity) and integrate all these goals into the policies and programmes of HEIs, hence addressing the lack of consensus, which is a major obstacle identified by Gonçalves Serafini et al. (2022) and Hong et al. (2023). Finally, the method's design pays attention to EDI aspects, both in terms of data collection (via questionnaires and focus groups) and through the draughting of research challenges (research challenges model), in an attempt to tackle the persistence of gender inequality in research-related activities (Cuthbert et al. 2023).

Nevertheless, obstacles were encountered throughout the process. The absence of prior scientific collaboration among the research teams proved a considerable hurdle for the WG. In terms of matchmaking and building consortia, it became evident that the interests of CHARM-EU partner researchers needed to be gauged beforehand. There was also a pressing need to incorporate additional project team members from outside the Alliance due to the lack of official or central university units willing to facilitate partnership requests. Furthermore, existing networks sometimes lacked multidisciplinary diversity, and there was a struggle to maintain a balanced representation of partners in terms of seniority and gender. Identifying and motivating suitable principal investigators proved difficult. When it came to support for proposal development, some teams faced challenges due to insufficient support with proposal writing and the pressure of tight deadlines, which hampered the development of effective working dynamics among researchers. Additionally, there were instances where expanding research teams to fill skills or knowledge gaps was not feasible.

When assessing the procedure and its outcome, a number of aspects appear to be key to refine its future application. From a methodological point of view, testing a participatory process and arriving at the definition of research challenges was already an achievement for the project. The experience of navigating through six distinct challenges led to a wealth of insights and actionable recommendations. The most significant outcome was the formation of CHARM-EU-centred consortia, as the challenges facilitated the creation of strong connections between researchers who had not previously collaborated. The experience, on the other hand, suggested that future proposals would greatly benefit from a pre-established programme of research interactions, such as seminars and meetings, to smooth collaboration among researchers. There is also a need for a systematic procedure to identify potential principal investigators for European projects. In order to make joint research support more efficient at an alliance level, the most significant requirements are related to: (1) enabling seamless communication between research support units, and working towards a joint research support structure; (2) strengthening the inter- and transdisciplinarity approach (establishing central links connecting discipline/faculty support units and involving external stakeholders); and (3) creating a joint system where research data can be registered and stored with the purpose of networking, partner searching, etc. Lastly, the

introduction of incentive schemes, whether at the university or alliance level, is recommended to motivate researchers to engage more actively in these collaborative efforts. These are now integrated into CHARM-EU's long-term R&I strategy, via a set of specific actions aimed at creating an innovative and transdisciplinary co-production environment that will function as a meeting place for researchers (matchmaking and networking facilitation), as well as encouraging and supporting common research proposals between CHARM-EU partners (and other societal and university partners).

These recommendations can be combined with those that resulted from the third TORCH Annual Forum "Science with and for Society in European Universities Alliances: Cross-Alliances Forum 2023", hosted by Université Libre de Bruxelles, which included representatives of 37 alliances and the European Commission (TORCH Consortium, 2023b). The future challenges in the research dimension of the European University Alliances, as identified at that meeting, include the need for continuous and sustainable funding to support joint research agendas and innovation activities. The short-term nature of existing projects and funding does not allow for institutionalisation. Policymakers need to collaborate to create comprehensive funding schemes, and the ERA policy agenda must align with the alliances' goals. Additionally, there are concerns about balancing excellence with the administrative and legal constraints that come with funding requirements.

These strategies can accelerate institutional change at R&I-intensive universities; their positive impact is expected to extend to institutions with a less pronounced focus on R&I, acknowledging the crucial role of transdisciplinarity and interculturality in devising innovative solutions. Research excellence requires an excellent R&I support structure that ensures RRI, along with broader societal engagement, to guarantee transdisciplinarity. Beyond alliance frameworks, R&I collaborations typically operate at the project level, lacking high-level joint institutional support. CHARM-EU provides an umbrella structure that facilitates multidisciplinary contact between researchers willing to tackle complex research questions, by leveraging external stakeholders and garnering support from strategic administrative units and university leaderships. This also increases the possibilities for researchers (especially those at early career stages) to boost their involvement in international cooperation networks. In addition, there is considerable potential to include the local ecosystems of the different partners.

Data availability

The questionnaires utilised in the participatory process described in this paper are fully available as supplementary materials. The datasets generated during the process are not publicly available in compliance with the EU GDPR, as they contain personal information pertaining to the participants.

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Notes

1 See Kaldewey (2018) to understand how the concept of "grand challenges" has influenced the framing and communication of agendas by scientists and policymakers.
2 CHARM-EU was created in 2019, within the first round of Alliances funded by the EC. It was also selected among the first round of Alliances to develop its R&I dimensions through a SwafS project (both funding initiatives are described in Section 2 below). Among other objectives, CHARM-EU aims to foster greater interaction and interconnections between the teaching and research missions of the universities, as several partners are research-intensive universities and members of LERU. More information on the Alliance can be found at: https://charm-eu.eu/.
3 See https://rea.ec.europa.eu/funding-and-grants/horizon-europe-widening-participation-and-spreading-excellence/european-excellence-initiative_en
4 See "Commission presents a blueprint for a European degree".
5 See call: Pilot institutionalised EU cooperation instruments to explore the feasibility for a possible European legal status for alliances of higher education institutions.
6 See https://education.ec.europa.eu/news/64-european-universities-alliances-now-active.
7 See https://charm-eu.eu/learning/educational-offer/master-programme/.
8 The app is available at https://charm-eu.eu/research-innovation/researchers-hub/bibliographic-and-collaboration-network-apps/.

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Author contributions

Supervision: RR, AD-G, VR. Conceptualisation: RR, AD-G, VR, JL (methodology was thoroughly discussed among the TORCH Working Group). Data acquisition and curation: JL. Data analysis: RR, AD-G, VR, JL (institutional validation was discussed among the TORCH Working Group). Writing (original draft): VR, CE, JL. Writing (review and revisions): JL, VR, CE, RR, AD-G.

Competing interests

The authors declare no competing interests.

Ethical approval

The questionnaires and their distribution among researchers were approved by the University of Barcelona's Bioethics Commission (ordinary meeting on 23rd July 2021) and ratified by Trinity College Dublin's Ethics Board, as well as by the Data Protection Offices of the other universities concerned (Utrecht University, Eötvös Loránd University, and University of Montpellier), in full compliance with the EU GDPR. The authors certify that the study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent

The data were collected through online surveys conducted during August 2021 and October 2021. The surveys were accompanied by a comprehensive privacy statement that respondents were required to review and agree to before participation. Consent covered participation in the survey, data processing details (e.g., types of personal data, purposes of processing, and methods), and publication of results. Respondents were informed of their anonymity, the research objectives, the intended use of their data, and that participation posed no risks. Consent was obtained in writing through explicit agreement to the privacy statement provided online. The privacy statement, compliant with GDPR (Regulation (EU) 2016/679), outlined the responsibilities of the data controllers—the CHARM-EU consortium—and provided contact details for data protection officers. The study did not involve vulnerable individuals, minors, or any form of payment or incentivisation. Participants were assured that their data would not be shared with third parties outside the TORCH project and would only be retained until project completion or earlier, upon withdrawal of consent. The supplementary material includes the complete set of survey questions supporting this research.

Additional information

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