GLOBAL RESEARCH COUNCIL

21st Century Public Engagement and Mission-orientated Research: **ADVANCING SUSTAINABLE FUTURES FOR ALL**

This book was authored by ***Professor Rasigan Mararajh,*** Professor and Chief Director of the Institute for Economic Research on Innovation at Tshwane University of Technology, and nodal head of the DSI/NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP) at Stellenbosch University, South Africa.

CONTRIBUTORS INCLUDE:

Dr Fulufhelo Nelwamondo, CEO, National Research Foundation (NRF)
Prof Andrew Thompson, Oxford University and former International Champion, UK Research and Innovation (UKRI)
Dr Aldo Stroebel, Executive Director, NRF and Co-Chairperson of the GRC Executive Support Group
Mr Michael Bright, GRC Executive Secretary, and Deputy-Director International (Global Partnerships), UKRI
Ms Dorothy Ngila, Director, NRF
Mr Benjamin Sharman, GRC Deputy-Executive Secretary, and Senior Policy Manager, UKRI

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ACRONYMS

AAAS	American Association for the Advancement of Science
AIRA	Africa Infodemic Response Alliance
ASTIII	African Science, Technology, and Innovation Indicators Initiative
COVID-19	Coronavirus Disease 2019
GCRF	Global Challenge Research Fund
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
GNI	Gross National Income
GRC	Global Research Council
IFAD	International Fund for Agricultural Development
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
MDG	United Nations Millennium Development Goals
NRF	National Research Foundation of South Africa
NSI	National System of Innovation
SDG	United Nations Sustainable Development Goals
STI	Science, Technology, and Innovation
UKRI	United Kingdom Research and Innovation
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations
UN-WOMEN	United Nations Entity for Gender Equality and the Empowerment of Women
WFP	World Food Programme
WHO	World Health Organization

FOREWORD

Fulufhelo Nelwamondo and Andrew Thompson

The Global Research Council (GRC) postponed its 9th Annual Meeting from 2020 to 2021 in response to the global COVID-19 pandemic. The pandemic presented a significant challenge requiring a global response and therefore many GRC Participant Organisations have been focused on mobilising the scientific and technological expertise, nationally and internationally, needed to address both the public health challenge, as well as its wider socio-economic impacts.

As well as addressing the pandemic, GRC Participating Organisations have been working to reduce the impact on the scientific community's ability to support the other important challenges we collectively face. There is potentially much we can learn from our response to the pandemic which might help inform our future approach to global challenges. The global research community now needs to come together to ensure those lessons are shared.

The pandemic has disrupted efforts to achieve the 2030 Agenda for Sustainable Development, and threatens to reverse years of progress on poverty, hunger, health care and education. As the GRC meets 'virtually in Africa' it is important to recognise that, while the virus has impacted everyone, it is affecting the world's poorest and most vulnerable the most. Greater collaboration across disciplines, sectors and international borders is required if we are to realise the decade of action to deliver the global goals. This will require new thinking and new approaches.

While trust in science and scientists remains high, it varies across different groups and countries/nations. The pandemic has highlighted these differences as well as the challenge of maintaining public confidence in science. The pandemic has shown how science is sometimes inconclusive, can take time to produce results, and that scientists inevitably do not always agree. Governments have implemented public health measures on the advice of scientists. Compliance with these measures by the public can be challenging, and science has had a key role in explaining why they are necessary.

In an age where the public wants information and solutions quickly, and where scientific expertise has sometimes been undermined for political purposes, there is a risk that public trust in science will be eroded. The pandemic has highlighted the need to consider more carefully the interplay between science and society, and how the scientific community engage and communicate with its various publics.

It is in this historical context, and with the thematic foci of the 9th Annual Meeting, that this book about Public Engagement and Mission-orientated Research has been compiled. A unique approach has been followed with the analysis and synthesis of 69 case studies, contextualised with the two themes, submitted by GRC Participating Organisations. The case studies reflect the diversity of GRC Participants whilst also representing a wide variety of approaches and practices. They also demonstrate the interplay of mission-orientated research with public engagement.

Research councils are agencies through which the relationship between the sciences and society (its publics) are mediated. They also have a role to play in establishing a process where this can take place. The global research community potentially has the capacity and capability to generate, translate and disseminate knowledge relevant to achieving grand challenges, working with policy-makers and other stakeholders to identify policy priorities/problems; assess options, implement solutions and evaluate their effectiveness; and translate the specific challenges, such as the Sustainable Development Goals, into measurable and country-specific targets.

However, while researchers already foster partnerships with peers, government and local communities in order to achieve scientific and societal impact, these interactions can often be ad-hoc, short-lived, e.g. for a project, or unsustainable. Longer-term and sustainable strategic partnerships are, therefore, needed to address these grand challenges. This may necessitate rethinking the ways in which knowledge is generated, validated, and accessed whilst reframing the role of science and technology as critical contributors to innovation and thereby development.

The book comprises five chapters and four annexures. An introductory essay presents a brief overview of the evolution of the contemporary conjuncture and locates the current dynamics within the literature of world systems analysis. The next chapter provides a brief account of the history of the GRC with a focus on the initial outcomes generated and the impacts created in its nine years of existence. Two subsequent chapters present the discussion documents on Public Engagement and Mission-orientated Research. These two chapters served to guide discussions in five regional consultations which were undertaken in 2019 and have been augmented with references to a number of case studies collated from the GRC Participating Organisations during 2019/2020. A concluding chapter summarises the learnings. The annexures present the final Statements of Principles, as well as a summary of the case studies collected.

CHAPTER 1: Emerging challenges evolving in the early 21st Century

Rasigan Maharajh

Never before in documented human history had global cooperation and collaboration in science enabled such a rapid mobilisation of significant human and other resources towards an international mission of arresting the spread of a virus and reducing the negative impacts of the pandemic on people and the societies they occupy. Notwithstanding such a remarkable achievement from research and development, the benefits emerging from science and technology remain unevenly distributed. The Secretary General of the United Nations, warned that "…defeating COVID-19, now that we have begun to have the scientific capacity to do so, is more important than ever" (2021).

This critical assessment by the UN raises the spectre of a socio-economic and political differentiation that would impact upon contemporary world systems. The World Bank segregates world systems according to "Gross National Income (GNI) per capita (current US$) calculated using the Atlas method[1]" and thereby determines four groupings of economies, namely high-, upper middle-, lower middle-, and low income countries. Utilising this classification system renders world systems as comprising 29 low-income countries, 50 lower middle income countries, 56 upper middle-income countries, and 83 high income countries. This hierarchical ordering system of the countries of the world according to their incomes provides a vivid snapshot of the combined, uneven, yet common world we currently occupy with increasing precarity. These income level categories also provide a possible proxy indication of the capacities, capabilities, and competences of the countries production systems.

COVID-19 and the prevalence of zoonotic viruses in our current context has been inextricably linked with the decimation of biodiversity at an accelerating pace and on a global scale. As reported by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), "Nature is declining globally at rates unprecedented in human history – and the rate of species extinctions is accelerating, with grave impacts on people around the world now likely" (2020). According to Peter Daszak, "…there is no great mystery about the cause of the COVID-19 pandemic – or of any modern pandemic. The same human activities that drive climate change and biodiversity loss also drive pandemic risk through their impacts on our environment. Changes in the way we use land; the expansion and intensification of agriculture; and unsustainable trade, production and consumption disrupt nature and increase contact between wildlife, livestock, pathogens, and people. This is the path to pandemics" (IPBES, 2021).

The UN had already convened its Conference on Environment and Development in Rio de Janeiro, Brazil in 1992. The 'Earth Summit' as it became popularly known, was seized by evidence of the interconnected environmental challenges of global warming, pollution and biodiversity and the social challenges of poverty, health, and population growth and mobility. The gathering committed to "a programme of action for sustainable development worldwide" known as Agenda 21 and also adopted the Rio Declaration on Environment and Development which comprised 27 principles (UN, 1992). A major guiding principle for development that was derived from the 'Earth Summit' is the notion of common but differentiated responsibilities. Whilst this principle would largely influence the various positions of the global South, the global North represented by the more advanced and mature capitalist countries such as the USA, Japan and those in the European Union, largely sought to relegate the concept to essentially environmental and climate change issues.

At the transition to the new millennium, a new set of international developmental goals was discussed and adopted.

1 *The World Bank's Atlas Method of Conversion replaces market exchange rates with a conversion factor which for "any year is the average of a country's exchange rate for that year and its exchange rates for the two preceding years, adjusted for the difference between the rate of inflation in the country and international inflation; the objective of the adjustment is to reduce any changes to the exchange rate caused by inflation" (https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-the-world-bank-atlas-method-detailed-methodology).*

The Millennium Development Goals (MDGs) lay down a set of targets based on eight international developmental objectives that were to be achieved before 2015 (UN, 2000). The MDGs had sought to generally redress conditions of absolute poverty and deprivations. Whereas it sought to enable a less inequitable international order, the shaping of the eight international development goals by the development financing instruments of the Bretton Woods Agreement saw them being implemented as mainly objectives of and for the global South. This was largely the consequence of the MDG's focus on poverty reduction. Work on the successor regime began in 2011. This post-MDG package is radically different from the previous two iterations (Agenda 21 and the MDGs). The successor regime to the MDGs is a range of sustainable development goals (SDGs). These were eventually drafted in seventeen goals with 169 targets adopted by the UN's General Assembly in 2015. According to the UN, "The central challenge in designing the post-2015 development agenda is to ensure that efforts to improve the quality of life of the present generation are far-reaching, broad and inclusive but do not compromise the ability of future generations to meet their needs. Accomplishing this goal hinges on the ability of the international community to ensure access to resources for growing numbers of people, eradicate poverty, move away from unsustainable patterns of consumption and production, and safeguard the environment" (2015).

As argued by the United Nations Conference on Trade and Development (UNCTAD), "…this is a very important part of the challenge, but for a developing country, the question is whether its development can be sustained not only environmentally but also economically, financially, socially, politically and so forth. A true development agenda can only be based on this broader, developmental concept of sustainability – ensuring that development can be sustained in all its dimensions, rather than only seeking to minimize environmental impacts. This again points to a more integrated agenda, encompassing both more viable and inclusive national development strategies and changes in the global economic system to accommodate and support them. If progress towards social and environmental goals is not underpinned by effective national strategies for sustainable and inclusive development, or if the global economy is incompatible with such strategies, that progress will not be sustainable beyond 2030" (2013).

The UN has argued that "…mainstreaming STI into other SDGs appears to be a necessary complementary requirement for promoting knowledge-sharing and for building capacity to face the multiple challenges posed by sustainable development. Many statistics and indicators on STI related issues are available, but they rarely connect or measure the input of STI in achieving development goals. In the light of the complexity of STI, knowledge-sharing and capacity-building and their multiple impacts on and contribution to sustainable development and poverty eradication, a series of goals, targets and indicators could usefully be considered" (UN, 2014: 7). As argued by Steffen et al, "…there is an urgent need for a new paradigm that integrates the continued development of human societies and the maintenance of the Earth system in a resilient and accommodating state" (2015: 736).

Linking science and technology to innovation has unleashed creative destruction at unprecedented levels. Whilst much of these benefits have tended to improve the material conditions of existence for large numbers of people, capitalism and the international political economy have also impacted in defining access and participation. Thus, whilst our overall aggregate productivity has increased to a level that ensures that the necessities of living such as food, shelter, and bulk infrastructures are readily available, all of the peoples of the world do not share in the bounty. Financialisation and neo-liberalism have broken the virtuous circuit between the realisation of surpluses and their re-investment in productive capability formation. Recent evidence shows that countries are variously adopting policy frameworks that seek economic stimulation, fiscal austerity and environmental sustainability without unpacking the detrimental and counter-factual effect of the capitalist requirement for infinite growth. It is the structural relationship between people and planet that requires much more public engagement to enable truly progressive transformations.

Homi Kharas of the Brookings Institute recognises that "…scientists and engineers are needed to introduce the innovations that could reduce climate change (and indeed to achieve many of the other SDGs)" (2016). Kharas argues this perspective in the context of the shift from intergovernmental global agreements to a new theory of change based on the uses of "…market forces to drive business towards scalable investments that simultaneously generate sustainable solutions to development challenges; [the creation of] more data from more sources with more disaggregation, and make these more easily transparent and accessible, to drive towards evidence-based reforms and accountability; and [the encouragement of] innovations (technical, organisational, and business-model) to drive the world away from business-as-usual" (ibid.). Jayati Ghosh has recently shown how the Marianna Mazzucato' work advocates "… a 'mission' approach to address society's complex challenges and to transform capitalism, enabling a more just and sustainable trajectory" (2021). Whilst it remains debatable about the extent to which a more benign and equitable capitalism is indeed possible or even attainable, it is clear that the challenges for science and technology are of such critical important that a paradigmatic shift is urgently required. This may necessitate also rethinking the ways in which knowledge is generated, validated, and accessed whilst reframing the role of science and technology as critical contributors to innovation and thereby development.

Mazzucato defined mission-oriented innovation policies as "…systemic public policies that draw on frontier knowledge to attain specific goals" (2018). In a study of the economy of the USA between 1947 and 2018, Matteo Deleidi and Mariana Mazzucato found that "…a permanent increase in public expenditures, targeted toward strategic sectors and focused on the promotion of innovation and mission-oriented innovation policies, generates the largest effect in terms of output and investment growth" (2021). This research finding provided further support for the idea that "…targeted innovation policies produce a strong and direct effect on the R&D investment decisions of firms, leading to new directions for technical change" (ibid.). Complementing the mission approach has been widening public engagements, and the rise of 'citizen science[2]' amongst other forms of participation and inclusion.

Public engagement processes emerge from earlier attempts across history of broadening the participation and access by non-professionally trained people with the praxis of science and was very prominent in the various 'people's science' movements and initiatives that sought to tighten the relationship between science and society in the 20th Century. According to Cesnulaityte, "…polarisation, populism, and low levels of trust in governments have prompted academics, practitioners, politicians, and policy makers to reflect upon innovative ways of breathing new life into democratic institutions" (2021). Leading peer-to-peer theorists, Michel Bauwens and Vasilis Kostakis argue that the enabling ICT infrastructures are affording society the opportunity to rise above the seeming paradoxes and suggest "…a new convergence that would combine both commons-oriented open peer production models with common ownership and governance models, such as those of the co-operatives and the solidarity economic models" (Bauwens & Kostakis, 2014). Such optimistic possibilities have to however be reconciled against objective realities of the contemporary conjuncture. Inappropriate and irrelevant proprietorship in the face of a ubiquitous digital integration appears almost quixotic. The inability to maintain secrecy of data and the widening of capability formation across the developing world offers new impetus for rekindling international collaborations in science and technology.

Speaking at the launch of the Africa Infodemic Response Alliance (AIRA), the Regional Director of the WHO for Africa: Matshidiso Moeti, cited data from the UN's Secretary-General's initiative on big data and artificial intelligence which showed that "…information about the virus has been shared and viewed over 270 billion times online and mentioned almost 40 million times on Twitter and web-based news sites in the 47 countries of the WHO African Region between February and November 2020" (UN, 2020). According to Moeti, "…in health emergencies, misinformation can kill and ensure diseases continue to spread. People need proven, science-based facts to make informed decisions about their health and wellbeing, and a glut of information – an infodemic – with misinformation in the mix makes it hard to know what is right and real. This crucial new alliance brings unique reach, knowledge and skills to help stop the impact of dangerous misinformation" (WHO Africa, 2020). Redressing the infodemic requires urgent attention to both public engagements with science as well as incorporation into the framing of science missions.

2 *Variously also known as crowd science, crowd-sourced science, civic science, volunteer monitoring, or networked science.*

Contemporary world systems are marked by conditions of physical over-production, material under-consumption, and an infodemic of fake news and deliberate misinformation. Whilst overall improvements in the aggregate material living conditions of humanity are evidenced as resulting from the extension of the provision of various public good infrastructures including water supply, housing, electricity, transport connections and a wide range of essential products and cultural activities, these are unfortunately not universalised. Globalisation has enabled higher levels of interdependence through international linkages in global commodity chains of production, distribution, and consumption. The expansion of the internet and online connectivity has also accelerated the rate at which information becomes available and is diffused across world systems. Whilst both of these characteristics offer some succour for increasing international collaboration and cooperation, they can also generate negative outcomes and impacts as well. The cumulative impact of human activities on the planet's ecosystems and its biodiversity presents a clear and near existential threat to continued human survival. The spread of false information has contributed to increasing hesitancy amongst significant segments of society with respect to COVID-19 vaccines.

In all of this, we can clearly see that it is not necessarily our home planet that is at risk, but rather ourselves as a species-being. As we advance further into the 21st Century, it is imperative that we acknowledge, nurture, and extend the role and function of science as a major contributor to the global knowledge commons. Science will enjoy the deepest and most enduring legitimacy possible from a closer connection with society and relegate alternative facts to the dead-end portended by post-truth[3].

3 *Oxford University Press announced its choice for Word of the Year in 2016 as the adjective 'post-truth', which was defined as "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief" (OUP, 2016).*

CHAPTER 2: The Global Research Council - Historical and Contextual Evolution and Outcomes and Impacts to Date

Michael Bright and Aldo Stroebel

The Global Research Council is a virtual organisation, comprised of the heads of science and engineering agencies from around the world, dedicated to promoting the sharing of data and best practices for high-quality collaboration among funding agencies worldwide.

Established in 2012 following a Global Summit on Merit Review[4] organised by the United States National Science Foundation, heads of research councils from over 50 countries agreed and endorsed its first Statement of Principles on Merit Review at this Summit. These were developed with two primary objectives. Firstly, the worldwide agreement on core, high-level principles would foster international cooperation between funding agencies that support the scientific community. Secondly, for those countries that are developing new funding agencies, the principles would provide a global consensus on the key elements necessary for a rigorous and transparent review system.

Since then the GRC has continued to meet annually, convening the heads of the main research councils internationally to discuss issues of common concern. Since 2012, it has published several Statements of Principles on topics ranging from Merit/Peer Review; Research Integrity; Supporting the Next Generation of Researchers; Open Access; and Interdisciplinarity to Assessing and Evaluating the Impact of Research. All Statements of Principles are published on the GRC website and have informed policy development in several participant organisations.

In recent years the Global Research Council has begun to revisit previous topics, to share learning and good practice in their development and implementation; consider barriers to implementation faced; and deliberate on any updates needed to its Statement of Principles and for further actions that might be required. In 2018, the Global Research Council returned to the topic of Merit/Peer Review and endorsed an updated Statement of Principles on Peer/Merit Review.

When developing and strengthening their own national research funding structures and institutions, countries often look to learn from international good practice. The GRC's discussions and activities provide a forum to promote and encourage interagency learning and institutional capacity building. It has established two Working Groups on Gender and Partnered Learning, and in 2019 the GRC published its first booklet, produced by the Gender Working Group entitled *Supporting Women in Research: Policies, Programmes and Initiatives Undertaken by Public Research Funding Agencies*[5]. The case study booklet is a significant contribution in furthering mutual learning amongst Global Research Council participants and across the sector, by showcasing actions various participants are taking to further the quality and status of women in research.

During its first nine years the Global Research Council has established itself as an effective forum for dialogue among participants, with good representation from across its Regions, and between developing and developed nations. It is becoming a recognised 'brand' across the international research policy and funding community, and provides an ongoing forum for the discussion of important science policy issues to improve the environment for international cooperation and collaboration.

In 2019, at the São Paulo meeting, several GRC participants expressed a need to more proactively promote multilateral collaboration between participant organisations. The Sustainable Development Goals were identified as a potential

4 *https://www.nsf.gov/news/news_summ.jsp?cntn_id=124178*

5 *https://www.globalresearchcouncil.org/fileadmin/documents/GWG/GRC_GWG_Case_studies_final.pdf*

framework to shape and guide dedicated support for international research cooperation.

The GRC is, therefore, ideally placed to help foster a common understanding and approach towards mission-oriented research to support the delivery of the SDGs. As a virtual organisation, the GRC brings together research funding agencies from across the world. This unified approach is needed to effectively address the challenges associated with establishing a concerted approach towards collective and dedicated action.

In addition, the GRC aims to not only improve communication and cooperation among global research funding agencies but also to promote the sharing of best practice and data to support high-quality collaboration among funding agencies worldwide. Ensuring that funding agencies and wider stakeholders within the research and policy landscapes have access to this best practice, and the data that underpins them, is crucial in shaping how best to proceed as a collective.

A collective voice and approach towards action will not only ensure that funding agencies are aligned strategically, but also help leverage and influence policymakers and decision makers who ultimately shape wider national and supranational approaches towards these challenges.

Finally, the GRC seeks to respond to opportunities and to address issues of common concern in research and education and explore mechanisms that support the global science enterprise and broader global scientific community. Addressing the grand challenges of today are, therefore, in line with this vision for the GRC and can provide a framework and overarching aim for continuing cooperation and dialogue between its participants.

CHAPTER 3: Public Engagement With and For Science

Rasigan Maharajh and Dorothy Ngila

1. INTRODUCTION

The approach to Public Engagement adopted in this chapter primarily seeks to encourage an increased utilisation of science in addressing social, economic, and ecological challenges confronting humanity in the 21st Century. It also recognises the imperative of redressing perceptions of a deficit in trust between the multiplicity of publics and the enterprise of sciences through re-establishing and expanding confidence in scientific practices (albeit, more in some disciplines than in others)[6]. As elucidated in an editorial in Nature: "...that means that any attempt to use a *Pugwash*[7]*-style approach* to address today's pressures should be strengthened by recent understanding of the importance of inclusivity – with a meaningful role for public engagement – and a place at the table for researchers from diverse backgrounds and from across disciplines, not only science and engineering" (Nature, 2019: 153)[8].

The chapter focuses on two main issues, namely:
The role and motivation of public funding agencies in mediating existing and potential tensions between science and society (its publics) in the context of broad and intricate complexities confronting the peoples of the world; and
Reflections on expectations, approaches and good practices for public engagement that support the utilisation of public engagement as a strategy and mechanism by research councils to better enable a seamless interaction between science and society (its publics) and thereby to bridge the gap between them.

This chapter examines critical aspects of the contemporary conjuncture, elucidated and linked to the work of GRC participants. It also defines public engagement in the context of Responsible Research and Innovation, and further connects the original discussion paper on the topic (developed during 2019) with case studies drawn from members of the GRC.

2. THE CONTEMPORARY CONJUNCTURE: COMPLEX INTERCONNECTEDNESS IN TIMES OF ACCELERATED CHANGE

The human population is unevenly distributed across the regions of the world. Notwithstanding individual and social location, all the peoples of the world are increasingly being confronted by accelerated changes in their bio-physical environments (IBES, 2019)[9]. As noted by the Stockholm Resilience Centre, the changes in the environment have a relationship with the type and form of socio-economic and political development being pursued by all the countries of the world (Steffen et al., 2018)[10]. In approaching the third decade of the 21st Century, urgent attention is required to

6 *Heidi Ledford draws upon a recent Pew Survey (2 August 2019) to assert that "...confidence in researchers might be on the rise but concerns about misconduct and potential conflicts of interest remain" (Ledford, H. 2019. US trust in scientists is now on par with the military, Nature News, 6 August). Ledford summarises that "survey participants who had more knowledge about science had greater confidence that researchers act in the public interest. And people reported that providing open access to data, as well as conducting independent reviews of research findings, would boost their confidence in the results" (ibid.).*

7 *Cf. The Pugwash Conferences on Science and World Affairs which drew upon the Russell-Einstein Manifesto of 1955 to engage critically about the existential threats posed by nuclear weapons to life on earth. Pugwash has just completed its 12th Quinquennium in 2018. More details are available at: https://pugwash.org/.*

8 *Editorial. 2019. Scientists must rise above politics – and restate their value to society, Nature 572(7768): 153.*

9 *IBES. 2019. Global Assessment on Biodiversity and Ecosystem Services: Summary for Policymakers, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn.*

10 *Steffen, Will; Johan Rockström; Katherine Richardson; Timothy M. Lenton; Carl Folk; Diana Liverman; Colin P. Summerhayes; Anthony D. Barnosky; Sarah E. Cornell; Michel Crucifix; Jonathan F. Donges; Ingo Fetzer; Steven J. Lade; Marten Scheffer; Ricarda Winkelmann; and Hans Joachim Schellnhuber. 2018. Trajectories of the Earth System in the Anthropocene, PNAS 115(33): 8252–8259.*

redress the unevenness in the quality of life experienced by the peoples of the world, and also to improve the quality of outcomes and impacts generated by scientific enquiry. The UN's Conference on Sustainable Development sought to reconcile the challenges of human and social development within planetary boundaries through the publication of a non-binding statement entitled *The Future We Want*, and which was endorsed by 192 participating governments in 2012[11]. The latter mentioned process also gave rise to the formulation of seventeen sustainable development goals (SDGs)[12] for the world system.

SDGs require good quality data and the availability of research capacities, scientific capabilities and innovative competences in the various National Systems of Innovation (NSIs). Research Councils that fund science for the public good are central to the provision of objectively verifiable evidence and the generation of scientific and technological capabilities in their respective NSIs and also for the global knowledge commons. Counterfactually, the rapid emergence and accelerated diffusion of alternative 'facts' and the emergence of 'post-truths'[13] have served to negatively impact on the public's levels of trust in the enterprise of science. Research councils are often the agencies through which the tensions between the sciences and society (its publics) are possibly mediated whilst further advancing improved accountability for the investment of public resources and increasing the legitimacy of scientific praxis with society (its publics). Research councils not only have a role to directly mediate these relationships but also to ensure that a system is established where this mediation becomes intrinsic to the research process.

Efforts that seek to legitimise scientific praxis are also advancing though remaining imbued with ambiguities and differing definitions derived from national experiences and global circumstances. The realm of the public engagement in the sciences is, therefore, also not excluded from present disagreements, dissonances, and incoherencies in world systems. Vincent's analysis of 'public engagement' in the sciences recognises the concept as a buzzword which forms linguistic technologies, and which specifically "…generate matters of concern and play an important role in trying to build consensus; … set attractive goals and agendas; [and] … create unstable collectives through noise" (2014)[14]. Motala defines 'socially engaged or public scholarship' as that which is "…derived from the co-construction of knowledge out of meaningful engagements between academics and the 'communities' and 'publics' of the university – especially such communities that are 'outside' the university but reliant on the useful roles that can be played by critically thinking intellectuals in institutions of higher learning" (2014: 1)[15]. Some research councils are already invoking 'citizen science' as potentially linking earlier attempts at broadening the participation and access by society and the sciences such as the people's science movements and initiatives such as Science for the People, the Union of Concerned Scientists, Scientists for Global Responsibility, Science and Democracy World Forum, Citizen Science Foundation, and the BurGErschaffen WISSen (GEWISS), amongst others. Research councils are considering various forms of public engagement in the ex-ante and ex-post evaluation phases, and in fulfilling additional mandates. In doing so, research councils increasingly need to ensure that the boundaries of sciences are clearly demarcated and the interface with society stabilised through their practice of establishing common sets of principles and good-practice guidelines.

11 *UN. 2012. The World that We Want, Outcome Document of the United Nations Conference on Sustainable Development, Rio de Janeiro.*
12 *UNGA. 2015. The 2030 Agenda for Sustainable Development, Resolution 70/1, United Nations General Assembly, New York.*
13 *The Oxford English Dictionary recognised 'post-truth' as its 'Word of the Year' and defined it as 'relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief' in 2016 (cf. NACI, 2017; amongst others).*
14 *Vincent, Bernadette Bensaude. 2014. The Politics of Buzzwords at the Interface of Technoscience, Market and Society: The Case of 'Public Engagement in Science,' Public Understanding of Science 23(3): 238–253.*
15 *Motala, Enver. 2014. Public Scholarship, Democracy and Scholarly Engagement, Education Policy Consortium, Department of Higher Education and Training, Tshwane.*

3. RESEARCH COUNCILS AND PUBLIC ENGAGEMENT

According to Dai et al., funding agencies and researchers have historically constituted the role of leading actors in defining research priorities and setting science agendas (2018)[16]. Dai and colleagues, however, note that "…these processes have been criticised as having insufficient public engagement although there has been a growing trend of involvement of a diverse range of actors, especially in research sectors such as health, environment and urban planning" (ibid.). The working paper of the Organisation for Economic Cooperation and Development (OECD) drew on a study conducted by Mitton et al., funded by the Canadian Institutes of Health Research, which found that "…there is a very substantial body of literature from the past quarter-century exploring questions of public participation in priority setting and resource allocation. Much of this is conceptual, theoretical, or advocacy-oriented, but an increasing number of empirical case studies have been published" (2009: 226)[17].

A more recent study of 17 science granting councils[18] in sub-Saharan Africa found that research councils "…are essential actors in national systems of innovation" and "…perform a number of crucial functions that contribute to the effective and efficient functioning of [national systems of innovation] such as disbursing funds for R&D; building research capacity through appropriate scholarships and bursaries; setting and monitoring research agendas and priorities; advising on science, technology and innovation policies; managing bilateral and multilateral S&T agreements; assessing the communication, uptake and impact of publicly funded research; and many more" (Mouton et al., 2014: 8)[19]. The study also found that "…such councils ideally act as fair and disinterested agents of government whilst at the same time representing the interests of the scientific community nationally as well as regionally and internationally" and that "…they are crucial 'intermediaries' in the flow of international funding and technical support to R&D performing institutions in a country" (op cite.). Table 1 lists the twelve areas in which Research Councils typically operate.

16 *Dai, Qian; Eunjung Shin and Carthage Smith. 2018. Open and Inclusive Collaboration in Science: A Framework, OECD Science, Technology and Industry Working Papers 2018/07, Organisation for Economic Co-operation and Development, Paris.*
17 *Mitton, Craig; Neale Smith, Stuart Peacock, Brian Evoy and Julia Abelson. 2009. Public Participation in Health Care Priority Setting: A Scoping Review, Health Policy 91: 219–228.*
18 *Research Councils include variations in nomenclature such as: science granting councils; national commissions for science and technology; national sciences councils; and national academies of science (Mouton et al., 2014). This Chapter, and the Discussion Paper, treated them all with equivalence.*
19 *Mouton, Johann; Jacques Gaillard; and Milandré van Lill. 2014. Final Report: Study on Strategic Priorities, Objectives and Practices of Science Granting Councils in Seventeen Countries in Sub-Saharan Africa, Centre for Research on Evaluation, Science and Technology, Stellenbosch University, Stellenbosch.*

Table 1. Typical Functional Areas of Research Councils

1. Disbursement of research grants (various categories);
2. Disbursements of scholarships and loans (mostly Master's and Doctoral students);
3. Funding support for infrastructure development;
4. Valorisation of results (dissemination and uptake of research reports and findings);
5. Supporting scientific publishing/scientific journals;
6. Advocacy to the STI;
7. Collect data and statistics on S&T and R&D;
8. Capacity-building/training of researchers;
9. Policy advice;
10. Setting research agenda/research priorities;
11. Management of scientific collaborations and agreements; and
12. Coordination of the [National System of Innovation].

Source: Mouton et al., 2014: 10

Whilst the first three mentioned functional areas essentially fulfil traditional science funding responsibilities, the other eight functional areas broaden and widen the mandates of the research councils. Thus, in many contexts, the criticality of the research councils in ensuring the functioning of their respective NSIs are neither insignificant nor trivial. It is therefore imperative that the research councils in their role as intermediaries between the society in general and the science and technology practitioners in particular pay closer attention to enabling public engagement. The demand for such functionality is buttressed by various global, regional, and domestic surveys that reiterate a significant reduction in the levels of trust amongst people and the domains of the sciences.

Many research councils have already embarked on advancing public engagement. As noted by Venni Krishna, "…every Asia-Pacific country embraced and introduced policies relating to innovation in varying forms. Consultancy and collaborative links with industry being traditional forms of engagement, new policy, and institutional measures in technology transfer and innovation to engage with society and business enterprises are gaining prominence" (2019: 11)[20]. Australia sought "…to develop the relationship between science and society, and thus enable the sciences to achieve greater value by creating 'a scientifically engaged Australia'. By this we mean a society that is inspired by and values scientific endeavour, that attracts increasing national and international interest in its science, that critically engages with key scientific issues and that encourages young people to pursue scientific studies and careers" (Australia, 2010: 2-3)[21]. South Africa also declared that "…to fully realise the social, economic, and environmental benefits of the significant investment in science, research, and innovation, […] a country must communicate and engage the wider community more fully in science and in an understanding of the knowledge economy to which [it] aspires" (NRF, 2012)[22]. These statements resonate well with the definition of public engagement as "…intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public" (CPEST, 2019)[23]. The importance of learning as a cooperative venture that enables both the public and the community of scientists and technologists to realise mutuality and co-dependency is highlighted. Figure 1 provides a visual model to illustrate public engagement:

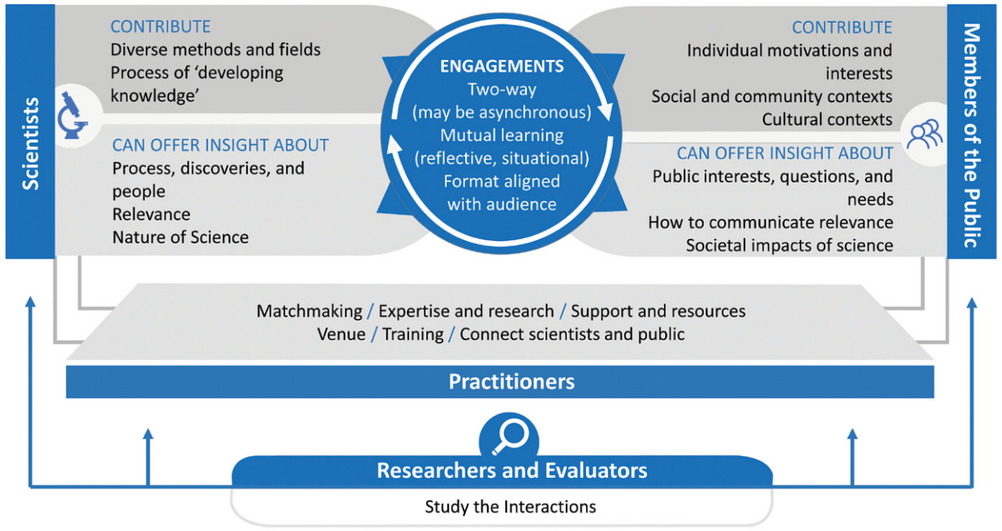

Figure 1. AAAS Visual Model of Public Engagement with Science
Source: CPEST, 2019

In Figure 1, the participants in public engagement are scientists and the public (scientists are also members of the public). In some NSIs, a range of 'practitioners' who have specialist capabilities in facilitating learning, networking, and generally connecting sciences with society operate between scientists and the public. Such intermediaries are important and necessary stakeholders but may, however, be insufficient for the complexities of our combined, uneven, yet common global conjuncture. It may therefore be necessary to prescribe the core publics as scientific communities, civil society and the policy apparatuses of government (CAISE, 2009)[24].

The eminent innovation scholar, Mariana Mazzucato, has argued that "…even though the nature of missions requires that they be selected at the political level, the selection process must have a strong element of public involvement. This is both because innovation benefits from multiple and diverse influences, and also because without civic engagement, the risk of alienation from the broader public and a purely technocratic approach is too high. A mission will not inspire people unless they are part of it. A rigorous process of evaluation is needed to ensure continuing relevance and commitment and to prevent selection being captured by either passing fashion or vested interests" (2018: 21)[25]. Research councils also fulfil a custodial function with respect to the provision of public goods and services in the sciences which are often specified in their legislated mandates which ostensibly seek to promote and sustain scientific enquiry. It is incumbent upon them to also prescribe guiding principles and good practices to facilitate and encourage wider and deeper engagements with sciences. Processes of public engagement convened and coordinated by research councils should be sufficiently broad-based and not captured by specific corporate interests such that no 'publics'

20 *Krishna, Venni V. 2019. Universities in the National Innovation Systems: Emerging Innovation Landscapes in Asia-Pacific, Journal of Open Innovation: Technology, Market, and Complexity 5(43): 1-21.*
21 *Australia. 2010. Inspiring Australia: A National Strategy for Engagement with the Sciences, Department of Innovation, Industry, Science and Research, Commonwealth of Australia, Canberra.*
22 *NRF. 2012. Science Engagement, National Research Foundation, Tshwane and also: RSA. 2015. Science Engagement Framework, Department of Science and Technology, Tshwane.*
23 *CPEST. 2019. Many Approaches to Public Engagement, Center for Public Engagement with Science and Technology, American Association for the Advancement of Science, Washington DC.*
24 *CAISE. 2009. Many Experts, Many Audiences: Public Engagement with Science and Informal Science Education. A CAISE Inquiry Group Report,*
25 *Mazzucato, Mariana. 2018 Mission-orientated Research & Innovation in the European Union- A Problem-solving Approach to Fuel Innovation-led Growth, European Commission, Brussels.*

are excluded from processes. Each 'public' may require that the research council utilise specific strategies that best serve the needs and requirements of that 'public'. Research councils constitute the main intermediary between the nexus of the sciences, policies, and the publics. Many research councils have already embraced thus far an increased focus on science education, science awareness, and science communication activities whilst also examining their explicit expectations for evaluation of public engagement during ex-ante evaluation processes of research projects. Research councils are, therefore, inextricably bound to facilitate public engagements as a means towards improving their performance as well as improving the functionality of their NSIs. Table 2 presents a logic model for public engagements with science as developed by the American Association for the Advancement of Science (2016)[26]:

Table 2. AAAS Logic Model for Public Engagement with Science

Inputs	Participants & Activities	Short-term Outcomes	Medium-term Outcomes	Long-term Outcomes	Vision
Research Evaluation Practitioners Leadership programmes Support to scientists Communication and engagement training Institutional support for scientists and publics Funding (incl. broader impact and other funding requirements) Strategy of communication	Participants Scientists Publics Practitioners Activities Public dialogue approaches Policy deliberation approaches Knowledge co-production approaches University-led cooperative engagements approaches Everyday engagements	Scientists humanized/public individualized	Build trust between publics and scientists	Build trust between publics and scientists	Sound, evidence-informed public decision-making on science-related issues Dialogue on critical science-society issues embedded in public discourse Influence individual and collective action and behaviour Influence policy Influence research agenda Research that is responsive to societal/ needs and interests Resilient STEAM workforce Science embedded in daily life
		Positive effect	Longer-term positive effect about science	Long-term positive effect	
		Increased sense of public engagement identity	Shared appreciation of public engagement Do more and better engagement (more able and comfortable) Build relationships to continue public engagement with science	Engagement is part of work and life (protocols, plans) in strategic and reflective ways Institutional change	
		Intention to act or engage again Increased skill/ ability to engage critically Increased self-efficiency	Act on something from engagement Be ready to advocate/ amplify Increased preparations to engage between science and society	Shared scientific or social content and understanding with networks	
		Increased interest and motivation around topic	Increased willingness to consider science-society intersections	Improve goals or focus of research Hear/understand others' views about science	
		Increased understanding of the process of science and social institutions	Increased ability to discuss science-society intersections	Frame science to be relevant to publics Framing knowledge outcomes for use by scientists and decision-makers	

Source: Adapted from AAAS (2016)

As noted by PERFORM, "…effective science communication to the academic community, the larger public and to policy makers has become an important aspect of research. While research institutions across the world demand greater output and impact, the support for achieving this goal is often left to individual researchers with little guidance,

26 *AAAS. 2016. Theory of Change for Public Engagement with Science, American Association for the Advancement of Science, Washington DC.*

training and support" (2018)[27]. Research councils increasingly perform outcomes-based assessments which seek to measure the realisation of impacts arising from their investments in research and development. As depicted in Table 2, various inputs from the sciences are transformed through the activities of participants into outcomes that are stratified according to time. The AAAS's logic model suggests that successful and meaningful public engagements improve that performance of NSIs through enabling increased participation, redressing systemic and institutional exclusion, and ensuring alignment with relevant and quality public knowledge goods and services. Such practices by research councils allows them to further entrench sciences in the daily lives of the various publics, enables the flow of information into the policy domain, and thereby effect an improved perception of the utility of sciences in society in general.

4. EXAMPLES OF PUBLIC ENGAGEMENT INITIATIVES OF GRC PARTICIPATING ORGANISATIONS

The call for case studies in Public Engagement with Science generated 42 submissions from GRC Participants, summarised in Annexure 3.

The case studies received reflected the diversity of GRC Participants whilst also representing a wide variety of approaches and practices. The location of a GRC participating organisation played a particularly determining function as noted in the Saudi Arabian contribution which suggested that its public engagement with science activity sought "increasing qualified national competencies to support the development of local content". Such enlightened self-interest is further reflected in the case study from Oman which specified "…most of the barriers are the cultural challenges as the concept of engaging the public in the form of co-learning and co-production of knowledge is still at the infancy stage. The project team is applying a multidirectional approach to enhance public participation, which include the following: (1) awareness through social media; (2) adding the formal dimension to the participation by communicating with the management to nominate the participants; and (3) maintaining continuous presence at media in order to retain the public interest as well the linkage with the project".

The participants of the GRC self-categorised their case studies according to a list of nine possible types. Notwithstanding that all submissions were not filtered according to the common typology, the overwhelming majority did, and the results are presented in Table 3.

Table 3. Categorisation of Case Studies

Type of Activity	# of Cases
Science Education and Career Awareness Approaches	15
Public Dialogue Approaches	7
Public Engagement, Network Development and Support	5
Integrated Public Engagement Initiatives	3
Resourcing (Including Funding) for Public Engagement	4
Knowledge Co-Production Approaches	1
Citizen Science Approaches	3
Human Capital and Skills Development Initiatives for Public Engagement	1
Policy Deliberation Approaches	3

As is clearly discernible in the Table, the majority of public engagement cases submitted were categorised as being science education and career awareness approaches. Public dialogue approaches, public engagement network development and support, integrated science engagement initiatives, and resourcing (including funding) for public engagement types

27 *PERFORM. 2018. Understanding Current Practices of Science Communication in Serbia and Albania: Recommendations for Enhancing Effectiveness, Swiss Agency for Development and Cooperation, Belgrade.*

The results and evaluations of these initiatives delivered a variety of valuable insights such as in the case from Japan that demonstrated the possibilities arising from "…bringing into consonance with those people involved what we specifically do." Another positive was noted in a case from Sweden which resulted in "…synergies between public engagement and open science [being] identified". A case study from Germany led to an assertion that "…when the need arises, the DFG also speaks out in cooperation with other scientific organisations and comments on current political events". Numerous further reflections, insights, and learning are contained in the case studies submitted.

With respect to barriers to public engagement activities and initiatives, South Africa and Chile experienced challenges with recruitment as noted in the Chilean submission which specifically identified the "…recruitment of students from rural areas and vulnerable students". A Japanese case suggested that "…no funding/no prize money in this initiative could be a barrier for applicants" whilst another from Japan argued that "…the fund which was primarily collected to implement the initiative has been decreasing each year. Thus, one of the challenges to the initiative is to spark interest among various stakeholders including business communities". In the case study from Brazil, an innovative co-determination was constituted and reflected as "…jointly supporting a project between two research funders require agreement on all aspects related to the call for proposals, its review and the selection of successful projects".

The USA's cases raised the lesson of "…a challenge for U.S. federal government agencies is to simultaneously balance citizen science participation with privacy and security in data release", whilst in Japan appropriateness and relevance was surfaced in the learning that "…it was difficult to design a discussion session on basic science in a way that would attract the audience. Thus, the demonstrations such as a performance of robots and a space food tasting were incorporated into the session to make it more appealing". A further critical point embedded amongst the Japanese case studies was the question of language and is reflected in the learning that "…in presenting frontline research in English, it is difficult to deliver a lecture in a clear and more comprehensible way to young audiences. Thus, we are encouraging fellows to share good practices".

As public engagements with science are not necessarily demarcated by strict definitional boundaries such as those imposed by the categories of educational subject matter, Belgium suggested a further progressive lesson arising from "…finding a good mix of reviewers that can assess the two axes of the programme: the scientific quality as well the utilisation. External peer review and meta-review panels are done by a mixture of academics and experts from industry/societal stakeholders". Such a wide and variegated set of case studies offers much to the GRC and offers a segue to some concluding considerations on public engagements in science.

4.1 Barriers Encountered to Implement Public Engagement Initiatives

In analysing the public engagement case studies, tiered within the self-categorised types, a number of challenges were identified. The majority of the GRC participants indicated potential solutions to these barriers which provided insight to the nuanced and often challenging circumstances, both internal and external, that they face. A summary of these narratives is provided below:

One of the biggest challenges experienced by **citizen science approach programmes** was the fine balancing of community participation with privacy and security in data release. Other challenges encountered were a lack of funding, lack of resources, lack of skills development, the recruitment of students/participants and hence receiving suitable candidate applications.

Furthermore, projects were not completed due to a lack of internal commitment. A possible solution could be a suitable performance management system implementation. The interns' lack of commitment or completion of tasks could, however, be linked to a general lack of mentorship and support by host organisations. To overcome this obstacle, it is strongly advised to identify suitable host organisations prior to the launch of the project. This is managed by conducting site visits and prioritising site visits to new partners, and by listening and attending to challenges that the old partners encounter during the partnership. Although a proper performance management system can assist in the completion of tasks by interns, the real challenge here seems to be accountability and cooperation between stakeholders and partners. Building strong, trustworthy and functional relationships between partners and stakeholders, whilst creating and agreeing on mutually beneficial objectives and project deliverables, can help to overcome these managerial and operational challenges.

Some **integrated public engagement programmes** struggled to implement their projects, as the notion of engaging the public in the form of co-learning and co-production of knowledge is still a strange and foreign concept to the general public. To overcome this cultural challenge, project teams applied multi-directional approaches to enhance public participation, which include the following: (1) awareness through social media; (2) adding the formal dimension to the participation by communicating with the management to nominate the participants; and (3) maintaining continuous presence in the media to retain the public interest as well as the linkage with the project.

The lack of skills development, and the practical challenges related to this, hindered the successful implementation of **knowledge co-production programmes.** Possible solutions to these obstacles could be better coherence between the scientific part of the programme, and the utilisation aims. It is also important to think beyond the scientific project period, the early involvement of the stakeholders, the fact that utilisation goes beyond "dissemination", and that user involvement is more than just 'claiming to be interested'.

The success of knowledge co-production programmes also largely depends on involving 'all-rounder' reviewers who can assess the scientific quality of the programme, as well as the utilisation aspects. External peer review and meta-review panels should be done by a mixture of academics and experts from industry/societal stakeholders.

Policy deliberation programmes could furthermore benefit from communicating the aims and objectives of the programmes in comprehensible terms to the general public. Communicating scientific research and information in such a way that the general public can understand, i.e. in layman's terms, seems to be an obstacle encountered by **public dialogue approaches** as well. "It was difficult to design a discussion session on basic science in a way that would attract the audience", one of the programme leaders wrote. "Thus, demonstrations such as a performance of robots and a space food tasting were incorporated into the session to make it more appealing." Participation of researchers and private sector partners was also a challenge for public dialogue programmes. Convincing stakeholders and partners to invest their time and energy into these programmes, prevented the successful and sustainable implementation of programmes. **Public engagement and network development support programmes** mostly succeeded where lasting, sustainable relationships between stakeholders and partners were established. This was mainly done by conducting individual visits to partners, and spending time with them to explain the importance of the project and the potential mutual benefits for all. As the time and resources of some partners are limited, they were asked to align what they already do with the public engagement initiatives, and in return, they received visibility and national presence on social media and websites. Another suggestion to encourage public participation was to align activities with already-existing science festivals or other established public engagement initiatives. A useful suggestion was to make use of the summer months to engage with the public and to develop networks, as people are already engaging in public activities and are keen to socialise.

Resources for public engagement programmes also experience a lack of funding, problems regarding the registration of non-profits, or proof of an organisation's non-profit status. Performance measurement was another obstacle, as it has been challenging to identify appropriate metrics for measuring the impact of science outreach to youth. Challenges were experienced in term of privacy-related concerns about collecting data related to equity, diversity and inclusion for this programme from the youth participants. Application of evaluation merit criteria to diverse types of applications was a barrier limiting successful implementation. The programming that applicants propose is diverse, e.g. camps,

workshops, mentoring programmes, teacher training, competitions, etc. Ensuring that the committee members evaluate each application based on its merits prior to considering the funding recommendation has helped overcome this barrier. Additionally, combining intensity and reach within the same criterion has helped support programmes with large reach and a low intensity as well as programmes with a more limited reach and a higher intensity.

Language barriers and/or the communication of complex scientific concepts in layman's terms are challenges that were also experienced in **science education and career awareness initiatives.** Furthermore, one of the main challenges is to attract young people's interest in the fields of science and technology versus other options that are presented in the era of information technology, such as video games or social networking programmes. Initiatives are trying to work around this obstacle by adopting IT solutions in developing, presenting and delivering contents.

Funding, furthermore, was also experienced as a hinderance. A suggestion was made that projects should adapt to the financial limitations of the project, i.e. make use of the funds actually available, and do what is realistically possible with the project funds. Another important consideration is to assess and rationalise each public engagement intervention in terms of its impact and to make funding choices based on this assessment. Working together to overcome obstacles has additionally proven to be one of the most valuable resources in science education initiatives. In this way, past experiences were leveraged to overcome obstacles together.

Most public engagement initiatives moreover experienced challenges of continuation and sustainability; Continuation, programme completion and sustainability of initiative after the support implementation period are general and serious challenges in this section. A crucial question seems to relate to how the implementing agency continues with activities independently after the support phase ended.

Another challenge is the measurability of impact of a policy; In order to measure the impact of the policy, it is necessary to conduct follow-up surveys to determine whether the programme participants have selected a scientific course when entering university. But it is difficult to retain personal information at the executing institution for a long period of time, and also it is costly to do such surveys. It is also difficult to set integrated indicators for student evaluation. Furthermore, research ethics and privacy concerns make it difficult to follow up on the activities of students at universities and in society. Programmes find it challenging to get information via follow-up surveys.

The success and sustainability of science education programmes largely depends on the quality of relationships between partnerships and stakeholders. Establishing sustainable, trustworthy and productive relationships among communities, teachers and schools are hence imperative for these initiatives, as well as most public engagement initiatives, to succeed.

5. CONCLUSION

Research councils remain essential components of all states in world systems. Research councils are accountable to the public at large and especially through the governments that are constituted with temporal mandates from the citizenry of the various national systems. Governments collect revenues from the societies they govern for the purposes of advancing socio-economic and political development of their citizens. It is these public resources that are entrusted to research councils for the purposes of advancing knowledge frontiers and addressing bio-physical and social challenges of the conjuncture.

Thus, whilst research councils are accountable to the State for the agency afforded to them, many are also accountable to the communities of scientists that they support in the advancement of knowledge and the derivation of applications which improve their material lives; and to various publics that are ultimately beneficiaries of the investments made on their behalf. Research councils are, therefore, in perpetual processes of performing boundary-spanning activities to ensure that they execute their multiple obligations efficiently and effectively while making sure that the needs of each constituency are met in a way that does not compromise that of other publics.

Public engagement is an increasingly explicit expectation demanded of research councils. Public engagement also allocates to research councils a key role in realising potential impacts of publicly funded research and in the outcomes resulting from scientific enquiries. By ensuring sufficient consultation and widening the dialogue to the various publics in the different regions and countries, public engagements with the sciences can also serve as mechanisms for legitimising scientific praxis and re-enabling the public's trust in sciences. As noted by Pham, "...even though the societal impact of the science community's public engagement has been difficult to measure, available studies show a general positive correlation between high-quality community engagement and positive public attitudes towards science research" (2016). As further acknowledged by Mazzucato, "...all available and proven channels of communication with citizens should be explored so citizens can feel enthusiasm and trust in the process of change" (2018: 22) .

In responding to the challenges of the contemporary conjuncture, research councils can expect further demands on the performance of science and technology agencies. By engaging with the public on, and with, science, research councils can also influence the course of human history and encourage the building of resilience and sustainability of humanity on the planet. Realising such progressive ambitions requires that research councils are themselves properly resourced, capacitated, and competent in the deployment of public engagement approaches for the purposes of mutual learning and socio-economic and political development for all.

CHAPTER 4: Mission-orientated Research

Benjamin Sharman and Dorothy Ngila

1. INTRODUCTION

Mission-orientated research funding is growing in prevalence in many national and international contexts. These frequently place emphasis on creating change in – or impact on – society and reflect ambitions which are best realised in collaboration and consultation with societal actors. Mission-oriented research, therefore, seeks to provide systemic approaches towards achieving specific goals and utilising a solution-based, outcome-oriented approach. Mazzucato cited Ergas who defined missions as "…big science deployed to meet big problems" (1987). Mission-orientated innovation is a model whereby designing and implementing research initiatives is increasingly seen as the means towards harnessing the capabilities and interest of the global research community, to work together towards an agreed and evidence-based set of endpoints, or missions.

A focus on mission-oriented research funding is linked to the objective of positioning science granting councils in closer proximity to global science policymaking through how research agendas are set and prioritised by GRC participating organisations to support these global policy frameworks. It is also linked to the importance of justifying the use of public funds to support research and innovation that addresses the socio-political, economic and sustainability questions; and the use of strategic partnerships and internationalisation to support collaborative research efforts, which must inform the implementation of these policy frameworks.

There is a wide range of global 'grand challenges' where mission-oriented research would provide an appropriate approach. These include exploiting new technologies, materials, and understandings – such as artificial intelligence and quantum technologies – to stimulate the next industrial revolution; and harnessing big data to provide a data-driven understanding and organisation of an increasingly connected global community. It is also crucial that these missions are designed to ensure the economic and social development of the world's population, as well as provide an effective response to the major challenges facing the world today, such as climate change, growing inequalities, and urbanisation.

To that end, and building on the momentum of previous discussions and ambitions within the GRC's participants, the United Nations' Sustainable Development Goals (SDGs) provide an example of a framework for developing and refining such missions around a common set of overarching objectives to achieve a better and more sustainable future for all, and ensuring such missions effectively respond to the global challenges we face. The SDGs, initially launched in 2015, also underpin the UN's broader 2030 Agenda for Sustainable Development, which covers a wide range of interrelated goals, including poverty eradication and economic growth, social inclusion, environmental sustainability and peace for all people by 2030. The impact of such a solution-based approach towards advancing the attainment of the SDGs – and its adoption by the international research community – has the potential to be both far reaching and transformative in how we understand and address today's global challenges.

The UN convened its first Sustainable Development Goal Summit which brought together Heads of State and Government to comprehensively review progress in the implementation of its adopted Agenda and SDGs in September 2019. The political declaration entitled *Gearing Up for a Decade of Action and Delivery for Sustainable Development* proposed the launching of a more ambitious and accelerated response to reach the 2030 Agenda, with a pledge to make the coming decade one of action and delivery. While recognising many of the efforts since 2015, including the response from academia, the declaration noted that progress has been slow in many areas. Vulnerabilities and deprivation have become more entrenched, and assessments have showed that there is a risk of missing the poverty eradication target. Inequalities in wealth, incomes and opportunities have been increasing in many countries. Biodiversity loss and green-house gas emissions have continued at rates that could bring disastrous consequences for humanity. Global health threats, more frequent and intense natural disasters, spiralling conflict, violent extremism, terrorism and the related humanitarian crisis and forced displacement of people, threaten to reverse much of the development progress in recent decades.

The declaration recognised the specific challenges and vulnerabilities faced by African countries, least developed countries, landlocked developing countries, small island developing states and countries in conflict and post-conflict situations, in pursuing sustainable development. Therefore, as part of the decade of action and delivery, the declaration committed to solving challenges through international cooperation and enhancing global partnerships. It also committed to investing in data for SDGs, encouraging international cooperation to support the most vulnerable countries who face the greatest challenges in generating data and statistics. Specifically, and of most relevance to GRC participants, the UN commits to harnessing science, technology and innovation with a greater focus on digital transformation for sustainable development. It states "…we will promote research, capacity-building initiatives, innovation and technologies towards advancing the SDGs and promote the use of scientific evidence from all fields to enable the transformation to sustainable development. We will foster international cooperation to support developing countries in addressing their constraints in access to technologies".

Looking further than the SDGs, Agenda 2063 is the African Union's blueprint for delivery of inclusive and sustainable development. Agenda 2063 envisages a long-term 50-year development trajectory for Africa that is able to adapt in response to ongoing structural transformations; increased peace and reduction in the number of conflicts; renewed economic growth and social progress. The Priority Areas of Agenda 2063 can be linked to all 17 UN SDGs. The Science, Technology and Innovation Strategy for Africa (STISA 2024) places science, technology and innovation at the epicentre of Africa's socio-economic development and growth. It is anchored on six distinct priority areas that contribute to the achievement of the Agenda 2063 Vision. These priority areas are: Eradication of Hunger and Achieving Food Security; Prevention and Control of Diseases; Communication (Physical and Intellectual Mobility); Protection of Our Space; Live-Together-Build the Society; and Wealth Creation.

STISA 2024 further defines four mutually reinforcing pillars which are prerequisite conditions for its success: building and/or upgrading research infrastructures; enhancing professional and technical competencies; promoting entrepreneurship and innovation; and providing an enabling environment for STI development in the Africa continent. The strategy recognises the importance of international cooperation and therefore promotes mutually beneficial South-South and North- South cooperation.

2. RESEARCH AND INNOVATION TO ADDRESS GLOBAL GRAND CHALLENGES

Policy decisions on mission-oriented research to meet today's grand challenges need to be informed by policy-relevant evidence co-designed and co-produced with the pertinent stakeholders, taking into consideration local and political contexts. Universities and researchers are well placed to play a leading role in the cross-sectoral effort needed to address the grand challenges, providing valuable expertise, but also as they are considered as neutral, trusted and influential players by stakeholders and the public at large. Worldwide, such stakeholders have already begun to address these challenges, encouraged by initiatives of the United Nations, the not-for-profit sector, as well as national and international research and innovation funders.

The global research community potentially has the capacity and capability to generate, translate and disseminate knowledge relevant to achieving the grand challenges, working with policy-makers and other stakeholders to identify policy priorities/problems, assess options, implement solutions and evaluate their effectiveness, and translating the specific challenges, such as the SDGs, into measurable and country specific targets. However, while researchers

already foster partnerships with international colleagues, government and local communities, in order to achieve scientific and societal impact, these interactions can often be *ad hoc,* short-lived (for a project), or unsustainable. Longer-term and sustainable strategic partnerships are, therefore, needed to address these grand challenges, but this is non-trivial and requires more long-term investment and maintenance.

A significant challenge remains as to how researchers, especially those in low- and middle-income countries, can play a proactive and leading role in addressing grand challenges. These countries are often grappling with the challenges of expanding research capacity and fostering quality, while striving to maintain equitable access and relevance to the economy and to policy making. In many instances, governments are not aware of the large and relevant knowledge base and expertise potentially available to them, and researchers do not always perceive governments as partners for their knowledge. Consequently, the potential of each partner is not being harnessed to the fullest.

3. MISSION-ORIENTATED RESEARCH AND THE SDGs

The SDGs themselves are too broad to be achieved through funding any one research project, in one grant cycle by one agency. Conversely, research projects will remain isolated in their impacts if funders are not clearly linking projects to their ability to contribute to an SDG and sharing that information. Therefore, in order to harness the power of research and innovation to address the SDGs' transformative approaches are required.

Mission-oriented research is an approach which can be used to inject urgency into the development of solutions for societal challenges like climate change, as well as the provision of global public goods, such as clean drinking water, public education and public health services. The goal of a mission is to be ambitious, aim high, be innovative and move fast. The European Commission, for example, views research missions as a link between broad challenges and concrete projects. Missions set clear and ambitious objectives that can only be achieved by a portfolio of research projects with supportive measures, such as policy interventions, and involvement of all stakeholders and users of research.

There are a number of key characteristics of mission-oriented approaches, which can be summarised as:

- **The diffusion of results** is a central goal and is actively encouraged;
- The mission is defined in terms of **economically feasible technical solutions** to particular societal problems;
- The direction of technical change is **influenced by a wide range of actors** including Government, private firms and consumer groups;
- **Decentralised control** with a large number of agents involved;
- Emphasis on the **development of both radical and incremental innovations** in order to permit a large number of firms to participate;
- **Complementary policies** vital for success and close attention is paid to coherence with other goals;
- Missions should be **well defined.** More granular definition of the technological challenge facilitates the establishment of intermediate goals and deliverables, and processes of monitoring and accountability.

According to Mazzucato (2018), "...missions should be broad enough to engage the public and attract cross-sectoral investment; and remain focussed enough to involve industry and achieve measurable success. By setting the direction for a solution, missions do not specify how to achieve success. Rather, they stimulate the development of a range of different solutions to achieve the objective." With this definition, mission-orientated research approaches could be used to make an important contribution to addressing today's grand challenges, and specifically the UN's SDGs. As illustrated in Figure 1, Mazzucato's vision for the SDGs is that they will form grand challenges which can be broken down into various missions, and further broken down into particular 'projects' as demonstrated in Figure 2.

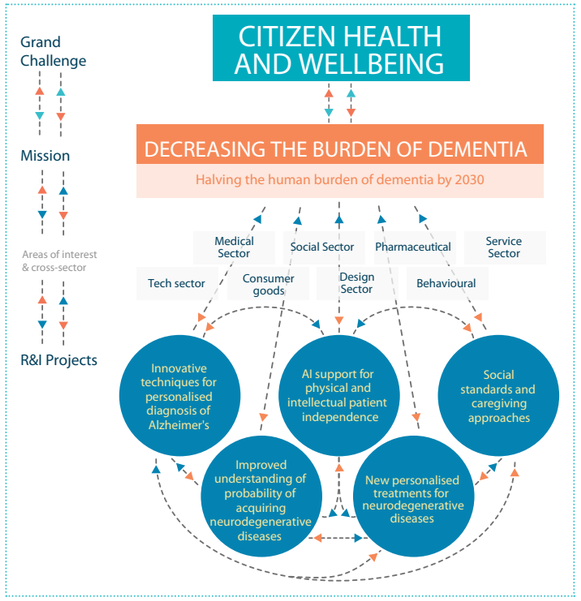

Figure 1. Mazzucato's vision of the movement from broad challenges to specific missions

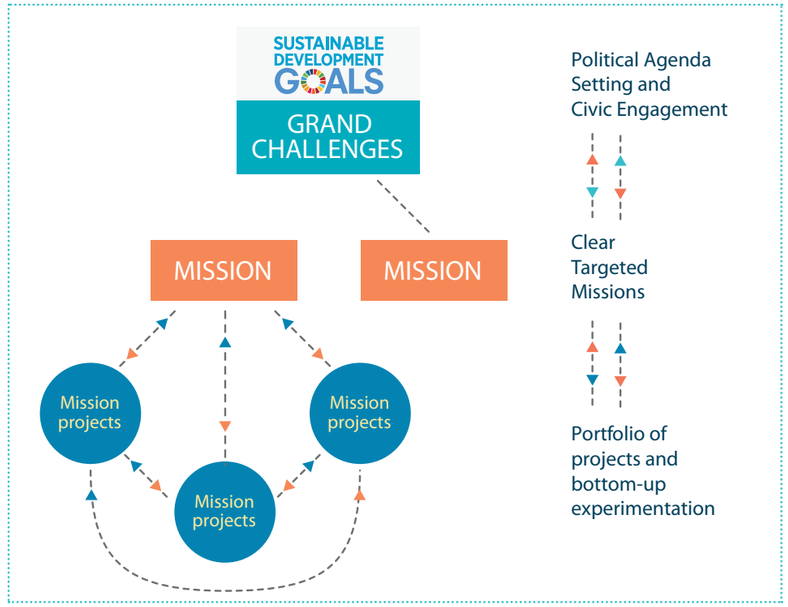

Figure 2. An example of how SDG can be broken down into 'Missions' and 'Projects'

Missions must also enable bottom-up solutions and experimentation, as well as stimulating cross-discipline academic work, with a strong focus on the intersection between the natural sciences, formal sciences, social sciences and humanities.

The trajectory taken to reach a mission will not follow a single, linear path and iterative learning across projects and funders should be part of the process. Missions, therefore, need a timeframe which enables this engagement,

learning and impact, while at the same time having a delivery date. Crucially, it must be possible to say definitively whether the mission has been achieved or not.

4. APPROACHES TO IDENTIFYING MISSIONS

Missions should be determined through a fine-tuned participatory diagnosis of a problem, including the potential solutions available. Who decides the mission is, therefore, a key issue.

The selection of missions should also incite broad public engagement as well as a wide interest from broader stakeholders in the civil, not-for-profit, and business sectors. This will in turn spur further political and financial commitment.

Through such participatory dialogue, the selection of co-designed missions should also fulfil the following criteria:

- Missions should engage the public. To do this, missions must outline exciting opportunities for bold and inspirational research and innovation, whilst aligning with broader social and developmental agendas and goals.
- Missions need to be very clearly framed, with a clear direction which is targeted, measurable and time bound.
- Mission objectives should be ambitious, but realistic, research and innovation actions.
- Missions should be framed in such a way as to spark activity across and among multiple scientific disciplines (including the social sciences and humanities), across different industrial sectors, and different types of actors.
- Missions should not be achievable by a single development plan, but rather should be open to being addressed by different types of solution, with a clear expected outcome.
- Missions should also engage as much as possible with regional- and country-level strategies, in order to help guide research and innovation initiatives across multiple actors and sectors.
- Acknowledging and incorporating national- and regional-level comparative advantages in particular scientific domains, such as Chile's geographical and climatic strengths in supporting astronomical observatory (see Case Study), to ensure appropriate expertise and capabilities are fully utilised in the attainment of missions, as well as sufficient buy-in from local stakeholders is present.

5. BENEFITS AND CHALLENGES OF MISSION-ORIENTATED APPROACHES TO RESEARCH

There are a **number of benefits** in adopting a mission-oriented approach to research framed around the SDGs or other grand challenges.

Such research has the potential to generate more immediate and visible impact on society and the economy. Highlighting potential impacts at the proposal stage will encourage researchers to think about how their research will benefit society and the economy. In turn, researchers may become aware earlier of how their research could be translated into application.

Earlier engagement with relevant societal stakeholders will also improve the researchers' understanding of what is relevant and of interest to stakeholders and thus shape both the research questions and ultimately the research results towards more immediate impact. In return, societal stakeholders might show more interest in and understanding of the research outcome than can usually be expected from post-research communication. Moreover, such initiatives can also assist research funding organisations as an advocacy tool in budget negotiations. At the same time, it will help political decision-makers to better justify research expenses to society.

Coupled with these benefits, there are a number of challenges associated with mission-oriented research that should be acknowledged and, where possible, mitigated in order to maximise the benefit and inclusivity of such approaches.

Primarily, ensuring an appropriate balance between the affirmation of scientific excellence as the primary evaluation criteria for use-oriented research against the potential societal and economic impact of research in effectively addressing grand challenges is crucial. This includes the recognition that one way to ensure this could be to separate evaluation procedures for excellence and impact.

Caution should also be exercised when using societal and economic impact as funding criteria for curiosity-driven research. Such impact is often unexpected, unintended and materialises much later. Societal or economic impact assessment, which can take both these uncertainties as well as the long-term nature of impact into account, still need to be further developed and refined. In 2019, the GRC endorsed at its Annual Meeting a *Statement of Principles on Addressing Expectations of Societal and Economic Impact*. The Statement called for research to 'address the increased expectations of societal and economic impact', whilst highlighting 'the value of both investing in research that advances and transcends the boundaries of knowledge as well as supporting research that may deliver more immediate and measurable societal and economic impact'.

6. THE NEED FOR INTERNATIONAL COOPERATION ON MISSION-ORIENTED RESEARCH

The challenges facing today's world are intrinsically global in nature and, therefore, require global responses to help mitigate their consequences. Development challenges also cross borders, regions and continents, and are often invariably linked to wider global challenges such as climate change. The solutions to these challenges, therefore, must also transcend national boundaries. A total of 193 countries that have signed up to the SDGs, for example, and as such they provide a common framework for engagement across a range of funders, countries and governments.

Research specifically targeting these challenges – from effectively identifying the problem to developing and implementing an appropriate pathway for their resolution – is crucial to addressing these challenges. Whilst modern research partnerships are increasingly international, they are often bilateral and sometimes even multinational, but rarely on the supranational scale needed to address inherently global issues such as climate change, with the Belmont Forum offering an almost unique example of such scale in approach towards global challenges being achieved effectively. As research funding organisations, we can provide the global researcher community with the tools and wider support to effectively address these challenges through international research activities.

Researchers can rapidly and effectively work across borders in a way that many policy-makers are unable to achieve. Researchers are also less restricted than policy-makers in what they can say publicly and are, therefore, well placed to highlight concerns or priorities that policymakers may feel unable to actively promote. It is paramount, therefore, to bridge the divide between researchers conducting these missions and the policy-makers who will direct how the outcomes and benefits of the research are realised. Influencing decision-makers will require a concerted approach under one unified voice from the research community. Such a framework of support by research funding bodies will help support researchers to connect and collaborate internationally; access new knowledge produced outside of their current research communities; and join forces to address global challenges under a unified mission-oriented approach.

7. BUILDING MOMENTUM TOWARDS AN INTERNATIONAL APPROACH FOR MISSION-ORIENTED RESEARCH ON SDGs

Whilst collaborative approaches towards mission-oriented research and grand challenges have been discussed and tested in various forms in recent years, there is an increasing interest from the research funding community to combine these approaches with a coherent plan for addressing the SDGs through mission-oriented research. Previous discussions and initiatives, such as the International Science Council-led Global Forum of Funders and a Research

Council of Norway (RCN)/OECD CSTP workshop on Global Public Goods[28], have identified a number of priorities to achieve this, including the need for:

- Greater collaboration among science funders and the research community to address the world's most pressing challenges, as exemplified by the SDGs;
- More effective cooperation and coordination between national research funding agencies – including development research funders – to achieve coherence and impact in developing and emerging countries and communities receiving Official Development Assistance (ODA) funding;
- Increasing public investment in research and innovation that can deliver global public goods, including the use of mission-oriented research and innovation policies;
- Developing robust internationally harmonized indicators for financing such initiatives;
- Stronger international collaboration on research infrastructures to better exploit the STI resources available in these infrastructures;
- More effective governance models that exploit flexibility and innovation, including addressing the complex relationships between partners in a multitude of bilateral and multilateral networks.

The Inter Academy Partnership – a global partnership of over 140 science, engineering and medical academies – has also, in May 2019, published a report entitled *Improving the Scientific Input in Global Policymaking*[29]. The report called for an increase in evidence-informed policy-making and mutual learning, and to use the global science community to help understand and account for interactions between the SDGs. The UN's Global Sustainable Development Report for 2019 is the only comprehensive global report on sustainable development and brings together a broad range of existing scientific assessments and reviews global progress and future sustainable development pathways in an integrated way. The report concludes that scientific rigor and active engagement with the 2030 Agenda are indispensable, complementary cornerstones of current science in the service of international development, and by adopting different modes of research and interaction with explicit societal goals like the SDGs – such as taking them either as an endpoint, a starting point, or a means of designing research – scientists can collaboratively address diverse development challenges and expand the scope for concrete policy action. Additionally, UK Research and Innovation (UKRI) has commissioned seven UK leading universities, research centres and the United Nations Development Programme (UNDP) to work together to better understand the ways in which science, technology and innovation contribute to the SDGs. The two-year initiative was announced in July 2019 and a full report was expected to be published in the course of 2021.

8. CASE STUDIES: CURRENT MISSION-ORIENTATED APPROACHES TOWARDS GRAND CHALLENGES

A number of GRC participants are currently using mission-oriented research initiatives in relation to address global grand challenges. The call for Mission-oriented Research Case Studies generated 27 submissions from GRC participating organisations, contained in Annexure 3.

The case studies were self-classified by the GRC organisations into possible defined types and an open-ended 'other' category, indicated in Table 4 below:

28 *Cf. https://council.science/current/news/funding-science-for-sustainability/*
29 *Cf. https://www.interacademies.org/node/49792*

Table 4. Categorisation of Mission-oriented Research Case Studies

Type of Activity	# of Cases
Research Funding Programme	14
Capacity Building Initiative	6
Policy Deliberation Approaches	1
Centres or Other Infrastructure	5
Mobility and Exchanges	1

As is clear in the tabled data, the overwhelming majority of cases were classified as research funding programmes. This is unsurprising because of the core mandate of the GRC participating organisations. The 'Other' category included innovation, dissemination, and the promotion of accessibility of research as types of mission-orientated objectives being pursued.

All of the cases include an incredible amount of useful and relevant lessons. The submission from the Peoples Republic of China provided explicit lessons gleaned from their experiences in the administration of mission-orientated programmes, whilst some others incorporated the partnerships between their respective productive sectors, research system, and an orientation towards the achievement of national development objectives such as Saudi Arabia 2030 and Oman 2040. The following five cases provide overall summary learning from the case studies on mission-orientated research programmes.

1. Chile: Astronomical Observatories

The geographical conditions in the north of Chile make the skies in these latitudes exceptional for astronomical observations. Therefore, it is no coincidence that for half a century now, the largest and most modern observatories in the world have settled in Chile. This comparative advantage over other countries provides an opportunity to focus on astronomy as mission-oriented research that develops not only science, but also technology, education and innovation in the industry.
In order to achieve all this, it is necessary to generate a long-term strategy that involves different levels of public-private interaction. Funds for research, telescope time reserved for the local scientific community, a regulation that protects the darkness of the skies, a State Office that coordinates synergies with the different stakeholders and the administration of lands reserved for the installation of astronomical projects, are some of the initiatives implemented that point to gain benefits from this natural laboratory.

2. European Commission: Horizon 2020 Societal Challenges

Under Horizon 2020, the European Commission introduced the concept of Societal Challenges where they defined cross-cutting areas of activity for research. The initiative saw seven Societal Challenges included within the Horizon 2020 Framework Programme, which brought together resources and knowledge across different fields, technologies and disciplines, as well as covered activities from basic research to market-oriented activities.
This approach increased coherence and coordination and led to a move away from traditional sectoral research programming. However, impact was still assessed at the level of individual projects whilst the broader impact on society was not assessed.
The interim evaluation of Horizon 2020 and the high-level group chaired by Pascal Lamy found that the next framework for research and innovation would need to make it easier for citizens to understand the value of investments in research and innovation; and maximise the impact of investments by setting clearer targets and expect impact when addressing global challenges. Taking a mission-orientated approach was, therefore, seen as one way this could be done.

3. South Africa: DSI-NRF Centres of Excellence

Established in 2008 and with a combined investment of USD 82 million thus far, the Department of Science and Innovation (DSI)-NRF Centres of Excellence (CoEs) are physical and virtual centres of research committed to developing novel ideas that focus on critical matters facing South Africa. The CoEs concentrate existing capacity and resources to enable researchers to collaborate on projects that are locally relevant and internationally competitive. There are fourteen CoEs, as well as the National Institute for Theoretical Physics and the Centre for Indigenous Knowledge Systems, both of which are implemented aligned to the CoE modalities.

The CoEs are specifically designed to accelerate delivery of appropriate human resources and knowledge capacity as well as raising international competitiveness, visibility and esteem of South African science. They are considered national assets for societal benefit, promoting collaborative inter- and transdisciplinary research, and the diffusion of knowledge to where it is needed. They fulfil three key aspects, also critical in the delivery of the SDGs: innovation, excellence, and relevance. This strategic investment is contributing to South Africa's National Development Plan 2030 and the country's attainment of the SDGs. In their collective, the CoEs contribute to SDG 1, 2, 4 and 5.

The CoE in Strong Materials has developed a diamond sensor for radiography measurements for mammography, thereby increasing the efficiency and effectiveness of such testing for women. The CoE in Biomedical Tuberculosis Research has developed a TB Screening Kit. The CoE in HIV Prevention developed an antibody (CAP256- VR26.25. LS) which neutralizes HIV-1. Finally, the CoE in Tree Health Biotechnology contributed to a saving of R1.2billion in forestry biocontrol of pathogens in the period 2008 to 2014.

The CoEs' long-term strategic research and human capital development platforms offer evidence-based outputs and outcomes and are aligned to the objectives of mission-driven research in the South African science landscape.

4. United Kingdom: Global Challenge Research Fund Interdisciplinary Research Hub Programme

The Global Challenge Research Fund (GCRF) is a £1.5 billion fund to support cutting edge research that addresses the challenges faced by developing countries. GCRF promotes challenge-led, disciplinary and interdisciplinary research initiatives to address the problems faced by developing countries. The SDGs provide a broader framework from which the solution-based approaches of the GCRF's approach is defined.

The GCRF's Interdisciplinary Research Hub programme supports transformative research and innovation at scale to address intractable development challenges. There are 12 Hubs which address the breadth of the SDGs and involve 550 researchers, 400 unique partner organisations in 85 countries.

One example is the 'GCRF Accelerating Achievement for Africa's Adolescents Hub' which seeks to address the cycle of poverty, violence, low education and poor health that affects many young people in Africa. This Hub will work with policymakers, NGOs and adolescents themselves to discover which combination of services can most efficiently and cost effectively help adolescents reach their potential. By testing different combinations such as malaria prevention, business skills and violence prevention, this Hub will identify 'accelerator' packages to boost nutrition, health, schooling, employment, gender equality and safety for teenagers across Africa. This Hub involves 15 partner countries and 56 partner organisations, highlighting the value of multiple researchers in multiple countries linking projects to shared missions framed in the SDG's. The initiative will in turn contribute towards SDGs 1, 2, 3, 4, 5, 6, 8, 16 and 17.

5. United States of America: 10 Big Ideas

Since 2017, the U.S. National Science Foundation (NSF) has been building a foundation to spur bold, interdisciplinary questions that will frame the NSF's long-term research priorities. These 10 Big Ideas include navigating and mapping the rapid changes of the Arctic; understanding the genetic code and rules that predict an organism's observable characteristics and interactions with its environment; using powerful new syntheses of observational approaches to provide insights into the nature and behaviour of matter and energy; and similar other grand scientific challenges.

Funding these interdisciplinary ideas will push forwards the frontiers of U.S. research, lead to discoveries as yet unpredictable, and provide innovative approaches to solving some of the most pressing problems the world faces. They will also require collaborations among academia, industry, private foundations, other agencies, science academies, and society.

8.1 Barriers Encountered to Implement Mission-oriented Research Initiatives

In analysing the mission-orientated research case studies, tiered within the self-categorised types, a number of challenges were identified. The majority of the GRC Participants indicated potential solutions to these barriers which provided insight to the nuanced and often challenging circumstances, both internal and external, that they face. A summary of these narratives is provided below:

Some mission-oriented **research funding programmes** did not receive enough applications that propose projects that adequately engage with partners and stakeholders in the countries where the challenges are relevant. This includes academics and non-academics (NGOs, governments, industry). To overcome this challenge, improved proposal guidelines for research projects were developed and a series of engagement events were launched to inform the applicant community about best-practice.

In general, research funding programmes have difficulty building a peer review community that can give applicants' research proposals the right level of scrutiny. This can be overcome by creating an international development peer review college of academics and users who are able to give the proposals the level of assessment they require. Similarly, bringing together a research community with disparate research interests around a common goal or challenge is no easy task. This can be overcome by creating focused challenge areas to align research calls to increase the mission focus of the fund. Furthermore, jointly supporting a project between two research funders requires agreement on all aspects related to the call for proposals, its review and the selection of successful projects. Fortunately, this can be resolved through proper dialogue and communication between funders.

One of the most crucial concerns or barriers experienced in this section, was how to utilise research outcomes (newly obtained knowledge and technologies through projects) for real life improvements (government services, new products in the local/universal market). Similarly, the question of how to balance newly developed S&T findings and developing societal implementation was mentioned in the case studies.

Furthermore, the fact that project teams tend to be formulated through already existing ties might be a drawback for some research initiatives, as often innovation and the diversification of approach might be affected. Consequently, some mechanisms might be needed to promote brand new partnerships. Additionally, differences in organisational culture and communication are aspects that can influence the success of a research initiative. Different administrative procedures can often inhibit of a project with great potential. No clear solutions to these administrative obstacles were provided in the case studies.

Project coordinators working with/in **centres or other infrastructure** reported that it takes time and culture shifts to establish the high-functioning governance structure needed to operate large scale networks. These challenges can be overcome by sharing best practices among research networks, publishing a best practice guide for governance and operations of networks, whilst also providing regular staff support and orientation sessions for newly funding networks. The implementation and/or development of centres and infrastructure are complex initiatives; one of the challenges is the engagement with industry – all the projects have non-academic partners, but only some of the relationships are strong.

Capacity building initiatives encountered challenges related to funding and administrative matters. One project coordinator reported that "…high-level challenge missions were set by Cabinet, after which the science community worked together to create a focused programme of inter-disciplinary research which would address each mission. This took considerable time and several iterations of the assessment process for all 11 Challenges. The move to a collaborative funding model that required multidisciplinary approaches was a shift that required substantial relationship building and a change in scientists' mind sets from competition to collaboration. This process could be more efficient if Government takes a more active role in setting the specific strategic direction and facilitates the collaborations. Independent governance helps manage institutional bias and competition. Challenges initially operated under interim governance groups, with the permanent governance groups only appointed once strategies were set. Earlier appointment of permanent governance and independent leaders focused on the outcome of the challenge (not institutional funding) would shorten the set-up phase. With a focus on achieving the mission, it is also critical that the leaders appointed not only have science credibility but also can work relationships with a broad range of stakeholders."

9. CONCLUSION

Public engagement carries a natural symbiosis to considerations around mission-oriented research. Missions of great scientific endeavour have often captured the imagination and engagement of the wider public, from millions of citizens watching the first humans land on the moon, to active participation in national and international biomass surveys. Ensuring public involvement in the identification and participation of, as well as ultimate benefit from such missions is essential to their overall success. Missions must, therefore, be framed within challenges that are broadly agreed to be of high social importance and provide for a range of opportunities for engagement by wider society (Mazzucato, 2018).

CHAPTER 5: Mobilising Public Engagements and Mission-orientated Research to Achieve the Sustainable Development Goals

Rasigan Maharajh

This chapter presents data about the current state of global inequalities; describes the contemporary conjuncture emergent from the four megatrends identified by the UN and its multilateral agencies; and the global state of research and development. The economic, social, political, and ecological circumstances of world systems have been indelibly altered by the emergence of a global syndemic at the beginning of 2020. Richard Horton, the editor in chief of The Lancet defined syndemics as being "…characterised by biological and social interactions between conditions and states, interactions that increase a person's susceptibility to harm or worsen their health outcomes" (2020: 874). It is within such deep contextualisation acknowledging the wider array of co-dependencies the world has had to appreciate the global phenomena whilst gazing at the inner workings of scientific research praxis. The virus has helped convey important lessons about the enterprise of science, accentuated the importance of the precautionary principle, and further contributed to improving public engagements whilst also encouraging mission-orientated research.

Empirical evidence continues to confirm the iniquitous distribution of the disease amongst the population and has served to intensify and amplify the debate about the determination of research priorities, the allocation of public resources, the praxis of science, the generation and accessibility of the research results, and the capacities of society and governments to absorb and utilise the findings of research in the responding to the global syndemic. Thus, debates about the relationship between science and society have intensified and expanded within countries and amongst them too. The Secretary General of the United Nations (UN), argued that "…inequality defines our time," in delivering the 18th Nelson Mandela Annual Lecture. It is exposing fallacies and falsehoods everywhere: The lie that free markets can deliver healthcare for all; the fiction that unpaid care work is not work; the delusion that we live in a post-racist world; the myth that we are all in the same boat. Because while we are all floating on the same sea, it's clear that some of us are in superyachts while others are clinging to the floating debris" (Guterres, 2020).

The Department of Economic and Social Affairs of the United Nations Secretariat subtitled its annual World Social Report 2020, as *'Inequality in a rapidly changing world'* (UN, 2020). The Report acknowledges that its earlier incarnation [UN. 2005. World Social Situation] had presciently warmed a decade and a half earlier that "…growing inequality could jeopardise the achievement of internationally agreed development goals" (UN, 2020:2). For 2020, the UN focused on four major megatrends or global forces driving inequality: "technological innovation, climate change, urbanisation, and international migration" (ibid.).

TECHNOLOGICAL INNOVATION

As outlined by the UN, "…the potential of new technologies cannot be realized if entire segments of the population lack access to them" (UN, 2020: 150). This provides further support for domestic research efforts to be advanced so as to ensure that technological innovation does not leave any one behind. Disparities between and within the countries of the world clearly indicate an unevenness of access based on the UN's finding that "…new technologies are reinforcing various forms of inequality and creating new 'digital divides'" (UN, 2020:6). Based on the rapid pace at which the technologies are advancing, the UN remains concerned and warns that "…many of the benefits from new technologies that developing countries could realize may not materialize if Governments and leading firms, which are often located in developed countries, fail to reduce barriers to the entry and diffusion of such technologies" (UN, 2020: 6-7). In summary, the UN recognises that technological innovation is potentially disruptive and is currently contributing to processes of rapid structural change. The UN does not however embrace an inevitability of impending catastrophe approach, but rather suggests that "…proactive policies and supportive institutions can help ensure that technological dividends are broadly shared" (UN, 2020:7).

CLIMATE CHANGE

The UN recognises that climate change is a megatrend of significant importance. According to the UN, "…climate change is affecting both the prevalence and depth of poverty, thereby contributing to inequality. It is making it harder for people to escape poverty and is increasing their vulnerability to falling into poverty, due to price shocks caused by sudden changes in agricultural production, natural disasters and environmentally triggered health problems" (UN, 2020: 8). The dynamics of climate change also contribute to weakening inter-generational solidarity as "…the disruptions caused by climate change are likely to reduce the livelihood opportunities of future generations, especially in countries hardest hit, and exacerbate downward intergenerational mobility" (ibid.).

The UN does however acknowledge that "…a just, equality-enhancing transition towards green economies calls for the integration of climate action with macroeconomic, labour and social policies aimed at job creation, skills development and adequate support for those who will be harmed. Policies aimed at reducing poverty and inequality, in turn, can help reduce the negative effects of climate change and provide the means for low-income households to engage in environmentally sustainable livelihoods" (UN, 2020: 8). Such an approach, of course, demands that national contexts are embellished within global compacts. Rather than merely seeking generic one-size-fits-all solutions, each situation requires significant amounts of local data which itself demands domestic investments in the capacities, capabilities, and competences for monitoring climate change.

URBANISATION

The majority of the world's population currently reside in urban agglomerations. This situation represents a massive change in the evolutionary history of humanity. Since 2007, 50.2% of peoples of the planet were counted as living in urban areas by their respective national statistical agencies. The shift from largely rural locations to urban complexes has been accompanied and facilitated by significant transformations in the organisation of everyday life and especially in securing the material means for survival across systems.

As noted by the UN, "…rapid urbanization has led to growing concerns about deteriorating health conditions. Even if maternal and child health are generally better in urban than in rural areas, they are at times worse in urban slums and other poor neighbourhoods of cities than in rural areas. Unregulated land and housing markets as well as poor urban planning can concentrate disadvantages in specific locations and lead to a vicious cycle of exclusion and marginalization. Slums are the most visible symptom of exclusion in divided cities. In 2016, one in four urban residents, or over one billion people, lived in slums" (UN, 2020: 9). Thus, whilst acknowledging that "…in most cities and towns, areas characterized by high levels of wealth and modern infrastructure coexist with pockets of severe deprivation, often side by side," the UN suggests that "…the current speed of urbanization, especially in poor countries, makes urban governance and appropriate urban design and planning increasingly urgent" (UN, 2020: 9 & 10). Such an approach, whilst obviously necessary, may not fully appreciate the state of local governance and the resources available to tackle the escalating and accelerating challenges.

INTERNATIONAL MIGRATION

Human mobility and the occupation of the planet by humanity has been a long-running phenomenon that is as old as our species-being. Whilst migration within national boundaries leads to unevenness and provides difficulties for sub-national planning agencies, international migration is now considered as elements of the international crisis of our contemporary conjuncture.

Notwithstanding its importance across time, current world systems are seized by the impacts of migration on the economy. Source countries tend to lose capacities and capabilities, whilst host territories gain skills and associated benefits. This inequity tends to advantage higher income level countries and disadvantage those that are less developed. Thus, and according to the UN, "…international migration generally benefits most migrants and their countries of origin and destination. Yet its costs and benefits are not shared evenly across countries or within countries" (2020: 10).

For the UN, countries of origin benefit from the accrual of remittances and other transfers by migrant communities abroad, whilst destination countries ensure that their labour market requirements are fulfilled. The UN also points to the high costs of transferring monies between national jurisdictions as an inhibitor of a more mutually beneficial relationship between the two sets of countries. A better appreciation for the mobility of humanity and its importance in the evolution of contemporary world systems could, therefore, definitely assist in lowering internal strife over contentious and conflicted social, economic, political, and ecological phenomena.

CONTEMPORARY GLOBAL RESEARCH AND DEVELOPMENT

According to the National Science Foundation (NSF), the world spent $2.153 trillion (current purchasing power parity dollars) on research and development in 2017 (NSF, 2020: 8). This huge amount of expenditure represented an increase of approximately 300% since 2000 and was very unevenly distributed across world systems. Just the combined total of the United States of America (USA) with the Peoples Republic of China (PRC) accounted for nearly half (48%) of all R&D expenditures in 2017 (ibid.). In assessing the trendline since 2000, the NSF determined that the PRC contributed approximately 32% of the overall global increases whereas the combined USA and the European Union's (EU) share amounted to just 37% of R&D expenditures in 2017 (op. cite.). This differential growth rate is the key reason identified to explain the decline in overall global share of research and development by the USA (from 37% to 25%) and the EU (from 25% to 20%) notwithstanding their respective national increases of 4.3% and 5.1% over the period. In zero-sum terms, the loss of share by the USA and EU was taken by Asia where "…China, Japan, Malaysia, Singapore, South Korea, Taiwan, and India increased their combined global share from 25% to 42%" (NSF, 2020: 8-9).

With respect to R&D Intensity[30], the NSF identified South Korea as achieving the highest GERD indicator of 4.6% in 2017 (NSF, 2020: 9). According to the African Science, Technology, and Innovation Indicators Initiative (ASTIII), "…a big challenge with collecting and, above all, analysing R&D data in Africa is that data supplied by countries are often not complete usually because the data do not cover all four sectors: business, government, higher education and private non-profit institutions. An incomplete coverage of all sectors is a real challenge to the calculation of GERD intensity that are progressively being addressed by further training sessions, the well-known 1% target, nor is it possible to calculate the number of R&D personnel in a country. In fact, reliable GERD data only exist for 11 countries: Botswana (0.54% of GDP), Egypt (0.80%), Eswatini (0.32%), Ethiopia (0.62%), Ghana (0.38%), Kenya (98%), Mozambique (0.38%), Namibia (0.40%), Senegal (0.54%), South Africa (0.82%, latest figure), and Uganda (0.18%)" (ASTIII, 2020). Such data is indicative of a dynamic world system of research and development and the persistence of unevenness in both the capacity and capabilities to collate data about Science as well as in the differential spending in the various countries that constitute contemporary world systems. The data shows how the building of domestic capacities, capabilities, and competences in science, technology, and innovation serve to bolster the general development of the countries that invest in pathways that improve the performance of their respective national systems of research and development.

CONCLUSION

As humanity heads further into the 21st Century of the Common Era, research and development remains of critical importance. The advent of the COVID-19 syndemic has demonstrated the absolute importance of high-quality science

30 An indicator based on the ratio of R&D Expenditures to Gross Domestic Product (GDP).

and technology competences in all the countries of contemporary world systems. As advanced by Mazzucato and in citing a recent UK's Industrial Strategy Council report, "...effective, 'mission-oriented' government coordination – from industrial policy to investment in life sciences, strategic public procurement and public-private partnerships – has been key to the success story of Covid-19 vaccines" (2021). The distinct domestic systems that have evolved based on national circumstances and international dynamics are clearly not independent of each other and need to be effectively coordinated. The set of megatrends identified by the UN are illustrative of disruptive changes and challenges on the horizon of all of humanity notwithstanding country locations. Advances in science and technology hold much potential for redressing systemic and structural constraints. Encouraging public engagements with scientists and the whole enterprise of science provides a progressive pathway for increasing social and political support. As noted by Cesnulaityte, "...where governments, citizens, and stakeholders meet and work together to solve a pressing issue, can offer a starting point for a renewed relationship amongst them. One that is based on trust, openness, and co-operation, and has the potential to inspire a social contract based on these same principles" (2021). Mission-orientated research has demonstrated how resource mobilisation can also be directed towards the achievement of collective objectives in world systems. Taken together, these two principles of public engagement and mission-orientation afford humanity better prospects in combination with deliberative actions that redress inequalities and genuinely advancing a better life for all.

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ANNEXURES

ANNEXURE 1: 2020 GRC STATEMENT OF PRINCIPLES ON PUBLIC ENGAGEMENT

Preamble

Humankind is increasingly confronted by escalating and interdependent social, economic, political, and ecological challenges at an accelerated pace and on an historically unprecedented scale. Whilst global integration and digitalisation expands access to information within and across countries, society should always be able to critically examine scientific research, its presuppositions and assumptions, together with its methodological choices. Public engagement offers the possibility of reducing the distance between society and the enterprises of science, through enabling inclusion, facilitating participation, improving the integrity of research, and obviating unwarranted attacks against science.

National funding agencies are essential actors in their respective knowledge eco-systems, and are expected to mediate between society, its multiplicities of publics (including various civil society formations, the variety of branches of the state, the private and public enterprise sectors, and a myriad of scholarly and academic organisations), and the various domains of science in defining research priorities, securing resources, and setting agendas.

Through the process of regional consultations, the GRC participating organisations recognise the critical importance of public engagement whilst acknowledging the wide variety of forms and practices associated therewith.

Overarching Considerations

1. Knowledge emanating from publicly funded research belongs to the public.
2. Public engagement expands education and training across society whilst also fostering inclusivity and critical thinking amongst all participants.
3. Public engagement widens meaningful participation and improves trust in the enterprises of science.
4. Public engagement takes a variety of forms and practices that include the involvement of a diverse range of publics in knowledge-sharing, the setting of research priorities, advising on resource allocations, and determining the outcomes and impacts of science.
5. Whilst all fields and domains of science benefit from public engagement, practical emphases may vary between more fundamental and more applied research activities.
6. Funding agencies constitute a main intermediary between the sciences and publics in supporting research, expanding the capacities and capabilities of knowledge ecosystems, and ensuring improved accountability for the investment of public resources.

Principles

1. GRC participants recognise public engagement as purposeful and meaningful activities facilitated between researchers and their various 'publics', whereby the co-construction of knowledge is enhanced, and mutual learning generates benefits for all.
2. GRC participants agree that specifically targeted, and nuanced approaches are required to maximise critical engagement with science by the various publics within their respective knowledge ecosystems.
3. GRC participants recognise changes in the mandates of public funding agencies, from their historical roles in exclusively, yet narrowly, funding research towards including the funding of public engagement.

4. GRC participants agree that knowledge co-creation with various publics takes place at all stages of the research process, including upstream: through the identification and development of research priorities and strategies; midstream: through the involvement of publics in research; and downstream: through the public's benefit from, and understanding of the impact and scientific output of research.
5. GRC participants acknowledge that an appropriate leveraging of resources is required to further support and facilitate wider public engagements with science.
6. GRC participants acknowledge that the sharing of monitoring, evaluating, and learning metrics for public engagement will assist national funding agencies in improving their organisational capabilities, encouraging inter-institutional partnerships, and promoting increased public investments in the enterprises of science.

ANNEXURE 2: 2020 GRC STATEMENT OF PRINCIPLES ON MISSION-ORIENTED RESEARCH

Preamble

Mission-oriented research is an emerging model for addressing a variety of modern global grand challenges, which are increasingly complex and interconnected, and therefore require a broad and global multidisciplinary and multisectoral response. Mission-oriented research, therefore, provides an effective mechanism for creating change in, or impact on, society's ambitions for addressing these challenges. These ambitions are best realised in collaboration and consultation with a range of societal actors, from identifying the priorities through to delivering the solutions.

Mission-oriented research seeks to provide a systemic and broad approach towards achieving a specific goal, using solution-based, outcome-oriented approaches - 'Big science deployed to meet big problems'. Such an approach for designing and implementing research initiatives has emerged as a model that can harness the capabilities and interest of the global research community to work together towards an agreed and evidence-based set of end points, or 'missions'.

GRC participants recognise, respect, and value the diversity and pluralism of the global research and innovation eco-system, and the subsequent variety in understandings, approaches and priorities towards the attainment of global grand challenges.

Principles for the Model and Approach of Mission-oriented Research

GRC participants agree that:

1. Missions should be broad, long-term and outcome-oriented commitments which allow for a range of potential approaches and solutions in addressing a particular challenge. Missions should, therefore, be flexible and allow for the reprioritisation and/or expansion of the missions' scope as required.
2. Missions will require new, innovative and inclusive models for research funding across national funding agencies, which integrate capacities from a broad range of stakeholders, scientific disciplines and sectors, adopting new modalities and developing new capacities, underpinned by effective and mutually reciprocal knowledge exchange practices.
3. A broad approach to accomplishing missions – one that encompasses the full spectrum of scientific disciplines and encompass both the fundamental sciences as well as applied sciences – is required. The role of the social sciences and humanities, as well as multidisciplinary research, is, therefore, crucial in providing an effective and holistic approach towards missions.
4. Missions should also provide opportunities for discovery science as well as strategic research.
5. National and local priorities, contexts, capabilities and strategies must also be appropriately recognised and integrated into the scope and approaches of the missions alongside the broader regional and global frameworks.
6. Using broader global frameworks, such the UN's Sustainable Development Goals, as well as regional frameworks such as the African Union's Agenda 2063, can help steer the strategic approach and direction of missions by providing possible frameworks from which to develop and cluster these missions around.
7. Whilst the Sustainable Development Goals represent one particular framework that can be utilised for mission-oriented research, a range of frameworks exist that could be adapted to serve as a foundation for such missions,
8. Monitoring and evaluation of missions, as well as effective communication of their impacts, is needed to effectively demonstrate the benefit and value of these missions to wider stakeholders as well as garner their wider support of, and collaboration with.

Principles for Mission-oriented Research and Public Engagement

GRC participants recognise that:

9. There is a strong and mutually inclusive relationship between the mission-oriented research and public engagement themes, with public engagement recognised as an important component to the design and implementation of missions that are responsive to the needs and interests of the global citizenry.
10. As such, ensuring that a wide range of stakeholders (publics), including business, decision-makers and citizens, are effectively engaged in the identification, development and delivery of missions, as well as benefit from their outcomes, is essential to ensuring consensus and public engagement with the missions.
11. While research can make contributions towards specific goals, it cannot solve societal and global grand challenges alone, and therefore mission-oriented research must be connected to policy-making, education, governance, and dialogue with society.
12. GRC participants strongly reaffirm that capacity-building and knowledge exchange initiatives, including those engaging underserved communities (such as women or indigenous populations), would help further bolster the quality and investment to the missions.

Principles for the Role of the GRC and its Participating Organisations

GRC participants affirm that:

13. Whilst it is important to recognise the limits of national research funding agencies in delivering these ambitions, they can support the continuing development and use of mission-oriented research by providing long-term, sustainable mechanisms for the funding of these missions, as well as shorter-term mechanisms which are flexible and responsive to the dynamic and fast-changing nature of global grand challenges.
14. Fostering increasing international collaboration between GRC participants is also crucial in enabling countries to better respond to emerging challenges through mission-oriented research frameworks.
15. By bringing together a wide range of unique skills, expertise and resources to help address global grand challenges.
16. The role of the GRC in supporting and promoting mission-oriented research is to provide a strong, collective voice in discussions with wider stakeholders as well as by fostering a common understanding and framework for developing effective missions through the publication and endorsement of Statements of Principles.

Considerations for the Desire and Need for a Collaborative Approach by GRC Participants in Addressing Global Grand Challenges

GRC participants acknowledge:

1. The need for national funding agencies to work together in support of the accomplishment of missions that seek the attainment of global grand challenges.
2. The United Nations 2030 Agenda for Sustainable Development – underpinned through the Sustainable Development Goals (SDGs) framework – offers a timely and important opportunity from which to develop a common understanding and approach towards collaborative activity between the GRC's participants.
3. The desire to harness the opportunity presented by Agenda 2030 and work together, either through the GRC or outside of it, to identify and develop opportunities for a concerted collaborative action towards the attainment of the SDGs.

ANNEXURE 3: LIST OF PUBLIC ENGAGEMENT & MISSION-ORIENTATED RESEARCH CASE STUDIES

Extended Case Studies are available at: *https://www.globalresearchcouncil.org/fileadmin//documents/GRC_Publications/Expanded_Case_Studies.pdf*

3.1 - Public Engagement

Public Engagement Case Study Name	GRC Participant	Country
Strategic Basic Research	Research Foundation Flanders	Belgium
Little Inventors	Natural Sciences and Engineering Research Council of Canada	Canada
PromoScience (Science, Technology, Engineering, and Math Learning)	Natural Sciences and Engineering Research Council of Canada	Canada
Science Exposed – Research Image Contest	Natural Sciences and Engineering Research Council of Canada	Canada
Science Literacy Week	Natural Sciences and Engineering Research Council of Canada	Canada
Science Odyssey (repurposed National Science and Technology Week)	Natural Sciences and Engineering Research Council of Canada	Canada
EXPLORA Programme (Scientific Research at Schools)	National Commission for Scientific and Technological Research of Chile	Chile
European Research Council Public Engagement with Research Award 2020	European Research Council	European Union
Exkurs (Excursus - Insights into the World of Science), and Leibniz Lecture	Deutsche Forschungsgemeinschaft	Germany
Science Communication Module	Deutsche Forschungsgemeinschaft	Germany
Science On (Public debate series)	Deutsche Forschungsgemeinschaft	Germany
Citizen Science Projects and Initiatives	Leibniz Association	Germany
Fridays for Future – Dialogue between FfF Activists and Scientists	Leibniz Association	Germany
Senate Commissions (as policy advisors)/Alliance of German Science Organizations	Leibniz Association	Germany
SFI Discover Primary Science and Maths Programme	Science Foundation Ireland	Ireland
SFI Discover Programme	Science Foundation Ireland	Ireland
SFI Science Week	Science Foundation Ireland	Ireland
SFI/IRTE Joint Initiative	Science Foundation Ireland	Ireland
CHAllenge-driveN Convergence Engine (CHANCE)	Japan Science and Technology Agency	Japan
Fostering Next-Generation Scientists Programme	Japan Science and Technology Agency	Japan
Global Science Campus	Japan Science and Technology Agency	Japan
Science Agora and Satellite Events	Japan Science and Technology Agency	Japan
Solution-Driven Co-creative R&D Programme for SDGs (SOLVE for SDGs)	Japan Science and Technology Agency	Japan
STI for SDGs Award	Japan Science and Technology Agency	Japan
Super Science Highschool	Japan Science and Technology Agency	Japan
Support for Female Students in Choosing Science Courses	Japan Science and Technology Agency	Japan
Grants-in-Aid for Scientific Research Database (KAKEN)	Japan Society for the Promotion of Science	Japan
HIRAMEKI☆TOKIMEKI SCIENCE (Welcome to a University Research Lab - Science that Inspires and Inspirits)	Japan Society for the Promotion of Science	Japan
International Prize for Biology	Japan Society for the Promotion of Science	Japan
Nobel Prize Dialogue	Japan Society for the Promotion of Science	Japan
Science Dialogue Programme	Japan Society for the Promotion of Science	Japan
Fine Particle Control and Management R&D Programme	National Research Foundation of Korea	Korea
National Research Agenda	Dutch Research Council	Netherlands, The
The National Strategy for Research and Development 2040	The Research Council of the Sultanate of Oman	Oman
Engaging Stakeholders in Setting Research Priorities	Qatar National Research Fund	Qatar
Monitoring the Dissemination of Research Outcome to the Public	Qatar National Research Fund	Qatar
Motivate the Younger Generation to Engage in Science and Technology Fields	King Abdulaziz for Science and Technology	Saudi Arabia
Youth Science and Technology Journalism Programme	National Research Foundation	South Africa
Swedish Research Council initiatives	Vetenskapsrådet	Sweden
Trans.MISSION (Natural Environment Research Council and Hay Festival)	UK Research and Innovation	United Kingdom
UK School Seismology Project	UK Research and Innovation	United Kingdom
Public Participation in Science (Citizen Science and Crowdsourcing Projects)	National Science Foundation	United States of America

3.2 - Mission-orientated Research

Mission-Oriented Research Case Study Name	GRC Participant	Country
Strategic Basic Research – Selection Advantage for SDG Focus	Research Foundation Flanders	Belgium
FAPESP and Canada's International Development Research Centre (IDRC): Innovations for Marginalized Youth Economic Inclusion	São Paulo Research Foundation & International Development Research Centre	Brazil
ArcticNet (Networks of Centres of Excellence)	Natural Sciences and Engineering Research Council of Canada	Canada
PrioNet (Networks of Centres of Excellence)	Natural Sciences and Engineering Research Council of Canada	Canada
MEOPAR (Networks of Centres of Excellence)	Natural Sciences and Engineering Research Council of Canada	Canada
IC-IMPACTS Canada-India Research Centre of Excellence (Networks of Centres of Excellence)	Natural Sciences and Engineering Research Council of Canada	Canada & India
Mission-Oriented Research: Experience of National Natural Science Foundation of China	National Natural Science Foundation of China	China
Leibniz Research Alliances	Leibniz Association	Germany
SFI Industry Fellowship award	Science Foundation Ireland	Ireland
SFI Strategic Partnerships	Science Foundation Ireland	Ireland
Challenge-Based Funding Models	Science Foundation Ireland	Ireland
SFI Research Centres Programme	Science Foundation Ireland	Ireland
Spokes Programme	Science Foundation Ireland	Ireland
Science and Technology Research Partnership for Sustainable Development (SATREPS)	Japan Science and Technology Agency	Japan
Solution-Driven Co-creative R&D Programme for SDGs (SOLVE for SDGs)	Japan Science and Technology Agency	Japan
Science & Technology support Programme	National Research Foundation of Korea	Korea
National Science Challenges	Ministry of Business, Innovation and Employment (MBIE)	New Zealand
PILOT-E	Research Council of Norway, Enova and Innovation Norway – collaborative initiative	Norway
EJAAD	The Research Council	Oman
Grant Programme for Universities and Research Centres	King Abdulaziz City for Science and Technology	Saudi Arabia
Department of Science and Innovation (DSI)–National Research Foundation (NRF) Centres of Excellence (CoEs)	National Research Foundation, South Africa	South Africa
The Strategic Innovation Programmes (SIP)	Swedish Research Council for Sustainable Development; Vinnova, Sweden's innovation agency; Swedish Energy Agency	Sweden
National Research Programmes	Vetenskapsrådet, Swedish Research Council	Sweden
National Research Priority Programme (NPRP) – Cluster Track, NPRP-C	Qatar National Research Fund	Qatar
Thematic Grand Challenge Research Programme, TGRP	Qatar National Research Fund	Qatar
Global Challenges Research Fund	UK Research and Innovation	United Kingdom
NSF Convergence Accelerator	National Science Foundation	United States of America

Annexure 4: Summarised Case Studies

4.1 - Public Engagement Case Studies

Type of Activity	# of cases
Science education and career awareness approaches	15
Public dialogue approaches	7
Public engagement network development and support	5
Integrated public engagement initiatives	3
Resourcing (including funding) for public engagement	4
Knowledge co-production approaches	1
Citizen science approaches	3
Human capital and skills development initiatives for public engagement	1
Policy deliberation approaches	3

A. SCIENCE EDUCATION AND CAREER AWARENESS APPROACHES

Canada

1. Science Exposed, Research Image Contest

Science Exposed/La preuve par l'image is an annual contest devoted exclusively to images of scientific research in all fields of study except the arts. Canadian researchers in both the public and private sectors submit research images along with a catchy title and a brief, accessible description of their research. Introduced in 2016, the contest is hosted every year by the Association francophone pour le savoir (Acfas) in Quebec and the Natural Sciences and Engineering Research Council (NSERC), a federal research funding agency. It showcases images of Canadian research, fosters interest in science across all audiences, builds a database of scientific images of Canadian research, advances knowledge and provides new uses for scientific images.

Each year, 40 finalists' research images are selected by a jury. From that selection, the general public votes for their favourite images. Jury and People's Choice awards are given to the individual researchers or the group. Throughout the years, partnerships have been created with Radio-Canada and science museums to showcase the images to larger audiences. Research images are published online and can be used as wallpaper for cell phones, desktop computers and tablets.

Finalists' images have been assembled in a travelling exhibition, a digital exhibition and fun guessing game all hosted in a variety of institutions (universities, museums, science centres, libraries, festivals, etc.) across the country. These public engagement initiatives are excellent opportunities to reach out to the public, including the youth. Through this contest and associated products, Canadian researchers have a unique avenue to showcase their work in a creative way and tell their story to a broader audience.

Every year, there are a growing number of research images submitted to the contest from a wider variety of research labs. When possible, winners are invited to present their research at science festivals where their research images are shown. The travelling exhibition is often displayed at a winner's host institution.

2. Little Inventors

The Little Inventors programme was founded in the UK in 2015 and brought to Canada by the Natural Sciences and Engineering Research Council of Canada (NSERC) in 2016. This programme inspires students to think up and draw invention ideas that are ingenious, funny, and often fantastical. It offers a creative way to explore STEAM topics in

the classroom by encouraging children to explore their own creativity and become the inventive thinkers of the future.

Students are invited to think up invention ideas that will help solve a particular issue and make the world a better place. Teachers are supplied with online tools and a full resource pack to support the idea-generation phase with their students. Selected students work with a maker or artisan to develop their invention idea into a concrete object. Little Inventors ideas have been showcased at exhibitions in prestigious museums including Ontario Science Centre, Canada Aviation and Space Museum, Montreal Science Centre, and Little Canada Museum (Toronto), and at events such as the Canada Wide Science Fair. The Canadian Commission for UNESCO has signed up as NSERC's global partner.

The Little Inventors programme reaches children and youth (ages 5 to 15) through workshops with lessons delivered by teachers and partner organisations including libraries, museums, and science centres. Makers and artisans from across the country are matched with students (either in person or virtually) to turn the invention ideas into concrete objects, with the students' input. NSERC relies on three basic indicators to measure impact: the number of children exposed to Little Inventors, the number of idea submissions, and the number of participating schools. To date, over 600 children were reached across all provinces, whilst close to 600 invention ideas submitted. The Little Inventors space challenge (2017) reached over 83 000 children, whilst close to 3 000 invention ideas were submitted.

3 Science Literacy Week

Established in 2016, Science Literacy Week is a week-long celebration of science-based activities that showcase the excellence and diversity of Canadian science, whilst showing how exciting science is. Through this initiative, Natural Sciences and Engineering Research Council of Canada (NSERC) encourages science literacy and culture amongst both younger and older audiences. Science Literacy Week is open to a wide variety of partners across the country, such as government departments, museums, science centres, universities, schools, educators, parents, and libraries. These organisations and individuals host science activities for the public reflecting their own strategic goals and interests.

Some of the notable partnerships include: NSERC partners with Science pour tous to lead la Semaine de la culture scientifique with Quebec-based organisations. NSERC partners with Microfiches and an organisation closely linked to the identified theme of each edition to develop educational posters (English and French) available for distribution. NSERC partners with science magazines Les Explorateurs, Les Débrouillards, Curium and Owl Kids to celebrate National Science Reading Day. These magazines organise national contests (French and English) that encourage classrooms and individuals to dedicate part of their day to read a science book.

The partner organisations benefit from the exposure provided by Science Literacy Week and their participation in a nation-wide event, which allows them to showcase their work and accomplishments. Members of the general public who participate in events benefit from a greater understanding of the societal and economic role of science in the world and increase their curiosity and interest in science. NSERC relies on three basic indicators: the number of events, the number of organisations and the number of cities and communities hosting an event. A survey is conducted to gather feedback and areas of improvement from the partner organisations who registered an event. In 2019, 300 partners joined the initiative, whilst 650 events were launched in 250 cities.

Ireland

1. SFI Discover Programme

In support of its mission to have the most engaged and scientifically informed public, the purpose of the Science Foundation Ireland (SFI) Discover Programme is to support and develop the STEM education and public engagement sector in Ireland by investing in, developing and extending activity and ability in this area, whilst exploring and encouraging novel means of engaging the public in STEM.

The SFI Discover Programme funds education and public engagement projects through a competitive process which is internationally peer-reviewed. The programme includes two annual calls: the key programme which supports a range of activity and a specific call for Science Week Festivals and Events. The type of projects supported include formal and informal education activity, STEM festivals, theatre productions, competitions, online and live events and capacity building in the education and public engagement sector, etc. The annual call is open to a wide variety of applicants from academic institutions to private companies, industry associations, city/county councils etc. Funding of up to €50 000 can be awarded to one-year projects, while funding of up to €300 000 can be awarded to Projects of Regional or National Impact which are typically two years in duration. Funding above this threshold is available if the applicant can demonstrate matched cash funding for the full amount requested.

The Science Week Festival and Events Call funds a range of regional festivals that occur during National Science Week (November) each year. Support is also given to events in areas where no festival is funded. This call is also open to a variety of applicants and funding is typically for a maximum of €35 000 for a festival and €8 000 for an event. Approximately 15 festivals and 15 events are funded on an annual basis.

Over 400 awards totalling almost €25 million have been funded under the SFI Discover Programme Call between 2013 and 2019. A key aim of the programme is to engage with communities that are underrepresented in STEM and this has been achieved across the projects previously awarded funding.

2. Science Week

Science Week is an annual week-long event which takes place each November across Ireland. This nationwide event celebrates the science in our everyday lives. Science Week is an initiative of Science Foundation Ireland, and brings together significant partners from across industry, higher education institutes, schools, libraries and other organisations. It acts as a key engine to bring together different role models and champions from the world of TV and comedy, to writers, to renowned experts, many of whom volunteer their time to support the ethos of Science Week. The aim of this effort is to contribute to Ireland having the most engaged and scientifically informed public.

Science Week is the largest science festival in the country, engaging hundreds of thousands of the general public in workshops, talks, regional festivals, as well as through media such as podcasts and radio, and television programming with RTÉ, Ireland's national broadcaster. 2020 will mark the 25th anniversary of Science Week in Ireland.

Science Week is designed to stimulate interest, excitement and debate about STEM through accessible and entertaining interactions with the public to engage and inspire people of all ages and backgrounds. Science Week specifically aims to reach communities that are less engaged or that have less access to STEM engagements than others. This is enabled through a collaborative approach between the national coordination by SFI and the significant output by local event organisers. In support of this, Science Foundation Ireland provides financial and other supports to several regional Science Week festivals and events that reach, and are co-created with, communities at a local and regional level.

Science Week 2019 focused on climate action, seeking to help people understand climate change; how science and technology can help us create a positive climate future; and the impact we as individuals can have on climate change. Over 1 300 events took place nationwide as well as 13 regional festivals offering a range of opportunities for the public to engage with Science, Technology, Engineering, and Maths.

3. SFI/RTE Joint Initiative

Science Foundation Ireland (SFI) provides funding for broadcast programmes through a joint initiative with RTE – the national broadcaster in Ireland. The initiative has been in place since mid-2015 and is subject to annual review. The aim of the initiative is to weave scientific content into lifestyle and documentary type programming that is topical and relevant to the Irish public. Since its inception the initiative has supported programming that specifically targets

peak schedule slots, with content that engages with those audiences not easily accessed through face-to-face STEM engagements.

A range of science-related programming has been funded under the initiative including documentaries on the effects of stress in our lives (Stressed), data (Hacked And Cloud Control), why humans like to win (Henry Shefflin – Winning), commemoration of the 50th anniversary of the Moon landings (50 Years To The Moon And Back), and the role of robots in relation to jobs currently undertaken by humans (Will A Robot Steal My Job?).

Ireland has a large rural and agricultural community. SFI supported four series of Big Week On The Farm through the initiative. These week-long live event series looked at the role of science and technology in agriculture and rural life and the future of farming – the first three examined springtime on the farm with the final series taking place at harvest time in September.

Another live series which was broadcast during Science Week 2018 looked at the development of human beings at various stages of the life cycle (Growing Up Live). In November 2019, a series related to sustainable living was broadcast (What Planet Are You On?) to complement the Climate Action theme for Science Week 2019. This programme was very successful in a peak schedule slot, competing against the highest performing TV broadcasts.

4. SFI Discover Primary Science and Maths Programme

The Science Foundation Ireland (SFI) Discover Primary Science and Maths (DPSM) programme originated in 2003 with the aim of introducing primary school students to science in a practical, hands-on, enjoyable, and interactive way, and to support the roll out of a new primary school science curriculum in Ireland. Since 2010 the programme has been run in conjunction with the European Space Education Resource Office (ESERO) Ireland which uses space as a theme to inspire and engage young people in science and technology in the world around them. The key elements of the programme include CPD for teachers, in partnership with ESERO Ireland; the SFI Discover Science and Maths Awards; a network of SFI Discover Centres offering SFI- accredited primary STEM workshops and outreach programmes; and resources to support teaching STEM through inquiry.

To date 7 003 SFI Discover Science and Maths Awards have been presented to 1 733 primary schools across Ireland (52% of total), with 600+ schools participating annually. Furthermore in 2018, 43 403 pupils from 1 229 primary schools across Ireland attended a DPSM-accredited workshop in one of the 59 SFI Discover Centres, indicating that this network is a key resource for SFI to support informal STEM learning. DSPM has undergone annual external evaluation since 2015 (with the assistance of St Patrick›s College, DCU and the National STEM Centre, UK) which has repeatedly shown that participation in the programme is having a positive impact on teachers› approaches to, and confidence in, teaching STEM.

Through DPSM, SFI has a strong working relationship with the Department of Education and Skills (DES) and related support services. This engagement with the DES has led to SFI's intrinsic involvement in the development of the first STEM Education Policy Statement. SFI is recognised in the policy as a key partner in terms of funding and promoting public engagement and SFI has been specifically mentioned in the delivery of key actions from the Government's STEM Education Implementation Plan published in 2017.

Japan

1. Hirameki Tokimeki Science Initiative

Launched by the Japan Society for the Promotion of Science (JSPS) in 2005, the Hirameki Tokimeki Science initiative is committed to the communication of the results achieved in KAKENHI-funded research by researchers themselves to elementary, middle, and high school students in an easy-to-understand way. The aim is to promote science by offering opportunities for students to experience the cultural value and social significance of science, as well as strengthening their understanding of the meanings of science and its application in their everyday lives.

Partnerships and collaborations are formed by researchers supported by KAKENHI as well as and research institutions with which the researchers are affiliated. The upper grades of elementary, and middle and high school students are those who can participate in and benefit from this initiative. The programme is evaluated by external experts and the Minister of Education, Culture, Sports, Science and Technology every year as a part of the annual JSPS project evaluation.

2. Science Dialogue Programme

The Science Dialogue programme has been designed to provide Japanese high school students with the opportunities to listen to lectures (in English) given by international research fellows affiliated with the Japan Society for the Promotion of Science (JSPS) Overseas Fellows. Launched in 2004, the goal of the programme is to stimulate young students' interest in research and deepen their understanding of science through interacting with fellows. This programme furthermore offers fellows a great chance to communicate with local communities and strengthen their ties with Japan.

3. Support for Female Students in Science Courses

The Japan Science and Technology Agency (JST) launched the Support for Female Students in Science Courses programme in 2006 specifically to encourage female high school students to become scientists. The programme aims to provide opportunities for female students to interact with female researchers who are also engineers, and university students who are active in the field of science and technology. In addition, the initiative supports universities and other organisations that carry out initiatives in cooperation with local communities and companies.

For women to lead the next generation of scholars, and to play an active role in the future of science and technology innovation, more efforts are required to understand the career interest and motivations for junior and senior high school girls. We must encourage girls, parents, and teachers to increase awareness about the merits of choosing science and engineering, understand the contents of work in the science and engineering field, work styles, and careers of those who are working in science and engineering.

Up to ¥3 million per institution/year for two years has been made available for this initiative. In addition to efforts aimed at female junior and senior high school students in all prefectures, the programme promotes close collaboration with junior high schools, accelerates activities at local school sites, and strengthens the approach to the junior high school stage. In 2019, 15 organisations were participating in this programme, whilst 10 531 students participated in this initiative in 2018.

4. Global Science Campus (GSC)

The Japan Science and Technology Agency (JST) provides support for projects launched at universities which develop advanced, systematic and educational programmes in the sciences. The programme exposes students to international scholarly activities whilst allowing students to attend educational programmes. High school students from local areas close to each university, who display talent and potential, are selected and recruited to participate in these programmes.

The programme was launched in 2014 to develop capable personnel in the fields of science and technology. The programme aims to introduce students to research matters.

Parameters for these projects will include papers published in international journals, research presentations at international conferences, as well as participations in international science and technology contests. Universities aim to promote projects that integrate multiple different fields and utilise the unique characteristics of the local area.

JST provides support for four years and funding of ¥30 million per institution/year.

As a result of this initiative, many research results have been published in overseas journals. Many students who participated in the Global Science Campus programme (GSC) also participated as representatives in domestic and international science contests such as the International Science Olympics and the International Student Science and Technology Fair (ISEF). The participating students furthermore entered major universities in Japan and overseas universities such as the Massachusetts Institute of Technology. After the end of support, the programme will be funded by the university whilst also branching out to the Faculty of Humanities.

5. Fostering Next-Generation Scientists Programme

The Japan Science and Technology Agency (JST) initiated the Fostering Next-generation Scientists Programme in 2017 to support promising elementary and junior high school students interested in science and technology. The programme consists of lectures, conducting experiments, and tours of research facilities whilst encouraging students to explore their fields of interest. Each institution also selects about 10 students out of 40, assigning them to a specific laboratory. The students then receive individual guidance on how to write academic papers and conduct research.

Furthermore, students present their research annually during the 'Student Presentations' sessions. In addition, a 'liaison council' is held once a year where representatives of the executing institutions share their good practices and discuss common issues. For the graduates, JST actively promotes connections to 'Super Science High Schools' and 'Global Science Campuses' in the high school to support the continuation of students' efforts.

According to a questionnaire survey of participating students, 98% of the students answered "interest in the unknown (curiosity) has increased"; 95% are "willing to work actively"; 93% have "the desire to create something with their own ideas (creativity)"; and 89% "want to get a job related to science and technology in the future". Students have participated in various contests in Japan and obtained excellent results.

6. Super Science Highschool (SSH)

With a specific focus on the development of future international science and technology professionals, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has, since 2002, designated high schools to carry out advanced science and mathematics education. These schools, known as Super Science High Schools (SSH), provide the necessary support to promote developmental activities.

A total of 212 schools have been designated in 2019, (about 4% of high schools in Japan). A wide range of initiatives are implemented in SSH schools such as curriculum development, experiential learning, the promotion of subject research, science classes in English, presentation training, the development of teaching methods and teaching materials and the dissemination of the results to other schools.

During 2018, 114 061 students participated in SSH programmes. The Japan Science and Technology Agency (JST) furthermore organises student research presentations and information exchange meetings whilst supporting various SSH initiatives. Results indicate the programmes are successful. During 2017, for example, 50% of students participating in the International Research Contest were from SSH designated schools. In a survey conducted for graduates who were the main target of SSH activities, about 80% of the respondents majored in the science field of universities whilst the rate of graduates attending graduate school is twice that of science university students nationwide. The importance of 'study research', which is a unique initiative of SSH, is widely recognised, and 'Science and Mathematics' has been proposed as a new subject that will be implemented from 2022. 'Exploration of Mathematics' and 'Basics of Science and Mathematics Exploration', which are exploratory subjects covering mathematics and science, will furthermore be newly established.

Saudi Arabia

Motivate the Younger Generation to Engage in Science and Technology Fields

The Motivate the Younger Generation to Engage in Science and Technology Fields initiative was introduced in 2017 by King Abdulaziz for Science and Technology (KACST) in order to achieve one of the national strategic goals aimed at 'increasing qualified national competencies to support the development of local content'. This initiative is aligned with one of the Saudi Vision 2030 goals related to 'providing quality knowledge to the distinguished students in priority areas', through launching several projects that contribute to involving the younger generation in the fields of science, technology, and scientific research.

The initiative includes 18 programmes divided into five groups: scientific multimedia; scientific books, journals, magazines and reports; students' skills; scientific events; and programmes and websites. The main target audience for the initiative is students between 12 and 18 years, although some of the programmes also target the general public. The main stakeholders for the initiative are the Ministry of Education, King Abdulaziz and his Companions Foundation for Giftedness and Creativity (Mawhiba), the Ministry of Media, the Ministry of Communications and Information Technology and Mishkat Interactive Centre.

United Kingdom

UK School Seismology Project

The UK's British Geological Survey (BGS) introduced an active schools engagement programme in 2007. The UK Schools Seismology Project is one of these programmes, enabling schools to detect signals from large earthquakes happening anywhere in the world.

The sheer destructive power of earthquakes has always held a fascination for children. This long-term project capitalises on this natural interest by making use of earthquakes and seismology as a unifying theme in a set of simple classroom activities that teach a range of basic science concepts. The project also creates a 'wow' moment in the classroom by enabling schools to operate their own seismic recording station which is sensitive enough to record signals from large earthquakes that have happened on the other side of the world. Detecting signals from events of global significance has a dramatic effect on school children, making them realise that science is not a set of abstract ideas but rather a way of understanding how the real world actually works.

It is one of several projects that aims to improve science education in the UK. It aims to make science more interesting for students aged 11-16; improve the participation rates in physical sciences for students aged 16+; influence curriculum development in the UK; and raise awareness of geoscience as a scientific discipline for pre-university students.

The project has developed a simple seismometer system that can be used by schools to detect and record signals from distant large earthquakes. The project website includes teaching resources and data from recent earthquakes that schools have recorded. The project has promoted the installation of over 500 seismometers in schools across the UK and around the world.

The project also promotes and facilitates links between UK schools and schools in other countries that are also recording signals from large earthquakes (or even experiencing the actual earthquakes).

B. PUBLIC DIALOGUE APPROACHES

Germany

1. Public Debate Series: Science On

Science On is a public debate series organised by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) in cooperation with the Art and Exhibition Hall of the Federal Republic of Germany, otherwise known as

the Bundeskunsthalle. This biannual event focuses on topics that are of high societal importance and are widely (and sometimes controversially) discussed in the public sphere. The series focuses on the scientific perspective of these topics and aims to shed light on the background of an issue, make wider contexts understandable whilst enriching societal debates with scientific findings and assessments. The format of the programme is designed to involve the audience in as many ways as possible. Electronic voting also takes place among the audience in the hall on specific questions.

Topics that have been discussed between 2017 and 2019 on the programme thus far include antibiotic resistance, artificial intelligence, genome editing, the future of democracy, brain research, and freedom of art and science. These topics required a discussion with depth of content but at the same time the events had to be comprehensible and attractive to a large and diverse audience. The public debate series engages with the public in the Cologne/Bonn region whilst focusing specifically on a younger university audience, including school pupils with their teachers. So far, all events have been well attended or even fully booked (300-500 visitors). Approximately 50% of the audience were students. Video recordings are made available via YouTube, thus making the debates accessible to a larger audience. Through this debate series, the DFG and the *Bundeskunsthalle* aim to emphasise their commitment to making Bonn a strong centre for science.

2. Leibniz Lecture and Exkurs

In the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) lecture series "exkurs - Einblick in die Welt Wissenschaft" (Excursus - Insights into the World of Science), DFG-funded researchers present their work to a lay audience in easily understandable terms and concepts. The *exkurs* series currently comprises approximately eight events per year in three different German cities and consists of 50-minute lectures followed by a moderated Q&A. Topics of recent talks included microplastics in the environment, digital language assistants, restitution research, risk research, the development of super telescopes and robots as helpers in everyday life. The lectures are recorded, and the audio files are distributed via the DFG Media Library.

The Leibniz Lectures, which the DFG organises at different international venues, are similarly structured. The lecturers are not only top researchers but also recipients of the DFG's renowned research award known as the Gottfried Wilhelm Leibniz Prize, which comes with a large prize fund. They act as 'ambassadors' for German science and research.

3. Fridays for Future – Dialogue Between FfF Activists and Scientists

As the 'Fridays for Future' protests attracted more and more interest among Berlin pupils in early 2019, the Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science invited activists to the museum to discuss different aspects of climate change with scientific experts from Leibniz institutes. The initiative has evolved into a standing invitation, gathering up to hundreds of pupils on a weekly basis and achieving great public awareness.

The activity informs pupils about current research on climate change, covering different aspects (mitigation, adaptation, biodiversity impacts, climate economics, food production, etc.). It taps into their commitment and enthusiasm, allowing them to draw informed conclusions on which to base their policy demands. Furthermore, it acquaints pupils with the scientific process and the fact that scientific results may vary depending on the approaches or assumptions they are based upon.

Pupils are invited to the museum free of charge to meet with numerous experts, with an emphasis on interactive discussions, Q&A sessions and workshops rather than on lectures. The invitation to a research institution bestows activists with recognition from an 'established' institution while the formats of debate contribute to lower the burden of hierarchy between scientists and laypersons. The inclusion of various disciplinary perspectives as well as Leibniz institutes involved in policy advice familiarises activists with the diversity of scientific assessments and the process by which these can influence actual policy. Participants gain awareness for scientifically sound approaches and arguments.

The museum invites experts from various thematically-related Leibniz institutes (economic research, climate impact research, agricultural research, biodiversity) and other research institutions. The initiative has gained significant public and political recognition while upholding science's role as a provider of sound expertise. The museum presents itself as an accessible, open research institution that serves as a platform and marketplace for debate.

Japan

1. Nobel Prize Dialogue

With the Nobel Prize Dialogue initiative, The Japan Society for the Promotion of Science (JSPS) invites the world's leading scientists, including Nobel laureates, to participate in a dialogue via open lectures and panel discussions with the general public, students and young researchers. The initiative was launched in 2015 to foster public interest in science and technology whilst contributing to the advancement of science and technology.

JSPS organises the Nobel Prize Dialogue with Nobel Media AB, a public relationship arm of the Nobel Foundation. A partnership with corporations has been set up to finance each event. The general public, students and young researchers are invited to apply.

One of the measuring points is the number of participants in the dialogue. Generally, they seem to be extremely interested in understanding scientific themes given through the communication with Nobel laureates. In addition, JSPS asks participants to answer a questionnaire after the event. All participants and panellists are asked to answer a questionnaire to measure the participants' composition, their satisfaction with the event contents and the degree of their understanding about the theme.

2. 'Science Agora' & Satellite Events

Science Agora is an open forum established in 2006 by the Japan Science and Technology Agency (JST) to connect science and society, and to deepen the interaction between STI and society. The initiative provides the following diverse programmes: academic dialogue sessions; showcasing good practices addressing challenges and public engagement; sessions for high school students to present their studies; and booth exhibitions to show children the fun of science.

Partnerships and collaborations include science museums, national R&D institutes, private companies such as environment and chemical engineering, aeronautics, publishing, and future alliance centres which attend as exhibitors or host talk sessions. Speakers from global partners such as AAAS, EuroScience, DSI (South Africa), KOFAC (Korea) and CAST (China) are invited.

The success of the initiative is measured by monitoring participant numbers and analysing its attribution every year. Feedback has also been collected from participants in several ways through video recording, sticky notes, touch panel and submitting reports from session organisers. These feedbacks were visualised on the main stage of the venue.

Korea

Fine Particle Control and Management R&D Programme

The objectives of the Fine Particle Control and Management R&D Programme are to establish and promote problem-solving oriented R&D systems for solving fundamental societal problems. Since 2017, the Fine Particle Control and Management R&D Programme has aimed to fundamentally and scientifically solve problems of public health.

The National Research Foundation of Korea (NRF Korea) recognised the previous R&D achievements' lack of contribution to public life. The foundation analysed R&D, patents, markets, and monitored social issues. Public opinions were generated and core research areas were selected which included disasters, dementia, the environment, and safety. Citizens were asked to join the planning of the R&D programme through websites. A total of 66 ideas were submitted, with seven eventually developed into preliminary planning research objectives in 2018.

Opinions and ideas of the general public were curated through websites and the following public dialogues emerged: disaster/safety policy; solving social problems through science and technology; research; and nuclear power safety solutions.

Partnerships included stakeholders from all spheres of society including researchers, the general public, the government, and related organisations.

Sweden

Swedish Research Council initiatives

The Swedish Research Council supports public engagement in several forms in addition to its main task of science communication. Although the distinction between the two is sometimes difficult to draw, the Council arranges communication channels and platforms for science communication and public engagement, for example: public talks on various topics in science policy; dialogue forums on research results; forums for science communication (*Forum för forskningskommunikation*), a conference arranged in conjunction with the annual International Science Festival; the science information platform *forskning.se*, where research results are made available to the public; the web magazine Curie, devoted to the world of research; and Researchers' Grand Prix, a competition for presenting research in as captivating, inspiring and educational a way as possible in only four minutes.

The Council supports the activities of the Swedish civil society organisation, *Vetenskap & Allmänhet*, which works comprehensively with public engagement. One such activity is *ForskarFredag*, the Swedish version of Researchers Night. Under the umbrella of *ForskarFredag* an annual citizen science project for Swedish pupils and citizens is organised. The Council also participates in the design and funding of the Transfer call on public engagement, explicitly within the partnership programme ERA Cofound Aquatic Pollutants. Synergies between public engagement and open science are identified.

The Council initiated a new setup of calls for research funding to include and encourage public engagement activities. A pilot study is set to be implemented in natural sciences and engineering sciences. The Council also trains and educates scientists and communication staff within the areas of science communication and PE, both nationally and internationally.

C. PUBLIC ENGAGEMENT AND NETWORK DEVELOPMENT AND SUPPORT

Canada

Science Odyssey

With a focus on youth, Science Odyssey is a national 16-day campaign to raise public awareness and interest in science, technology, engineering, arts, and mathematics (STEAM). The campaign contributes to a robust science culture that values STEAM and allows the Natural Sciences and Engineering Research Council of Canada (NSERC) to take a national leadership role and provide a focal point for science promotion efforts. Every year in May it brings together almost 600 public engagement and outreach leaders who deliver over 1 000 events and activities in more than 350 cities with almost 600 000 people attending the events.

Science Odyssey builds on more than two decades of experience with the National Science and Technology Week (NSTW), which invited all science-based departments and agencies in the federal government to showcase their achievements in science and technology and the benefits of government-funded research. Under the Science Odyssey brand since 2016, the initiative is open to a wider variety of stakeholders including government, universities, colleges, polytechnics, institutes, science centres, museums, libraries, schools, educators, parents – and in particular, Canadian youth interested in STEAM.

Science Odyssey allows each partner to organise their own activities and events according to their own strategic outreach goals. By aligning activities with Science Odyssey and registering them on the SciOd.ca website, partners increase their visibility and impact and create synergies towards a true national celebration of STEAM. There is no cost associated with participating in Science Odyssey.

NSERC takes relevant indicators from a survey of participant organisations, combined with information provided when they register. The agency also develops metrics based on social media activity and website traffic.

For NSERC, the key indicators are the number of events, the number of organisations taking part, and range of cities and communities hosting an event. During 2019, 1 027 events were held, while 508 partners joined, and 286 cities were involved.

European Union

ERC Public Engagement with Research Award

The European Research Council (ERC) Public Engagement with Research Award 2020 was designed to recognise and celebrate ERC-funded researchers who have demonstrated excellence in public engagement and outreach. The first competition was launched on 24 September 2019 with the deadline for submitting applications by 10 January 2020. More than 130 applications were received in the following three categories: public outreach; press and media relations; and online and social media. A jury composed of international experts selected one winner in each category. The three winners were announced at an award ceremony in July 2020.

The prize for each winner includes a trophy; complimentary registration to EuroScience Open Forum (ESOF); reimbursement for reasonable travel and hotel expenses for attending the award ceremony; and visibility at the award ceremony. In addition, winning projects are featured prominently on the ERC communication channels, expanding the visibility of the project beyond the national level to EU audiences, for several months after the award. The expected benefit for the ERC is to gauge the public engagement activities carried out by ERC-funded researchers and relay them in its communication activities while encouraging its grantees to engage in such activities by providing examples of their work.

Furthermore, The ERC is funding researchers who have an obligation to communicate their research. This is, however, the first time an award is designed to recognise researchers who not only excel in research but also in public engagement around their ERC-funded research. The ERC direct-mails all eligible researchers and handles the pre-selection of proposals. Jury members are invited to select the best proposals - professionals in communication as well as representatives of public engagement organisation and European political bodies.

Only ERC-funded researchers are eligible to apply. The aim is to encourage ERC grantees but also communication officers in their host institutions/research organisation to engage the public with their research content.

Japan

Grants-in-Aid for Scientific Research Database (KAKEN)

Hosted since 1987 by the National Institute of Informatics (NII) in cooperation with MEXT and Japan Society for the Promotion of Science (JSPS), the database is open to the general public who want to read the results of KAKENHI-funded research on the Internet. It aims at advancing the practical application of research results in society and increasing general understanding about KAKENHI programme. The project hence provides resources (founded on publicly funded KAKENHI research) for the purpose of public engagement.

Partnerships and collaborations have been established with the National Institute of Informatics (NII) in cooperation with MEXT and JSPS. Anyone who is interested in the research supported by Grants-in-Aid for Scientific Research (KAKENHI) can apply.

The KAKEN database is evaluated annually by external experts and the Minister of Education, Culture, Sports, Science and Technology as a part of the annual JSPS project evaluation.

Qatar

Monitoring the Dissemination of Research Outcomes to the Public

The Qatar National Research Fund (QNRF) changed its projects' monitoring scheme to include public engagement as an assessment criterion, where awardees are required to report on their project's public engagement activities, e.g. public lectures, seminars, training, information material, events, etc. This will encourage awarded researchers to communicate their research outcome with the public; give ownership of the publicly funded research outcome to the public; and stimulate public interest in research and help recruit future researchers and research stakeholders.

The initiative, which was introduced in 2017 and took effect in 2018, enables researchers to participate in public engagement not only in their ongoing research but also their future research proposals.

United Kingdom

Trans.MISSION

The Natural Environment Research Council (NERC) and Hay Festival worked together to deliver the Trans.MISSION projects. NERC is the UK's main agency for funding environmental science and Hay Festival is an annual event that showcases the latest ideas in the arts, sciences and current affairs, alongside a rich schedule of music, comedy and entertainment for all ages.

Trans.MISSION I paired leading environmental scientists with award-winning artists to communicate cutting-edge research to new audiences at Hay Festival 2018 and beyond. Each pairing produced a piece of work - an animation, a series of still pictures with text, an infographic or animated text – that were launched during a series of public events in Hay Festival's 'Hay on Earth' programme (24 May - 03 June 2018). The climate scientist and mathematician at the British Antarctic Survey (BAS), Emily Shuckburgh, joined award-winning designer, author and illustrator Chris Haughton, to explore polar science and climate change. Atmospheric chemist, Ally Lewis, paired with Aardman Studios' Director, Dan Binns, to look at air pollution whilst climate scientist, Ed Hawkins, joined children's author, Nicola Davies, to analyse extreme weather events.

Trans.MISSION II was a global project that paired leading environmental researchers with storytellers to communicate science to new audiences. The project paired NERC researchers from Peru, Colombia and the UK with artists and storytellers in each country to create new stories about ongoing research projects. An artist, illustrator or animator was be commissioned to create an overarching piece - an animation, infographic or animated text - that will combine and communicate the common themes. These pieces informed, engage and inspire members of the public and future researchers regarding environmental science and the processes of research.

Trans.MISSION II was the first international public engagement collaboration project for NERC, with each new piece being launched at Hay Festival events in Arequipa, Peru (7-10 November 2019); Cartagena, Colombia (30 January - 2 February 2020) and in Hay-on-Wye, Wales (21-31 May 2020).

D. INTEGRATED PUBLIC ENGAGEMENT INITIATIVES

Germany

Science Communication Module

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) supports researchers in their efforts to communicate the topics and results of their scientific work to lay audiences. In all DFG science funding programmes, researchers can apply for support for self-selected formats of scientific communication. Examples include workshops or videos for students and teachers; exhibitions and participation in science days; public discussions; and industrial trade shows. Suitable projects may also pursue longer term PR strategies such as developing and maintaining a communication platform aimed at the general public. Methods may be chosen freely but must relate clearly to a funded project and significantly go beyond the host institution's standard public-relations activities.

The Collaborative Research Centres funding programme makes particularly intensive use of the Science Communication module. For example, a collaborative research centre in the field of geoarchaeology has designed a travelling exhibition entitled *2 Million Years of Migration* to show that migration is part of the history of human development. The exhibition is aimed primarily at school groups (as the most important social group that has to cope with the largest proportion of migration in everyday life today) and families, but also at people who are involved with the topic of migration on a professional or voluntary basis and migrants themselves. The exhibition was shown in several cities in Germany and received considerable media coverage.

Another collaborative research centre, in the field of materials science, developed a 'speed dating' format with scientists called *Meet Your Scientist*. Scientific staff members made themselves available for a short question and answer session in this dialogue-based format. Passers-by were involved in discussions at public events. Due to the relaxed and personal format, participants on both sides reported that in the future they would be more likely to have the confidence to enter discussions at public events.

The Netherlands

National Research Agenda (NWA)

The National Research Agenda, initiated by the Dutch Research Council (NWO) in 2015, aims to ensure that cross-fertilisation and smart collaboration between all the various partners leads to the whole being more than the sum of its parts. That is, after all, how science can excel and combined with applied and practice-based research, makes an important contribution to the quality of our lives, our society, and our economy.

This agenda should fire the imagination, challenge, and inspire researchers and society in general to achieve pioneering breakthroughs. It should ensure that research is closely aligned with societal and economic opportunities and requirements and identify those subjects in which Dutch research excels and is distinctive. Promoting Dutch research with its own unique agenda will boost the Netherlands' position in international alliances and put the country in the international vanguard in specific fields. This is important if it is to play a leading role in prestigious international alliances, so that the Netherlands becomes a magnet for talented scientists and knowledge-intensive business.

The agenda should not focus on the full spectrum of research but rather on those themes that benefit from coordination and collaboration. In particular, it should feature research that would be less efficient and effective if conducted by organisations or institutes working separately. The agenda should inspire and remove barriers between organisations, scientific disciplines, or sectors. By making connections and encouraging cooperation, it will enhance and revitalise existing agendas."

Oman

The National Strategy for Research and Development 2040

The main objective of public engagement in the development of the National Strategy for Research and Development 2040 is to enhance the role of civil society and different public segments in the formulation of national plans and strategies. The Research Council of the Sultanate of Oman's engagement plan launched in 2019 considered the role of public participation and recommended different tools of engagement. With the motivation to co-construct the experiences of strategy formulation, they adopt the neo-institutionalisation perspective in documenting all the stages of the project using ethnographic tools. The changes throughout the process are analysed and the outcomes published to share the process as an example of institutional innovation.

The approach was tailored to adopt three main principles of stakeholder's engagement: promotion of an inclusive and diverse stakeholder engagement through identification and mapping of potential stakeholders; engagement stakeholders early on and throughout the project phases through effective communication; and monitoring, evaluation, and documentation of the progress. These principles were applied to identify five core stakeholders and the tools of engagement were designed to allow maximum partnership and participation. In addition, the tool of pull/push communication was used to engage the wider public.

The project team adopted the social constructionist epistemological position, which involves co-production of knowledge and joint experience with the core stakeholders and the wider public. It was planned to enhance the spirit of ownership among the core groups as well as the public. These tools targeted different segments of the public in order to enrich the project with views and experience of diverse actors of the R&D ecosystem.

Two main indicators are used to determine whether the initiative has been a success: total number of participants at different project activities; and the nature of inputs from this participation. Data were collected through a five-question questionnaire that was sent to selected stakeholders (high interest/high influence + high interest). Ethnographic tools of observation and taking notes were also applied during two main sessions: high-level stakeholders' dialogues and youth dialogues.

E. RESOURCING (INCLUDING FUNDING) FOR PUBLIC ENGAGEMENT

Canada

PromoScience (Canada) 2000

NSERC's PromoScience Programme is the only national programme in Canada supporting initiatives that focus on science, technology, engineering and math (STEM) learning. The objectives of the programme are to increase science literacy among young Canadians, to boost the number of students who pursue studies and careers in STEM fields and to promote diversity in STEM through initiatives for girls, young women and indigenous populations.

PromoScience grants support organisations that inspire young Canadians to take an interest in science and engineering, that motivate students to study STEM and pursue careers in these fields and that create interactive, hands-on science experiences for youth. In addition, the programme supports organisations that focus on groups that are traditionally under-represented in scientific and engineering careers, and/or provide instruction and resources for science, math and technology teachers.

To be eligible for a PromoScience grant, organisations must be a Canadian-registered non-profit organisation, a post-secondary institution, or a non-federal museum or science centre. Organisations must also demonstrate ongoing involvement in the promotion of the natural sciences and engineering to young Canadians. Organisations may request funds for up to three years at a time. All eligible applications are peer reviewed by a selection committee. Members are selected from the science and engineering promotion community, and the education community, based on their stature and expertise.

In addition to the extensive evaluation done in 2016 (see link below), NSERC tracks the number of applications received as an indication of funding demand (2015=191, 2016=166, 2017=169, 2018=188, 2019=221). Given NSERC's increased focus on equity, diversity and inclusion (EDI), the agency tracks the number of PromoScience applications and awards that have been identified as having a focus on underrepresented groups, e.g. girls and indigenous youth. Sixteen case studies were conducted as part of the 2016 evaluation.

Japan

1. International Prize for Biology

The International Prize for Biology was established in 1985 to advance the biological sciences in a global context by annually awarding a biologist who has a superlative record of achievement in the subject field. The Committee for the International Prize for Biology is called every year to select a specific branch of biology for which the prize is awarded. The award ceremony is held in the presence of imperial family members, followed by a commemorative symposium and a public lecture to raise awareness of the field. A Prize Fund has been established by the Japan Society for the Promotion of Science for receiving and managing donations.

Partnerships and collaborations include the Committee on the International Prize for Biology (composed of biologists and leaders in the business communities), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Japan Academy, donors who have provided long term support for the prize, and the Japan Society for the Promotion of Science. The selection committee invites nominations of candidates for a specific research field of biology from relevant universities, research institutions and individuals each year.

One of the measuring points is the number of participants in the commemorative symposium held directly after the award ceremony. It appears to indicate the extent of interest by the general public, including biologists/scientists and laypeople, in the year's subject. The track-records of the prize for 35 years demonstrate a strong commitment by stakeholders to this initiative. A commemorative booklet of the award is published every 10 years. Currently, a commemorative booklet celebrating the 30th anniversary of the Prize has been posted on the Japan Society for the Promotion of Science (JSPS) website.

2. Solution-Driven Co-creative R&D Programme for SDGs (SOLVE for SDGs)

SOLVE for SDGs is a funding programme launched by the Japan Science and Technology Agency (JST) in 2019 to support integrated activities of stakeholder engagement and action, utilising STI aimed at the achievement of SDGs in local areas. The aim is to support not only the R&D phase but also the scenario creation phase processes. The initiative furthermore focuses on creating solutions to solve challenges, and not only pursuing the advancement of science and technology (new seeds are not essential requirements). Team-building exercises are imperative before application, which will also include the participants who are responsible for implementation.

This initiative is conducted by two departments at JST: the Department for Promotion of Science in Society, and the Research Institute of Science and Technology for Society (RISTEX). Participants and beneficiaries are any organisations based in Japan (university, private company, NGO, local government) working to solve societal challenges in Japan.

3. STI for SDGs Award

The STI for SDGs Award is a new initiative (2019) awarding the successful activities of stakeholder engagement and action that tackle societal challenges in local areas utilising STI. The Japan Science and Technology Agency (JST) expects these effective solutions to spread to other regions where people face similar problems resulting in contribution to local SDGs.

The award intends to encourage the utilisation of STI as a key tool of the activities in a co-creative and inclusive manner. Awarded projects are be widely disseminated through JST media and events to accelerate STI for SDGs activities in each region.

Special awards are given in collaboration with Ministry of Education, Culture, Sports, Science and Technology (MEXT). Beneficiaries and participants are any organisations based in Japan (University, private company, NGO, local government etc.) working to solve the societal challenges in Japan.

F. KNOWLEDGE CO-PRODUCTION APPROACHES

Belgium

Strategic Basic Research

The Strategic Basic Research (SBO) was initiated in 2004 by Research Foundation Flanders (FWO) and aims to fund innovative research with a specific focus on economic or societal applications. The evaluation of proposals is based on a score grid that deals with the scientific quality of the proposals as well as the perspective of and vision on utilisation. Both aspects are equally important. The evaluation of the utilisation includes the assessment of the applicant's vision on the potential for translation into concrete applications and the plan on how to bring innovation to the field.

The SBO programme breaks down into two parts: an economic programme part for projects with a primarily economic finality and a societal programme part for projects with a primarily societal finality. The ultimate purpose of an SBO project is to contribute to an influx of new ideas and concepts that, at a later stage, may be the basis for a new generation of products, processes or services in the business community and/or may solve issues that impede innovation (economic), respectively, the resolution of societal issues or the creation of new opportunities with a societal added value for Flanders (societal).

To reach this goal, applicants should embark in a joint project definition with economic and/or societal stakeholders (social profit organisations, professional groups and government departments/entities), whereby the latter indicate their needs and strategic interests, and knowledge centres then respond to these by formulating a research project. SBO is thus not aimed at pure and one-directional knowledge dissemination but at the acquisition of new knowledge in a dialogue between, on the one hand, one or more research centres that carry out the research and, on the other hand, the companies and/or societal actors that will subsequently translate the results into concrete applications.

Eligible organisations include all Flemish research institutions with, additionally, optional involvement (max. 20% of budget) of non-Flemish research institutions.

G.CITIZEN SCIENCE APPROACHES

Chile

EXPLORA Programme

The initiative, Scientific Research at Schools, aims to motivate students from the 5th to 12th grade to ask questions arising from their curiosity and motivation concerning natural or social phenomena and to develop them through a research project. The expected benefits are that students develop critical thinking and scientific skills, such as exploring, questioning, predicting, experimenting, analysing and investigating.

This initiative was established in 1995 and focuses on students who, accompanied by a teacher, develop the different stages of research. In the process of scientific research at schools, the questions must arise from the students according to their interests and motivations. The areas of study may be social sciences, natural sciences or technology. After defining the question, the stages of the research (hypothesis, objectives, experimental design, results analysis and conclusions) are developed during the academic year. Throughout the process students are expected to gain autonomy as they contribute to teamwork.
An innovative aspect of this initiative is that students are not only guided by their teachers, but also by a scientific advisor according to the chosen topic. To achieve this synergy, the Explora Programme plays a fundamental role in this process, since it is the articulator between the schools and the world of science.

The Explora Programme implements this initiative throughout the country, linking educational establishments with researchers, ensuring that students interested in carrying out research receive scientific advice from experts on the chosen topics. The role of the scientific advisor is to support the research process of the group, monitoring the progress of the work and providing recommendations if necessary, always respecting that the research questions emerge from the students. The research papers are presented at the Regional School Congresses, where the students present their research, and the winners compete in the National School Congress.

Germany

Citizen Science Projects and Initiatives

The Leibniz Association and its research institutes are proud supporters and promoters of citizen science initiatives. Citizen science is a well-established approach within Leibniz and a myriad of citizen science projects are in place at Leibniz institutes, much in line with the organisation's mission to pursue excellent research with societal impact.

In addition, the Leibniz Association and its institutes play a decisive role within German and European citizen science networks, structuring and nurturing the further development of the field. Leibniz has established a Leibniz Citizen Science Network, gathering 21 institutes especially active in this field and elected a representative of its Executive Board for Citizen Science. One of its institutes, the Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science runs the central German citizen science collaboration platform ("Bürger schaffen Wissen", Citizens create Knowledge) and hosts and chairs the European Citizen Science Association (ECSA).

Citizen science projects contribute to the pursuit of large research projects that rely on the non-systematic, or partially systematic, collection of large amounts of data and samples, thus lowering costs and efforts and increasing the coverage of such projects. On a wider perspective, citizen science also contributes to the co-design of research projects with societal implications and serves to communicate research and the scientific process. The networking efforts serve to exchange best practices and to establish standards for Citizen Science.

USA

Public Participation in Science

Citizen science has emerged as a powerful tool in the sphere of public policy and decision-making. For instance, in the United States, governments (federal, state, and local) work together with citizens and communities to plan for and respond to natural hazards and emergencies. Objectives and benefits of citizen science include addressing societal needs, providing hands-on learning in STEM, and connecting the public to federal agency science missions. U.S. federal agencies adopting crowdsourcing and citizen science approaches have benefitted from data and analysis they could not otherwise collect or perform.

A particularly innovative aspect in the U.S. federal context is CitizenScience.gov, an online 'one-stop shop' with a toolkit of resources to aid project management, and a government-wide listing of projects spanning a wide range of topics, geography, scale and complexity. There is clear, easy-to-find information on what/how/where/why of each project and about privacy, data ownership, intellectual property, and other terms of participation; participants can, therefore, make informed decisions. Furthermore, there is a Federal Community of Practice for Crowdsourcing and Citizen Science, a grassroots group that works across the government to share lessons learned and develop best practices.

As another innovative idea, online crowdsourcing games bring together cutting-edge technologies, such as game mechanics and sophisticated artificial intelligence algorithms, with human innovation and creativity for a 'best of both worlds' solution to complicated scientific problems.

In terms of partnerships, several U.S. federal agencies and science philanthropies have provided funding for researchers to involve citizen scientists in their projects. A growing number of organizations, e.g. Citizen Science Association in the United States, European Citizen Science Association, Australian Citizen Science Association, etc, seek to connect

citizen science projects in-country and globally and disseminate scholarship and best practices. These connections are key to answering questions at global scales.

H. HUMAN CAPITAL AND SKILLS DEVELOPMENT INITIATIVES FOR PUBLIC ENGAGEMENT

South Africa

Youth Science and Technology Journalism Programme

The Youth Science and Technology Journalism Programme primarily seeks to develop capacity in the community media for covering science and technology topics in indigenous languages and to advance the science journalism skills of post-graduate students. Introduced in 2016 by the National Research Foundation's South African Agency for Science and Technology Advancement (SAASTA), this programme seeks to contribute towards popularising science, awakening interest in science and developing a critical public that actively engages and participates in the national discourse of science and technology.

The objectives of the project are to develop basic science journalism skills in the youth and to enhance career opportunities; to enhance interest in science and technology in local communities and ensure the recognition of indigenous and grassroots innovation existing in communities; to enhance understanding of the importance of science and technology reporting in community media organisations; and to communicate specific Department of Science and Innovation (DSI) funded technology demonstration projects and general science stories in a variety of languages to local communities.

The project has been rolled out in three phases. The first phase prioritised the district municipalities where the DSI was implementing the Innovation Partnership for Rural Development Programme (IPRDP) innovative technologies in 2016. The second phase was completed in 2018, where the project was expanded to Gauteng and Northern Cape Province. The project focused on densely populated areas in Gauteng to ensure that the greatest number of people had access to the media coverage. The third phase of the project was the expansion in 2019 to the Western Cape and Free State provinces.

The project is aimed specifically at unemployed youth with undergraduate and postgraduate qualifications in science and technology, communications and/or journalism studies. The programme is monitored through tracking and documenting all media produced by the science journalism interns and reporting on this quarterly. Data has been collected on each cohort of interns and this can be shared. There are numerous examples of further engagement with the interns after completion of the 12-month programme, including some interns having started businesses in the science journalism and engagement space.

I. POLICY DELIBERATION APPROACHES

Germany

Senate Commissions (As Policy Advisors)/Alliance of German Science Organizations

As laid down in its statutes, the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) "...advises parliaments and institutions working in the public interest on scientific issues and fosters relations between the research community and society and the private sector." It was for this purpose that the Senate Commissions were established. They support the DFG with policy advice by, for instance, preparing statements on research-related issues that are relevant to society in accordance with purely scientific standards. The Senate Commissions are divided into two categories: Permanent Senate Commissions and Senate Commissions.

The Senate can establish Permanent Senate Commissions whose mandate extends over the longer term. This may be for important social, political or economic fields with a long-term perspective in which new scientific findings must be processed continually and across disciplines to serve as the basis for government action both nationally and internationally, or for politically and socially controversial, rapidly evolving scientific topics in which a recurring need for legislation with considerable relevance to research is anticipated. When establishing a Permanent Senate Commission, the need for the results of the Commission's work must be substantiated and its establishment on a permanent basis must be justified.

The Senate can appoint Senate Commissions in areas with a strong need for research, coordination and multi-layered structuring with the mandate to develop interdisciplinary approaches for complex coordination, improvement of the research infrastructure and establishment of structures conducive to research, where necessary in cooperation with other national and international organisations.

There are currently seven commissions on the following topics: Animal Protection and Experimentation, Food Safety, Genetic Research, Investigation of Health Hazards of Chemical Compounds in the Work Area, Key Questions in Clinical Research, Fundamental Issues of Biological Diversity, and Earth System Research.

Japan

CHAllenge-driveN Convergence Engine (CHANCE)

The objectives of the CHAllenge-driveN Convergence Engine initiative introduced in 2018 is the Integration of the activities of stakeholder's engagement envisioning future society, setting shared goals, making strategy including policy deliberation, building community and acting together.

The approach includes the following innovative initiatives: dialogue beyond boundaries (break silos!) to get together knowledge of diverse players to co-design an ideal future society with novel ideas & STI; create synergy combining each players' businesses and networks to accelerate implementation of scenarios to tackle challenges; popularise the concept of 'Co-design/Co-creation' to establish a solution-driven innovation ecosystem introducing convergence and diversity; and partnerships and collaborations that include companies, academia, NPOs, start-ups, research organisations, citizens and local communities.

This initiative is led by the Japan Science and Technology Agency (JST). Currently 32 activators (private companies, universities, national research institutes and NPOs) agreed to be members of CHANCE.

Successes are measuring by gathering feedback from participants in each event/workshop/meeting through questionnaires to be analysed and reported to MEXT. Several activities initiated under the CHANCE from last year are, amongst others, the 'SAKIGAKE'* Convergence Camp, where dialogue events were initiated involving young and promising researchers and stakeholders of the same generation from the private sector, academia and NPOs. The 'CHANCE networking event' that focused on a specific research project was a dialogue event for a specific R&D project on novel STI such as AI and artificial meat. Lastly, the 'JAPAN 2050' project was launched to identify challenges Japan may soon face, e.g. issues caused from hyper aging/declining population.

Qatar

Engaging Stakeholders in Setting Research Priorities

The Qatar National Research Fund (QNRF) organised a series of meetings for stakeholders during 2016 to deliberate and generate its research priority themes for its leading funding programme. The approach resulted in a comprehensive set of priorities that spanned all four pillars of QNRF, i.e. Energy & Environment, ICT, Biomedical and Social Science. The stakeholders included decision-makers and strategists from government, the public sector and industry. The benefits of the approach included public ownership of research priorities, priorities that are relevant and significant and research proposals and projects that have a better chance of being co-funded by stakeholders.

Annexure 4.2 - Mission-oriented Research Case Studies

Type of Activity	# of Cases
Research funding programme	14
Capacity building initiative	6
Policy deliberation approaches	1
Centres or other infrastructure	5
Mobility and exchanges	1

A. RESEARCH FUNDING PROGRAMMES

Belgium

Strategic Basic Research – Selection Advantage for SDG Focus

The SBO financing channel grants innovative research with the potential for and prospects of later economic or societal applications. This initiative was launched in 2020 by Research Foundation Flanders (FWO). The term 'strategic' refers to the problem-driven and application-oriented focus of the programmes. Projects should address a specific economic or societal need or challenge. The term 'basic research' refers to the need to gain knowledge beyond the current state-of-the-art before the problem can be solved. The evaluation is based on a score grid that deals with scientific quality of the proposals as well as the perspective of and vision on utilisation.

Projects with an elaborated focus on sustainable development may receive a selection advantage. For the purpose of giving a broad but still differentiating evaluation basis to the concept of sustainability that goes beyond the narrow 'environmental' interpretation, FWO delineates research topics as eligible for a 'bonus point' on sustainable development if they deal with SDG indicators that lag behind in Flanders.

For SDGs that lag well behind their targets, remedial actions will generate the greatest impact. Where adequate solutions for achieving the targets do not yet exist, strategic basic and applied research is an essential link in the societal value chain that could make the SDGs feasible. Obviously, such research can only meet its promises provided it is done in consultation with the other stakeholders of the societal pentagon (companies, government, financial institutions and citizens/associations). The latter should be supported by Letters of Intent and are subject to evaluation.

Eligible organisations include all Flemish research institutions with, additionally, optional involvement (max. 20% of the budget) of non-Flemish research institutions.

Brazil

FAPESP and Canada's International Development Research Centre (IDRC): Innovations for Marginalized Youth Economic Inclusion

In December 2017, the FAPESP (São Paulo Research Foundation) and the IDRC (International Development Research Centre) signed a research collaboration agreement to "…support scientific and technological cooperation between researchers supported by IDRC, and researchers supported by FAPESP, through the funding of joint research projects". The aim of the agreement is to build connections and networks among researchers in Latin America working to address similar development challenges. In the framework of this agreement in 2018, IDRC and FAPESP carried out a joint call for proposals on the "…innovations for marginalized youth economic inclusion".

The objective of the call for proposals was to support the generation and systematisation of knowledge, innovation, and evidence to foster economic inclusion for marginalised youth in Brazil and other Latin American and Caribbean countries. The call aimed to identify promising innovations and support piloting, learning and evaluation. It also wished to identify innovations that are being implemented and can be scaled up.

The joint call selected the project Coletiva Jovem (Youths Do Collective): a research and action project aimed at supporting production-oriented youth groups in the outskirts of São Paulo and Buenos Aires. This project is a collaboration between researchers at the Universidad Federal de San Carlos (UFSCar, Brazil) and the Facultad Latino Americana de Ciencias Sociales (FLACSO, Argentina). The research team located in Sao Paulo and led by Maria Carla Corrochano, while the research team in Buenos Aires led by Ana Miranda.

The project duration is two years and has two phases. During the first phase the central objective is to identify and analyse the employment and income creation initiatives on the part of youth groups and institutions in the peripheral areas of Sao Paulo and Buenos Aires. During the second phase of the research support centres will be created in both Sao Paulo and Buenos Aires for the productive inclusion of youth, with the participation of youth organisations, unions, commercial entities, government agencies, and civil society representatives.

Germany

Leibniz Research Alliances

Leibniz Research Alliances (LRA) pool complementary expertise from different Leibniz institutes to pave the way for longer term institutional collaboration and inter- and transdisciplinary research programmes with wide scientific appeal and societal relevance. LRA also serve to mark the expertise of the Leibniz Association in large fields of research. They are central points of contact for policy-makers, industry representatives, supporters, the media and the general public.

LRA and the associated funding mechanism have been in place for more than a decade. As of 2019/2020 a new mode of selection for LRA is in place. It seeks to combine the bottom-up initiative inherent to scientific knowledge-creation with a strategic approach that reacts to societal needs and strategic considerations, allowing to combine research from different Leibniz institutes along different research missions, grand challenges and/or themes.

In their new mode of selection, LRA seeks to approach tasks that are of current relevance to science and society, allowing them to pursue a mission-oriented research from a perspective that emphasises the strength of bottom-up research. They are allowed to form a critical mass, drawing together the expertise of different Leibniz institutes (and external partners), thus allowing them to surpass disciplinary boundaries and to address transdisciplinary needs.

This is done mostly by two means. Firstly, proposals for new LRA can now be handed in not just by the leadership of interested Leibniz institutes but may also be developed by Leibniz Strategy Forums (interdisciplinary lead groups, often formed by younger researchers, and nominated by the Leibniz Association's Board) and by further actors. Secondly, research proposals are put to examination by the Leibniz Board early on in the selection process and later reviewed by external scientific experts. The Board of the Leibniz Association consists of the leadership of the organisation, including representatives from the different scientific sections of the Association, and thus seeks to ensure an interdisciplinary and strategic approach.

LRA are open to collaborations reaching beyond the Leibniz Association, e.g. with universities, non-university research and infrastructure facilities, international research groups and industry partners.

Ireland

1. SFI Industry Fellowship Award

The Industry Fellowship award supports a post-doctoral researcher or academic member of staff in an Irish research body to go from academia to industry, or an industrial researcher to spend time in academia to work on an industrially relevant research project.

The Industry Fellowship programme supports collaborative research activities that span most areas of STEM and is open to all industry sectors. It is open to Irish or internationally-based, research-performing companies and academic institutions in Ireland. There is no requirement for the company to have an existing Irish base and if the researcher is moving to the company they can go anywhere in the world.

Fellowships can have a duration of between one and 12 months if full-time, and between two and 24 months if part-time. The maximum SFI contribution to an Industry Fellowship Award is €100,000 (which typically funds the salary and other costs of the researcher working in the company). Industry is required to support direct research costs, i.e. materials and consumables, which are not funded by SFI.

At the end of the fellowships, there are no restrictions regarding future engagement of the awardees and the host institutions. In the case of academic researchers moving to industry, the company can employ the person, the individual can move to another company or academia, or the individual can remain in any overseas country (subject to legal regulations). There is no limit to the number of projects a company can apply for and new applications can be made at any time, in line with the programme calls.

There are two fixed call deadlines annually, one mid-year and one at the end of the year. Submitted proposals are subject to international peer review.

2. SFI Strategic Partnerships

The Strategic Partnerships are a flexible mechanism for industry to engage with world-class academic researchers and have access to infrastructure and generate intellectual property. This partnership supports collaborative research activities that span most areas of STEM and is open to all industry sectors. It is particularly suitable for, but not limited to, pioneering research. It is aimed at supporting stand-alone initiatives of scale with strong potential for economic and societal impact for Ireland.

Any company is eligible to apply, regardless of their size, scale or location. The proposed research programme is funded 50/50 by the company and Science Foundation Ireland. There is no minimum or maximum project duration. It is up to the applicants to propose the most suitable duration for their project.

At the end of the partnerships, these may be expanded, or new partnerships proposed, both subject to satisfactory international peer review of the new proposal. This programme is always open, and applications can be submitted at any time. Proposals are first evaluated as a simple expression of interest, following which a full proposal is submitted which undergoes international peer review.

3. Challenge-Based Funding Models

Science Foundation Ireland (SFI) is currently taking multiple, complementary approaches to the development and implementation of challenge-based funding to enhance delivery of societal impact from government-funded research. As part of the development and design process, SFI has undertaken extensive engagements with international agencies involved in challenge-based funding, such as the Gates Foundation, the Institute of Innovation and Public Purpose (IIIP, UCL), NSF, NESTA, DARPA and INNO+. SFI is taking both a 'top-down' and a 'bottom-up' innovator-led approach that focuses on supporting small convergent challenge teams to identify and validate challenges in unconventional ways.

SFI has, to date, launched three bottom-up challenge calls. The first call was an open (non-themed) call - the SFI Future Ireland Innovator Prize. The key features of this initiative are a significant focus on team formation, convergence of ideas and disciplines, and both challenge and solution validation. The structure is also different to 'standard' research calls, as teams participate in several workshops.

During 2019, SFI launched two additional Future Innovator Prize calls – one in the area of AI for Societal Good and one in the area of Climate Action - Zero Emissions. Research teams were invited to compete for a €2 million prize award to address one of these significant societal challenges This could be through the development of a disruptive STEM-based solution that either leverages artificial intelligence or that has transformative impact potential in achieving net-zero greenhouse gas emissions in Ireland by 2050.

SFI is currently working through the identification and validation of compelling challenges for Ireland through analysis of national policy, consultation with key stakeholders, evaluation of Ireland's competitive edge and evidence and awareness of societal importance, prior to launching a number of top-down (narrow focus calls). Certain factors may be identified as part of this process which would strengthen the argument for taking the challenge-based route. These might include: the need to incentivise activity directed at a particular problem; the need to raise awareness of a problem; the need to bring expertise from different disciplines together; the need to include non-technical expertise in the scoping of the solution; and the adoption and regulation of the proposed solution.

Japan

1. Science and Technology Research Partnership for Sustainable Development (SATREPS)

Launched in 2018, Science and Technology Research Partnership for Sustainable Development (SATREPS) aims to acquire new knowledge and innovative technology that lead to the resolution of global issues and the advancement of science and technology. Through this process, SATREPS seeks to create innovative interventions. International joint research under this programme also aims to enhance the research and development capabilities of developing countries that will work towards sustainable research systems able to address and resolve issues.

SATREPS projects are chosen and developed in accordance with the following innovation criteria, namely, to envisage project outcomes being applied for the benefit of broader society as well as developing countries; to provide research and development and build research capacity for research on urgent issues in developing countries that lack proper resources and access; and to contribute to the resolution of global issues and scientific and technological progress.

JST and JICA (Japan International Cooperation Agency), which manages ODA, will collaborate to fund research projects. JST provides financial support to the Japanese research institutions for the project activities in Japan and JICA provides financial support to the research institutions in the ODA recipient countries within the framework of technical cooperation. The principal investigator (PI; applicant) must be affiliated with a Japanese research institution, be able to fulfil the duties as principal investigator for the international joint research project, and be able to engage in the international joint research from start to finish.

'Japanese research institutions' refers to universities, National Institute of Technology, independent administrative institutions, public sector research and development institutes, public service corporations, or private sector corporations.

Each SATREPS project is evaluated according to the programme's aims: building win-win relationships between Japan and counterpart countries in science and technology; addressing global issues and advancing science; and boosting self-reliant R&D capacity and sustainable research systems, training human resources and coordinating networking between researchers. Finally, SATREPS aims for the practical utilisation and implementation of research outcomes to contribute to society.

2. Solution-Driven Co-creative R&D Programme for SDGs (SOLVE for SDGs)

SOLVE for SDGs is a funding programme launched in 2020 to support integrated activities of stakeholder engagement and action utilising STI aiming at the achievement of SDGs in local areas.

The programme aims to support research and development endeavours with a specific focus on the scenario creation phase of projects. The focus will be mainly on creating solutions to solve challenges while the advancement of science and technology will not necessarily be prioritised. Team-building exercises are a requirement for applicants and the person responsible for the implementation process is also be expected to participate.

This initiative is conducted by two departments at JST (Japan Science and Technology Agency): the Department for Promotion of Science in Society and the Research Institute of Science and Technology for Society (RISTEX). Any organisations based in Japan (university, private company, NGO, local government etc.) working to solve the societal challenges in Japan can apply for funding.

Norway

PILOT-E

PILOT-E is a mission-oriented instrument addressing the energy challenge by combining funding schemes from three agencies and tailoring them into a one-stop shop for targeted projects. Launched in 2016 as a collaborative initiative by the Research Council of Norway, Enova and Innovation Norway, the basic idea is to combine existing financial schemes and instruments from the three participating institutes to mobilise and speed up the process for R&D to market. Each project should have a plan all the way to market to obtain funding.

The innovative aspect of PILOT-E is giving access to different schemes already existing with one application, thus simplifying the application process and reducing the financial risk for the companies in the participating consortia. The consortia are all coalitions of partners from industry, R&D institutes, and end-users.

The simplified and streamlined application process makes it easy for public funding agencies, political structures and those working in the industry, to apply. Finally, the idea is to see the projects materialise in the concrete deliveries planned in the application, e.g. a truck, or a new industrial process. If this is the case, the project will be considered as successful.

Saudi Arabia

Grant Programme for Universities and Research Centres

Launched by the King Abdulaziz City for Science and Technology (KACST) in 2017, the Grant Programme for Universities and Research Centres aims to improve Saudi Arabia's ability in producing world-class technical content by developing the infrastructure, workforce, and tools needed for R&D to sustain technical content production, which ties strategically to achieving the vision of Saudi Arabia 2030.

The programme was designed to distribute funding with the aim to increase potential outcomes by allowing entities to compete within specific subcategories. One subcategory was the Targeted Research Programme (TRP) which introduced four grant competitions that have a serious and short-term impact on the country. The first programme launched was The MERS-CoV grant programme which encouraged research teams around Saudi Arabia with various backgrounds, to tailor their goals and proposals to combat the spread of the MERS-CoV infection in Saudi Arabia. This programme is still running and initial results are encouraging.

The grant programme involved collaborators from around the world. It has participated with hundreds of international researchers and tens of international institutes. It has also engaged in the higher education of multiple students around the world. All R&D departments and institutes in Saudi Arabia can participate in the programme. The grant programme aims to produce several scientific papers and patents.

the immediate stakeholders are mainly the research and development groups, and they provide quarterly reports plus day-to-day communication through the GPURC portal. Feedback is collected after each communication and are evaluated and responded to within days. Yearly reports show the general feedback from the R&D groups. Some sub-categories programmes have other stakeholders, e.g. MOH in the case of MER-CoV) and they provide regular feedback through quarterly committee meetings.

Sweden

The Strategic Innovation Programmes (SIP)

In 2013, the Strategic Innovation Programme (SIP) was launch as the result of a collaborative initiative between the Swedish Research Council for Sustainable Development, together with Vinnova, Sweden's innovation agency, and the Swedish Energy Agency. The Strategic Innovation Programmes are public-private partnerships that define strategic research agendas, involving large networks consisting of companies and research and development performers. SIPs furthermore organise calls for proposals to do research and innovation projects that involve programme actors. They work on 17 different areas, for example bio-innovation, IoT, sustainable (Smart) cities etc.

SIP's big networks make the strategic cooperation between different spheres of Swedish life possible, which is an important precondition for finding sustainable solutions to global social challenges. Businesses, academia and organisations join forces under the umbrella of these programmes to develop the sustainable products and services of the future.

The programmes are based on a joint nationally-established strategic innovation agenda. The success of the programme has been guaranteed by the unique way that sector stakeholders have united behind the initiative. New stakeholders are also welcomed during the entire programme duration.

Qatar

1. National Research Priority Programme (NPRP) – Cluster Track, NPRP-C

In 2018, QNRF (Qatar National Research Fund), launched its NPRP-Cluster, which aimed at funding large proposals that address significant priorities in a holistic approach, which were multidisciplinary, multi-institutional and multi-faceted. The idea was to create consortia of researchers and stakeholders to work together to tackle topics of national significance and importance. A total amount of $5 million was allocated for five years.

The initiative's topics were generated through consultations with relevant stakeholders. This year's programme called for research proposals in four areas: carbon capture and utilisation; towards clinical implementation of precision medicine; cyber security of Qatar's critical infrastructure, and education.

QNRF received 25 proposals covering all four topics. The applications had significant components of collaboration and co-funding and engagement of national stakeholders.

2. Thematic Grand Challenge Research Programme, TGRP

The Qatar National Research Fund (QNRF) teamed up with several important national and international partners to jointly launch calls on topics of mutual relevance. The first call was a joint call with TUBITAK (the Turkish funding agency). Two calls were launched on Cybersecurity and Smart Manufacturing. The second call was the OSRA call, jointly funded with the Doha International Family Institute. The third call was the joint call with the Belmont Forum. The Forum is a consortium of 12 international funding agencies. Lastly, the Food Security call was jointly launched with the Ministry of Municipality and Environment, MME, in Qatar. The central objective of TGRP calls is to provide funding for projects that address a 'grand challenge'. The mechanism of ensuring the achievement of that objective is to team up with a strategic counterpart to ensure availability of resources and uptake of the research findings.

United Kingdom

Global Challenges Research Fund (GCRF)

The Global Challenges Research Fund (GCRF) is a £1.5 billion fund announced by UK Government (UK Research and Innovation (UKRI)) in late 2015 to support cutting-edge research that addresses the challenges faced by developing

countries. Alongside the other GCRF delivery partners UKRI is creating complementary programmes that promote challenge-led disciplinary and interdisciplinary research, including the participation of researchers who may not previously have considered the applicability of their work to development issues; strengthen capacity for research, innovation and knowledge exchange in the UK and developing countries through partnership with excellent UK research and researchers; and that provide an agile response to emergencies where there is an urgent research need.

The GCRF provides a unique opportunity to build a global community of researchers committed to sustainable development and the eradication of poverty. It complements, but also significantly expands and develops, other forms of international and multinational funding for development research, including governments, non-governmental bodies and foundations. The GCRF will allow UK research excellence to be deployed in a strategic way to generate solutions to the most significant and complex problems faced by developing countries while at the same time strengthening their research capability.

The GCRF is aimed first and foremost at addressing global sustainable development challenges and is intended to transform the lives of the worlds' poorest. The starting point for research and innovation funded through GCRF should therefore be a significant problem or development challenge. One particularly innovative aspect of the GCRF is The GCRF Challenge Leaders, who are responsible for the building and success of individual GCRF challenge portfolios and together collectively responsible for maximising the portfolios' overall research excellence and real-world impact.

The GCRF will look to develop strategic relationships with key partner organisations in developed and developing countries to ensure complementarity and avoid duplication and to explore, where appropriate, opportunities for joint or aligned activities. The GCRF will furthermore focus on challenges that are manifest within countries on the OECD Development Assistance Committee (DAC) list.

B. CAPACITY BUILDING INITIATIVES

Canada

1. ArcticNet (Networks of Centres of Excellence)

ArcticNet is one of 63 networks of researchers, universities, public and private partners to be funded during the 30-year history of the Networks of Centres of Excellence Programme of Canada's federal science funding agencies. ArcticNet represents Canada's largest commitment to date to explore the social, economic and environmental impacts of climate change and modernisation on the coastal Canadian Arctic. More than 150 researchers from 34 Canadian universities collaborate with federal, provincial and territorial agencies and departments, Inuit organisations and industry partners to conduct complex assessments of the regional impacts of climate change. ArcticNet's vision is a future where improved observations, modelling, capacity-building and knowledge exchange enable researchers, Inuit, Northerners and decision-makers to jointly develop adaptation strategies minimising negative impacts and maximising positive outcomes resulting from the transformation of the Canadian Arctic. ArcticNet's activities relate closely to Sustainable Development Goals #13 – Climate Action.

ArcticNet reports to a diverse board, with day-to-day operations led by an administrative centre. Federal granting agency funds flow to the network's host university and are strategically and competitively distributed by the network to investigators based at other post-secondary institutions who become network members. A Research Management Committee evaluates responses to calls for proposals and recommends funding decisions to ArcticNet's Board of Directors. ArcticNet researchers collaborate with research teams in Denmark, Finland, France, Greenland, Japan, Norway, Poland, Russia, Spain, Sweden, the United Kingdom and the USA. Partners involved include federal and provincial government departments, Inuit organisations, mining, fishing, shipping, and tourism industries. Partners are involved in the governance of the network at the Board level and in network committees.

NCE grantees are evaluated annually by a peer review committee that helps ensure grantees deliver on promises. Furthermore, granting agency staff sit on observers on network Boards and committees to ensure programme rules are followed and share best practices. Networks are evaluated against progress on five criteria: Management of the Network; Excellence of the Research Programme; Development of Highly Qualified Personnel (HQP); Networking and Partnerships; and Knowledge and Technology Exchange and Exploitation (Knowledge Mobilisation).

2. IC-IMPACTS Canada-India Research Centre of Excellence (Networks of Centres of Excellence) (Canada & India)

IC-IMPACTS is funded through a specialised NCE initiative known as the Canada-India Research Centre of Excellence (CIRCE) initiative designed to strengthen research ties between Canada and India in areas of mutual strategic importance.

IC-IMPACTS and its partners are developing and implementing community-based solutions to meet the most urgent needs faced by some communities in Canada and India: poor water quality, unsafe and unsustainable infrastructure, and poor health from water-borne and infectious diseases. Research projects are co-led by a Canadian PI and an Indian PI and funding is provided by both the Canadian and the Indian governments through the Indian Department of Biotechnology (DBT) and Department of Science and Technology (DST). IC-IMPACTS activities relate closely to Sustainable Development Goals #3 (Good Health and Well Being), #6 (Clean Water and Sanitation) and #9 (Industry, Innovation and Infrastructure).

IC-IMPACTS reports to a diverse board, with day-to-day operations led by an administrative centre. Like other NCE grantees, IC-IMPACTS was awarded funding in a two-stage competition. NCE grantees are evaluated annually by a peer review committee that helps ensure grantees deliver on promises. Oversight, monitoring and support of all grantees is undertaken by the granting agencies through a dedicated NCE Secretariat. NCE Secretariat staff liaisons sit on Boards and sub-committees to ensure programme rules are followed and share best practices. Granting councils will have contributed $22 million to IC-IMPACTS over the period 2014-2021.

Networks are evaluated against progress on five criteria: Management of the Network; Excellence of the Research Programme; Development of Highly Qualified Personnel (HQP); Networking and Partnerships; and Knowledge and Technology Exchange and Exploitation (Knowledge Mobilisation).

3. PrioNet (Networks of Centres of Excellence)

PrioNet was launched in 2005 to respond to a targeted call for a national Canadian network on bovine spongiform encephalopathy (BSE) and other transmissible spongiform encephalopathies (TSEs). BSE was a global grand challenge that caused an estimated $6 billion in economic losses for Canada, suffered when domestic BSE was identified in Alberta in 2003. PrioNet Canada achieved international attention for scientific advances and risk management strategies directed at controlling prion diseases and, after NCE funding ended, it directed capacity into therapeutic solutions for prion-like diseases of aging, such as Alzheimer's and Parkinson's.

PrioNet partnered with over 90 government and non-government partners during its seven-year mandate and developed patented technologies for prion detection as well as an integrated risk model for prion disease expansion that helped form the basis for public policy. The network funded 82 research projects and quadrupled the number of prion researchers in Canada from 29 in 2005 to 122 in 2012.

Like other NCE networks, PrioNet was initiated by a scientist but the network was required to incorporate as a not-for-profit organisation that reports to a diverse Board, with day-to-day operations led by an administrative centre. Federal granting agency funds flow to the network's host university and are strategically and competitively distributed by the network to investigators based at other post-secondary institutions who become network members.

As with all NCEs, PrioNet was awarded funding in a two-stage competition. NCE grantees are evaluated annually by a peer review committee that helps ensure grantees deliver on promises. Oversight, monitoring and support of all grantees is undertaken by the granting agencies through a dedicated NCE Secretariat. NCE Secretariat staff liaisons sit on boards and sub-committees. Granting councils contributed $35 million to PrioNet over the period 2005-2012.

Korea

Science & Technology Support Programme

The National Research Foundation of Korea (NRF KOREA) launched the Science and Technology Support Programme during 2006 to reinforce the S&T development and R&D capabilities of developing countries by supporting the cooperation between universities and research institutes of Korea and developing countries.

It consists of two types of programmes. The first is the International Cooperation Programme between institutes from Korea and partner countries which supports a variety of collaborating activities, such as doing research together; studying local demands and conditions; technology transfer and technical guidance, etc. to reinforce the research capabilities of partner countries. Each project is supported by KRW 100 million (≈USD90 000) per year, for three years. The second is the the Global Problem-solving Centre Programme which supports the establishment of a centre in the partner country which hosts Korean scientists to help with research; develop human resources; commercialise, etc. Each project is supported by KRW 500 million (≈USD450 000) annually for four years.

Partnerships and collaborations are formed between Korean institutes and partner countries' institutes, who sign MOUs and perform research together. The beneficiaries of this programme are researchers, universities, and citizens in partner countries. This programme supports 20 countries, including 16 international cooperation teams, and four centres in 2019. It has supported advanced technologies in Sri Lanka, Nepal, Cambodia, Myanmar, etc., and established local centres to develop local technologies in Cambodia, Laos, Tanzania, Vietnam, etc.

One example of a successful collaboration is the international cooperation between the Yeonsei University Dental College, Korea, and Peradeniya Dental College, Sri Lanka to research oral cancer. Researchers in Sri Lanka have been sent to Korea for training and both universities held international conferences on oral cancer to improve research capabilities. The global problem-solving centre in Nepal generates $36 000 in sales through technology transfer and commercialisation, and trains 772 people through entrepreneurship training.

New Zealand

National Science Challenges

The National Science Challenges are a government-funded initiative, established by the Ministry of Business, Innovation and Employment (MBIE) in 2014 to tackle the biggest science-based issues and opportunities facing New Zealand. This initiative enables a long-term (10-year) strategy for managing and co-ordinating mission-led science investments, and provides an opportunity for New Zealand's top researchers to work collaboratively across disciplines and institutions. Collectively, they are expected to deliver measurable progress on national-scale issues, but they will also enhance the reputation of New Zealand science and build research capability which would lead to better engagement between researchers, end-users and the Māori people.

The 11 Challenges represent a new way of funding research in New Zealand. Each has a host organisation (NZ research institute or university) and Governance Group, and individual Challenges are given the responsibility, freedom and flexibility to develop a research and business plan. The Challenge framework supports the integration of new ideas and allow for researchers and collaborations to refresh and renew. In addition, all research must give effect to the Vision Mātauranga Policy – a government framework that recognises Māori as important partners in science and innovation in New Zealand.

As the Challenges represent national-scale issues, they are intended to deliver national benefit in areas such as health, housing, biodiversity, technology, agriculture and climate change. MBIE regularly monitors and assesses the performance of each Challenge individually, based on information gathered at meetings or informal interactions, and assessment of annual progress reports and updates. A mid-way review was conducted in 2018 by MBIE's Science Board; the statutory body responsible for making independent investment decisions for a number of MBIE funds. The Science Board's decisions were informed by independent review panels, which conducted assessments of each Challenge's future strategy and past performance. The Board agreed to fund all 11 Challenges at the maximum funding amount for 2019-2024, bringing the total investment to $680.8 million.

MBIE commissions an independent survey of stakeholder satisfaction with individual NSCs. This includes feedback on involvement, engagement, and collaboration with the Challenge, as well as Māori engagement and use of Mātauranga Māori (traditional knowledge).

Oman

EJAAD

EJAAD – as a national mission-oriented innovation vehicle – was established in 2018 with a shared vision of more than 50 stakeholders from industry, academia and government in the Sultanate of Oman. EJAAD has the following objectives: to strengthen synergies between industry, academia and government; to provide the industry with applied, practical and competitive technological solutions; to stimulate the establishment of Centers of Excellence; and to develop Oman's Consultancy Corporate's in the areas of focus. EJAAD is expected to considerably impact Oman's ranking in Global Innovation Index, Global Competitiveness Index and certainly in Oman Vision 2040. EJAAD features in 69% of the Vision Priorities and has a direct link to more than one third of its Key Performance Indicators.

A simple R&D and Innovation Protocol was created to outline the main roles and responsibilities each sector should play, i.e. industry, government, academia. The protocol also highlights the integrative value proposition of this approach. This protocol was the 'innovative' framework to engage with more than 50 players in the market. EJAAD has also created focal points within each institution to govern and assure sustainable growth. The protocol was then translated into a working roadmap, with local partnerships and collaborations that include all energy industry sectors; all local academia and research institutions; and governmental organisations. International partners are the IEA, Hydrogen Council, UNIDO and the EU Commission. Stakeholders from industry, academia, biotech, logistics and environmental sectors can apply, as well as government stakeholders.

C. POLICY DELIBERATION APPROACHES

Sweden

National Research Programmes

In 2017, the Swedish government initiated seven national research programmes to address societal challenges. The national research programmes are broad, 10-year initiatives with the purpose of addressing societal challenges. Key objectives of the national research programmes are to contribute to solve societal challenges; to be long term (duration of 10 years); and to create synergies between existing actions to avoid unnecessary overlap and to build on cooperation and coordination. The national programmes are based on strategic research agenda, which provide an orientation of the research fields, of research funding institutions and of actors active in research communication.

The responsibility of these national research programmes is shared among national research funders in Sweden. The Swedish Research Council is responsible for the research programmes on migration and integration as well as on antibiotic resistance. The set-up is a programme management within the Research Council and a broad participation from other agencies and entities in management boards and reference groups. Specific calls are launched for the national research programmes.

Alignment is made with international cooperation when possible (such as the Nordic Collaboration for Migration and Integration and the JPIAMR Partnership Programme for Antibiotic Resistance).

D. CENTRES OR OTHER INFRASTRUCTURE

Canada

MEOPAR (Networks of Centres of Excellence)

The Marine Environmental Observation, Prediction and Response Network (MEOPAR) facilitates partnerships between academia, government, the insurance industry, the oil and gas sector, the marine transportation sector, ocean technology firms, coastal communities and not-for-profits, to reduce Canada's vulnerability to marine hazards and emergencies. MEOPAR funds leading-edge, multidisciplinary, and collaborative research; trains the next generation of marine professionals; and connects with partners, stakeholders and end users to anticipate, plan and adapt to the opportunities and challenges of a changing ocean environment. MEOPAR's activities relate closely to Sustainable Development Goal #13 (Climate Action) and #14 (Life Below Water).

A particularly important achievement of MEOPAR is co-creation of the Canadian Integrated Ocean Observing System (CIOOS). Formally announced in 2019, the pilot programme has established regional nodes nationwide, creating formal partnerships with the Ocean Frontier Institute (OFI); Dalhousie University; the Coastal and Ocean Information Network (COIN) Atlantic; the Fisheries and Marine Institute of Memorial University of Newfoundland; the Ocean Tracking Network (OTN); the St. Lawrence Global Observatory; the Tula Foundation; and Ocean Networks Canada (ONC) at the University of Victoria. This initiative links Canadian researchers and connects Canada to the international research community, and improves our ability to observe, predict and respond to a changing marine environment.

Like other NCE networks, MEOPAR is initiated by a scientist but the network must incorporate as a not-for-profit organisation that reports to a diverse board, with day-to-day operations led by an administrative centre. Federal granting agency funds flow to the network's host university and are strategically and competitively distributed by the network to investigators based at other post-secondary institutions who become network members. In any given year over 30 research projects are ongoing involving over 90 research investigators, over 120 partner organisations and over 30 Canadian universities.

As with all NCEs, MEOPAR was awarded funding in a two-stage competition. NCE grantees are evaluated annually by a peer review committee that helps ensure grantees deliver on promises. Oversight, monitoring and support of all grantees is undertaken by the granting agencies through a dedicated NCE Secretariat. More than 700 highly qualified persons have been trained by MEOPAR.

Ireland

SFI Research Centres Programme

The Science Foundation Ireland (SFI) Research Centres Programme was launched in 2012 to achieve this objective by creating new research centres and building on previously made significant large-scale investments. Seven research centres were funded as a result of the first Research Centres Call in 2012, five in 2013, and a further five in 2016. A key feature of SFI Research Centres is the consolidation of research activities across higher education institutes to create a critical mass of internationally leading researchers in strategic areas which become a key attractant to industry and lay the foundation for effective and productive academic and industrial partnerships. Additionally, these centres serve as international beacons for attracting talent and leveraging non-Exchequer funding with particular emphasis on industry and Horizon 2020. The goal of SFI is to develop a dynamic research centre ecosystem that can evolve to meet the changing needs of industry and society. Award duration is six years and award size can range from €1 million to €5 million per annum in direct costs. SFI fund up to 70% of the overall research centre budget.

The objectives of the Research Centres Programme are to achieve, maintain and enhance research excellence and leadership, as measured through indicators such as publication in top-tier journals and conferences, citations, editorship of top-tier journals, and giving invited lectures at top-tier conferences; to deliver significant economic and societal impact – research excellence with impact – which will be aligned with areas of strategic opportunity for Ireland; to increase the level of industrial and commercial investment in R&D activities with existing Ireland-based companies; to spin out new, high-technology start-up companies that have the potential to raise external angel or venture funding; to transfer technology, through licences, to Multinational Companies (MNCs) and Small and Medium Enterprises (SMEs) based in Ireland; to transfer knowledge, expertise and know-how to MNCs and SMEs based in Ireland; and, finally, to engage the general public and equip them with the tools to confidently understand and debate science, technology and engineering research in Ireland.

South Africa

Department of Science and Innovation (DSI) – National Research Foundation (NRF) Centres of Excellence (CoEs)

Established in 2004 and with a combined investment of USD 84 million thus far, the Department of Science and Innovation (DSI)-NRF Centres of Excellence (CoEs) are physical and virtual centres of research committed to developing novel ideas that focus on critical matters facing South Africa. The CoEs concentrate on existing capacity and resources to enable researchers to collaborate on projects that are locally relevant and internationally competitive. There are 14 CoEs, as well as the National Institute for Theoretical Physics and the Centre for Indigenous Knowledge Systems, both of which are implemented in alignment to the CoE modalities. The aims of a CoE are to: promote knowledge and human capital in areas of strategic importance to South Africa; promote collaborative research; promote and develop interdisciplinary research; systematically develop a creative research training environment that is internationally competitive; strive for the highest standards of quality, international competitiveness, and esteem of their science; and diffuse knowledge to where it is needed.

The implementation of COEs is significantly dependent on four models of partnerships: (1) local collaborations with national, provincial and local government, national research facilities, science councils, and independent research institutes; (2) universities (local and abroad) - COEs are often hosted by more than two or three universities with a host of collaborators from international university partners; and (3) international development and other partners.

CoEs are awarded on a competitive basis through a combination of open and focused calls to publicly funded Higher Education Institutions (HEIs) including Science Councils. CoEs are annually monitored by suitably appointed Steering Committees. Of particular interest is a CoE's strategic direction and financial control. Steering Committees can recommend the closure of Centres if progress is not satisfactory and aims and targets are not met. Stringent external renewal/continuation evaluations are performed in year five indicating outputs, outcomes and (expected) impact of NRF support.

Both the CoE Funding Instrument and the individual CoEs are subjected to reviews which include interviews with representatives of the affected stakeholder communities, and which are captured in the review reports of the independent review panels.

USA

1. NSF Convergence Accelerator

The National Science Foundation's (NSF) Convergence Accelerator effort is a new capability aimed to accelerate use-inspired convergence research in areas of national importance via partnerships between academic and non-academic stakeholders. The NSF Convergence Accelerator programme brings together teams of experts from across disciplines to focus on pre-identified grand challenge problems. The goal is to fund efforts that have a high probability of resulting in deliverables that will benefit society within a relatively short, fixed term of less than three years. The key characteristics of the grand challenges and the Convergence Accelerator approach are for use-inspired and application-

oriented problems with a focus on deliverables in a fixed-term, fed by basic research and discovery across disciplines, worked on by integrated teams including industry, academics, not-for-profits, government entities, and others.

The NSF Convergence Accelerator is a pilot programme, which issued its first grant awards in September 2019, focused on two of the NSF's Big Ideas: Harnessing the Data Revolution (Track A) and Future of Work at the Human-Technology Frontier (Track B). Highlight below is Convergence Accelerator Track A, focused on the NSF Big Idea Harnessing the Data Revolution (HDR) that seeks to enable new modes of data-driven discovery.

To help advance the progression from data to information to knowledge - to fully harness the data revolution - NSF seeks to create an Open Knowledge Network (OKN). A knowledge network allows stored data (both structured and unstructured data) to be located and its attributes and relationship to other data and to real-world objects and concepts to be understood at a semantic level. Today, technology companies develop largely proprietary knowledge networks, often specialised for customer needs, e.g. web search, advertising placement, and question answering. Instead, the Open Knowledge Network will build public-private cooperation and engage convergence teams from all areas of data science and science and engineering domains to create a shared, non-proprietary infrastructure.

Innovative aspects include a participatory design approach that considers the needs and perspectives of the many user communities, and intensive education and mentorship which includes the 'Convergence Accelerator Curriculum' of innovation, team science, as well as domain-relevant information.

2. Spokes Programme

The Spokes Programme is a flexible mechanism for industry to engage with Science Foundation Ireland (SFI) Research Centres. This programme can fund areas of STEM that are aligned with the research areas of one or more SFI Research Centres. The current research centres are focused on pharmaceutical manufacture, software, digital content, big data, telecommunications, photonics, medical devices, nanotechnology, marine and renewable energy, functional foods, applied geosciences, agri-food, advanced and smart manufacturing, neurological diseases and bio-economy.

Any research-active company is eligible to apply, regardless of their size, scale, or location. The proposed research programme is funded 50/50 by the company and Science Foundation Ireland. At the end of the Spokes Award projects may be expanded, or new projects proposed, both subject to satisfactory international peer review of the new proposal.

The Spokes Programme is always open, and applications can be submitted at any time throughout the year. Proposals are first evaluated as a simple expression of interest, following which a full proposal is submitted which undergoes international peer review.

E. MOBILITY AND EXCHANGES

China

Experiences of the National Natural Science Foundation of China

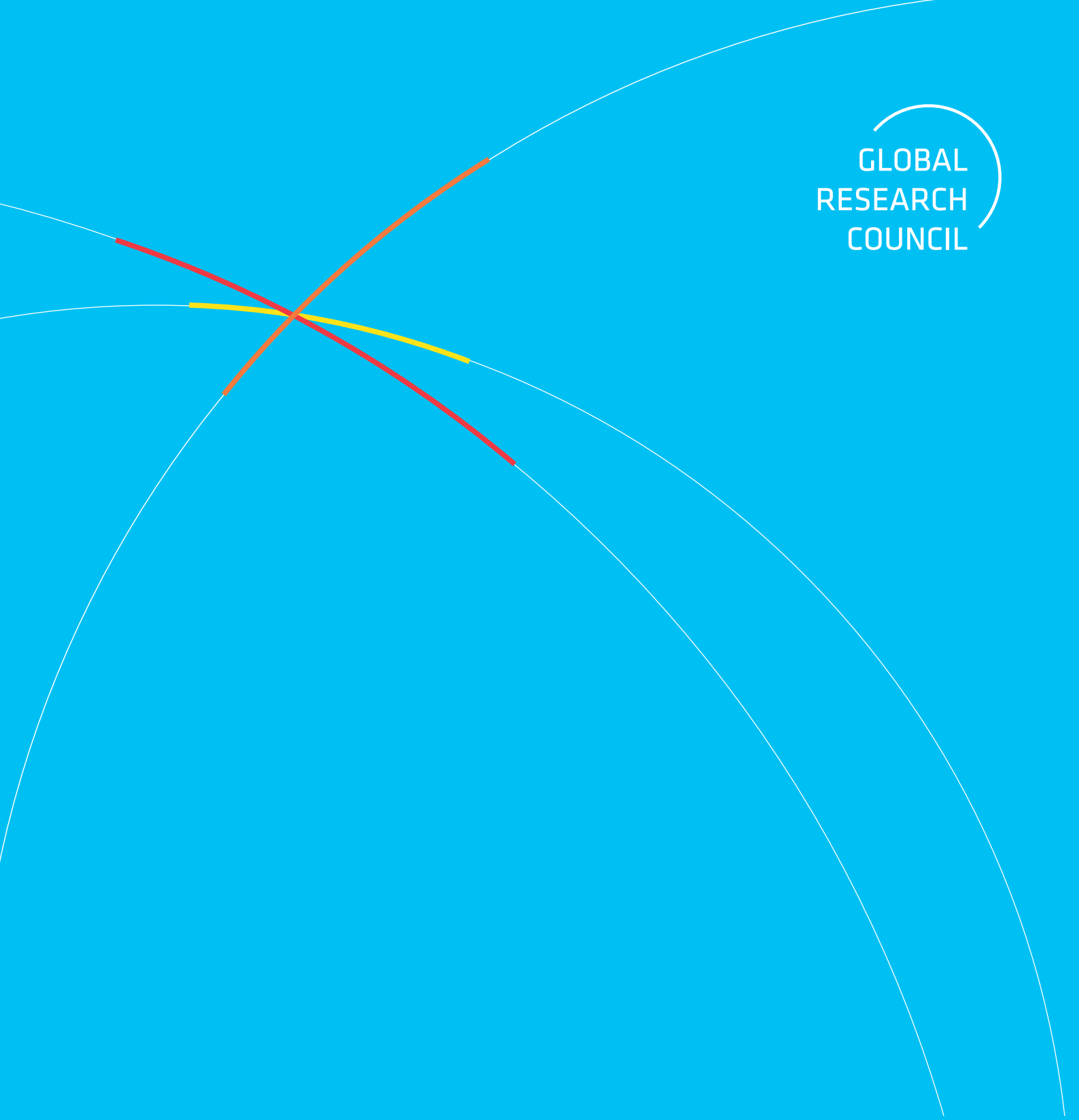
Focusing on the major strategic needs of China and scientific frontiers, the National Natural Science Foundation of China (NSFC) has set up key programmes, major programmes, major research plans and other mission-oriented programmes to address major economic and social challenges. The NSFC focuses on the important and frontier scientific issues to meet societal needs. With increased and continuous support, it also pays attention to the possible directions of major breakthroughs in interdisciplinary fields.

From 2018 to 2019, the NSFC allocated the special funding for 'Research on major basic scientific issues–African swine fever' to address this emergency, and launched key programmes clusters 'Preventing and reducing financial risks', major research plans including 'Toxicology and health effects of the particulate matter in the atmosphere ' and 'Basic research on the causes and coping mechanism of air pollution in China', whilst setting eight priority areas of key programmes, including 'Urban sewage regeneration and ecological storage'.

The NSFC has strengthened the connection with the various industries, hence establishing a systematic, normalised and in-depth coordination mechanism while taking the major national economic and social needs as an important basis for the allocation of science funds. The NSFC has also established the Joint Fund for Regional Innovation and Development and the Joint Fund for Enterprise Innovation and Development according to the issued paper titled the pilot work programme of the joint fund for the new era of the NSFC.

Furthermore, the NSFC has launched the 'The International Cooperation Programme for Sustainable Development Goals' in 2019. Guided by the principle of 'joint investment, mutual benefit and win-win cooperation', NSFC has coordinated with other funding agencies on issues of scientific research and talent cultivation targeting United Nations sustainable development goals (SDGs) to promote scientific development and enhance cultural exchanges and promote win-win cooperation.

For the partnerships or collaborations involved, the NSFC have signed framework agreements of 'joint fund for scientific research of comprehensive national science center and large-scale scientific device' with State Development and Reform Commission, the Chinese Academy of Sciences, local authorities of Beijing, Shanghai and Anhui to jointly strengthen support for the comprehensive national science center.



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