# Science, Technology, and Innovation for the SDGs – Progress, Future vision, and Recommendations

## Report of the UN Secretary General's 10-Member-Group of High-level Representatives of Scientific Community, Private Sector and Civil Society in support of the Technology Facilitation Mechanism

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## Summary

This report of the UN Secretary General’s 10-Member-Group of High-level Representatives of Scientific Community, Private Sector and Civil Society in support of the Technology Facilitation Mechanism, appointed by the UN Secretary General, aims to provide a broad perspective on science, technology, and innovation (STI) for the SDGs. It draws lessons from STI4SDG progress since 2015, and outlines elements of a future vision for STI in 2030. Most importantly, it provides recommendations for consideration by the UN Secretary General and UN system, Member States, scientific and technological stakeholders and related decision-makers. The recommendations are in the form of “political asks” and “high-impact initiatives” to be considered by decision-makers in the run-up to the SDG Summit in September 2023. The report contributes to the international community’s discussions on how we could make science, technology and innovation work best for sustainable development, in order to ensure a better life for present and future generations, in peace and environmental integrity, on this one planet that humanity shares.

Based on our work and deliberations within the Group, we have identified five major proposals and eleven recommendations for policies, political commitments, and high-impact initiatives. We consider them very important for achieving the vision for STI in 2030 which we outline in this report. The following table provides an overview of our proposals and recommendations.

| 10-Member-Group Recommendations of policies, commitments and high-impact initiatives | | | |
|---|---|---|---|
| | **Proposal** | **Category** | **Recommendations** |
| **Sustainability science & technology** | **A. Sustainability Science and Technology Cooperation Package for Current and Future Generations** | STI Funding for SDGs | **Recommendation 1:** Global governmental research funders boost spending on SDGs by 20% over the next two years (by 2025) |
| | | Institutions and cooperation | **Recommendation 2:** US$1 billion per year for a collaborative, global sustainability science centre and training network across geopolitical divides (with demonstration projects at scale in energy, food, climate, biodiversity, health, water and sanitation) |
| | | | **Recommendation 3:** Global network of banks of ideas, funds for innovation, and ethical councils for innovation |
| | | | **Recommendation 4:** Develop and implement national STI4SDG roadmaps, as strategic guideposts for all stakeholders |
| | | Example commitments – health science and technology | **Recommendation 5:** Prioritize investing in the first 1,000 days of a child's life particularly in the poorest settings within and between countries (providing modern medical and nutritional support for all children and their mothers before 2030) |
| | | | **Recommendation 6:** Share technologies and skills to solve the basic human rights issues of water, health, quality education, sanitation and food security. |
| **Digital technologies and networks** | **B. Building the next generation Web 3.0 distributed system for all by 2027** | Technology deployment, training, and cooperation | **Recommendation 7:** Governments commit to put in place policies, regulations, initiatives and funding to build the next generation Web 3.0 distributed system and make it work for all by 2027.<br>This would include the following democratization of the Web, capacity building, the creation of a collaborative, global, public-private UN school/centre on Web 3.0 and related tools, more effective international multistakeholder cooperation, agreement on minimum socio-economic, environmental and ethical standards, and funding commensurate with the challenge. |
| | **C. Capacity building on generative AI for the SDGs** | Training, cooperation, and governance | **Recommendation 8**: Build worldwide capacity for using, developing, and understanding the impacts of generative AI.<br>The initiative would include massive upscaling of collaborative training on generative AI and related emerging tools, including significant commitment of governmental funds complemented by other sources; effective international multi-stakeholder cooperation; sharing access to relevant fundamental research technology infrastructures; and agreement on global minimum socio-economic, environmental and ethical standards on generative AI. |
| | **D. One-UN programme on digitalisation** | UN programme for developing countries | **Recommendation 9:** Create a One-UN programme on digitalisation and sustainability in support of developing countries.<br>This programme would include the following tracks: democratic global digital cooperation and principles development; innovation and development; technical and policy capabilities for future-ready innovation ecosystems; and integration with the Technology Bank for LDCs. |
| **Resourcing** | **E. Global CDR fund and market** | Fund and market creation | **Recommendation 10:** Create a global carbon dioxide removal (CDR) fund and market to facilitate the sustainable deployment of CDR technology options.<br>This includes: (a) fund CDR research and demonstration projects and share their lessons worldwide; create coherent and consistent international rules for CDR deployment assuring the sustainability and permanence of the sequestration and storage activities; provide financial incentive for RD&D for CDR at the required scale; create a CDR market that is not competing (or crowding out) emissions mitigation. |
| | **F. Funding global public goods** | Funding, principles and networking | **Recommendation 11:** Boost global public investment in global public goods to reach (0.2% of GNI), and consider implementing the recommendations of the Expert Working Group on Global Public Investment ("Building a better system: Making Global Public Investment a reality" of July 2022) |

*Source: 10-Member-Group 2021-2023. Status: April 2023*

# 1. Introduction

## a) Context

The *United Nations Technology Facilitation Mechanism* (TFM) was created by the *Addis Ababa Action Agenda* and launched by the *2030 Agenda on Sustainable Development* in September 2015. It comprises the Multi-Stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum); the *UN Interagency Task Team on Science, Technology and Innovation for the SDGs* (IATT) and the *10-Member Group of High-level Representatives of Scientific Community, Private Sector and Civil Society,* ("10-Member Group"); as well as the online platform TFM 2030 Connect. Since 2015, the TFM has been coordinated by DESA. The interagency IATT has been co-convened in initial years with UNEP and currently with UNCTAD. The creation of the TFM was of historic significance, as it brought back substantive science, technology and innovation (STI) discussions to UN Headquarters in New York, after decades of political gridlock over intellectual property rights and technology transfer issues. The TFM has explored a new multi-stakeholder model of work for the UN system, which to-date has engaged 48 UN entities, more than 100 expert staff across the UN system, and thousands of scientists and stakeholders to facilitate STI for the SDGs. The TFM's STI Forum also holds a special role, as it reports formally to the *High-level Political Forum on Sustainable Development* (HLPF) in support of its formal review of SDG progress and its explicit function to "*strengthen the science-policy interface*".

Every four years and again in 2023, the HLPF will meet at the level of the UN General Assembly and review progress towards the SDGs and the 2030 Agenda, including in terms of trends and progress on science, technology and innovation for sustainable development. This so-called "SDG Summit" will be convened at UN headquarters from 18 to 19 September 2023.

It is thus timely to take stock and *draw lessons from STI progress for the SDGs and look ahead on what should be high-priority actions by decision-makers*, as the world prepares to embark on the second half of the SDG time frame until 2030.

## b) Objective and scope of the report

In this context, the *objective of this report* is to provide a broad perspective on science, technology, and innovation (STI) for the SDGs. It draws lessons from STI4SDG progress since 2015, and outlines elements of a future vision for STI in 2030. Most importantly, it provides recommendations for consideration by the UN Secretary General and UN system, Member States, scientific and technological stakeholders and related decision-makers. The recommendations are in the form of "political asks" and "high-impact initiatives" to be considered by decision-makers in the run-up to the SDG Summit in September 2023. The report contributes to the international community's discussions on how we could make science, technology and innovation work best for sustainable development, in order to ensure a better life for present and future generations, in peace and environmental integrity, on this one planet that humanity shares.

A range of data and materials sources were considered for this report. This includes, in particular, science-policy briefs and other articles by 10-Members and other inputs from UN-convened discussions with former 10-Members, and many. By its very nature, as scientists and engineers, our thinking is grounded in peer-reviewed literature and academic and private sector data. Hence, the reader should not expect to find official data and policy statements in this report.

### c) Work of the 10-Member-Group

The Integrated Policy Analysis Branch in the Division for Sustainable Development Goals of the UN department of Economic and Social Affairs serves as Secretariat to the *10-Member Group of High-level Representatives of Scientific Community, Private Sector and Civil Society* ("10-Member-Group") in support of the UN Technology Facilitation Mechanism. The Group is appointed by the UN Secretary General for a two-year term at a time. The term of the current group finishes this year.

All 10-Members work to deliver on the STI Forum, its organization and preparations. In addition, individual members can contribute towards specific related outputs in their areas of expertise and interest. Contributions could be – for example- through substantive inputs and guidance, connecting to/drawing from knowledge and practitioner networks, hosting specialized meetings through their institutions, directing research towards areas that support TFM outcomes, guiding the development and application of capacity building tools with country level impact, and helping with resource mobilization. Other recent examples include the development of multi-stakeholder partnerships to support the IATT workstream on STI4SDG roadmaps, as well as Webinars in support of specific TFM deliverables.

It is important to note that the 10-Member-Group is more than a typical UN expert advisory group. While it does provide policy and technical advice, it also operates more like a working group in which 10-Members take initiative, mobilize participation from their professional communities, and get directly involved in work on selected outputs, in line with their expertise. Unfortunately, akin to other UN advisory groups, finances are limited and therefore much work is done by leveraging networks, institutional work programmes and occasional earmarked donor support (financial or in-kind).

The 10-Member Group has mobilized expertise from their communities in a range of priority areas. Present 10-Members have made science-policy contributions on pandemic preparedness; health and wellbeing; emerging technology governance; modern and inclusive innovation systems; transformative scenarios and carbon removal from the atmosphere; green design and technology dissemination; the digital divide; and international research cooperation and funding. They have contributed to technical guidance material in support of the STI4SDG roadmap pilot projects, made recommendations for improving the global science-policy-society interface based on lessons-learned from the world's response to COVID-19, drawn on expertise from scenario analysts, government science advisors and decision-makers on high-impact actions for sustainable development. 10-Members have supported the organization of the annual STI Forum; enhanced the TFM online platform "2030 Connect"; contributed to the interagency IATT report "Emerging science, frontier technologies, and the SDGs – Perspectives from the UN system and science and technology communities" and the related "TFM findings on the impacts of rapid technology change on the SDGs"; to the STI4SDG Roadmaps Pilot Programme and its new Partnership in Action; and supported outreach on gender aspects in the context of STI.

## 2. Science, technology and innovation for the SDGs – Progress since 2015 and vision for 2030

Since late 2015 when the TFM was created, more than seven years have passed. Seven years is not a long time in science and technology, yet our scientific knowledge and technological capabilities have continued to grow exponentially and in some areas even at an accelerated pace. In this section we provide a broad and selective overview of progress and trends in STI since 2015 and outline elements of a vision for

STI4SDGs for 2030. We provide background on the successes and failures of STI4SDGs since 2015, on where we seem to be heading, and on the STI system that we are likely to see by the end of the decade.

## a) Big picture view

In the words of a former 10-Member, Peter Bakker of WBCSD, the SDGs are a gift to the world.[1] Indeed, we believe that as universal aspirational goals for all of humanity – in developing and developed countries alike – they can be and have been a shared blueprint and catalyst "for peace and prosperity for people and the planet, now and into the future". In its aspiration to "leave no one behind", they carry the promise to everything we can to help everyone reach their full potential. And science, technology and innovation is essential for almost all aspects of the SDG aspirations. While most countries have clear commitments to the SDG framework and sustainable development, and an increasing number of countries have developed STI4SDG roadmaps or other strategic STI plans, actual SDG progress has been mixed, within and between countries.

***Scientific and technology knowledge base and data flows***

There is no doubt that the world's scientific and technological knowledge base and overall data volumes have greatly increased since 2015.

In 2015, an estimated 1.5 million peer-reviewed articles were published in science and engineering in the world. The annual number of these publications has grown around 3-4% per year ever since. In 2022, an estimated 2.1 million such articles were published. At current trends, we can expect close to 3 million peer-reviewed science and engineering articles being published in 2030, i.e., twice as many than at the beginning of the SDGs. Disciplines have further specialized and narrowed to a level where "polymaths" and "integrators" across disciplines can no-longer bring together a comprehensive picture of the status of interdisciplinary scientific knowledge to inform policy and practical actions, without the help of a range of automation and artificial intelligence technologies. This has important implications for the kind of digital infrastructures and computational power that will need to be made much more widely available than in the past, since it is no-longer enough to confine it to research communities.

Enormous amounts of data are created and shared almost instantly across the globe. Whereas in 2015, there were about 10 zettabytes of data cumulatively in the digital universe, in that year alone about 3 zettabytes of new data were added. In 2022, we probably reached as much as 100 zettabytes and added around 15 zettabytes of new data in that year. In other words, we are dealing with about 10 times as much data than at the beginning of the SDGs and we were adding more data in 2022 alone than we had accumulated in all of history by 2015. Deep learning and big data business strategies mean that this growth will likely continue if not accelerate further. By 2030, data volumes may be 400 or more zettabytes, with at least 40 zettabytes of being added per year.

A paradox of our times is that we are more connected than ever before, have access to vast stores of data and knowledge at the push of a button, yet misinformation and data insecurity are major problems. And while data privacy has been greatly compromised, vast data silos abound.

[1] Colglazier, E.W. (2018). The Sustainable Development Goals: Roadmaps to Progress, Editorial in: Science & Diplomacy, 05/01/2018, https://www.sciencediplomacy.org/editorial/2018/sdg-roadmaps

This massive knowledge and data accumulation is not only a result of vastly improved technological capabilities, but also of specialization in ever narrower scientific subfields and of much higher education levels across the world. However, this combination of trends has in a way brought knowledge ever closer and accessible to our fingertips, yet ever more difficult to understand and assess in comprehensive terms drawing on a multitude of disciplines and knowledge bases. This has also been one reason for the attraction of misinformation and fake news despite higher education levels.

One constant in all of this has been the importance of fundamental and undirected scientific research. In the words of Abraham Flexner, humanity's greatest progress has been due to scientists who were "driven not by the desire to be useful but merely the desire to satisfy their curiosity…curiosity, which may or may not eventuate in something useful"[2]. This insight has less and less guided policy in the current times of uncertainty and geo-economic competition. We agree with eminent Robbert Dijkgraaf's 2017 diagnosis of the situation: "Driven by an ever-deepening lack of funding, against a background of economic uncertainty, global political turmoil, and ever-shortening time cycles, research criteria are becoming dangerously skewed toward conservative short-term goals that may address more immediate problems but miss out on the huge advances that human imagination can bring in the long term."[3]

***Global research cooperation and funding***

*R&D spending.* Achieving the SDGs by 2030 requires extensive research and development (R&D) efforts to address complex global challenges, such as poverty, inequality, climate change, and pandemics. Although global R&D spending has been increasing, reaching approximately US$2.5 trillion from all sources in 2022[4], investment remains concentrated in developed countries and China, with limited resources allocated to the Global South. [5]According to UNESCO, high-income countries account for 77% of global R&D expenditure, while low-income countries represent only 0.3%. R&D is even more concentrated in a handful of countries than these numbers imply. According to the US Congressional Research Service, in 2022, the 10 largest R&D-funding countries accounted for 85% of the global total; the top 20 R&D-funding countries accounted for $2.225 trillion, 94.6% of the global total.

*Research cooperation.* Furthermore, research collaboration and knowledge sharing are crucial for fostering innovation, leveraging expertise, and maximizing the impact of R&D investments. International scientific co-authorship has grown steadily, with more than 20% of research articles published in 2019 involving authors from different countries. However, disparities persist, with researchers from developed countries being more likely to engage in international collaborations than their counterparts in developing countries.

*Research funding for the SDGs.* There is no fully reliable, comprehensive global dataset tracking R&D commitments specifically for the SDGs, but sources like UNESCO and WIPO offer important insights into overall R&D investments and priorities for both developed and developing countries. In general, SDGs

[2] Flexner, A. (1939).The Usefulness of Useless Knowledge, Harpers, Issue 179, June/November 1939, https://www.ias.edu/sites/default/files/library/UsefulnessHarpers.pdf

[3] Flexner, A., and Dijkgraaf, R., (2017). The Usefulness of Useless Knowledge, Princeton University Press (February 21, 2017), ISBN: 978-0691174761

[4] This estimate is based on data of the US Congressional Research Service, as of Sept. 2022. It noted that total global R&D expenditures have increases from US$675 billion to US$2.4 trillion in 2020 (in current dollar terms). This total included OECD countries and Argentina, China (including Taiwan), Romania, Russia, Singapore, and South Africa, and estimated that R&D expenditures by other developing countries remained very small in comparison.

[5] Global Research and Development Expenditures: Fact Sheet, Updated September 14, 2022, Congressional Research Service, USA, No. R44283, https://sgp.fas.org/crs/misc/R44283.pdf

related to health, climate change, and energy tend to receive more R&D investments. For example, investments in health research (SDG 3) are substantial, driven by both public and private sectors. The Global Health R&D Observatory reported that global health R&D funding reached $40.8 billion in 2019, with the United States being the largest donor, contributing 42% of total funding. As of 2022, there were 59 times more health researchers in high-income countries than in low-income countries, and a mere 0.2% of research grants were awarded to low-income countries by major international funders of health research. In fact, only less than 0.5% of health products were for WHO neglected tropical diseases. Climate change (SDG 13) and clean energy (SDG 7) have also attracted significant R&D investments. The International Energy Agency (IEA) reported that *public* energy R&D investments in IEA member countries reached US$24 billion in 2021, with low-carbon energy technologies accounting for the vast majority of the total. There may be differences in the priorities of research funders in developed and developing countries. Developed countries, which account for the majority of global R&D investments, tend to prioritize areas such as health, information and communication technologies, and clean energy. Developing countries may prioritize areas more closely related to their specific development needs, such as shelter, agriculture, water, and sanitation. The biggest R&D donors vary depending on the sector and the SDGs being considered. However, some of the largest R&D investors globally include the United States, China, Japan, and the European Union. They contribute a significant portion of global R&D funding across various sectors, including those related to the SDGs. It is essential to note that these numbers are not exclusive to the SDGs and provide a broader perspective on R&D investments. Tracking R&D commitments and investments specifically for the SDGs remains a complex task, as research and innovation often span across multiple goals and targets.

*Public and Private R&D Funding.* Both public and private sectors play a vital role in financing R&D for the SDGs. Public R&D funding, typically provided by governments and international organizations, is essential for supporting basic research, capacity building, and projects with high social and environmental impact but lower financial returns. The Organisation for Economic Co-operation and Development (OECD) estimates that public R&D expenditure in its member countries reached 0.65% of GDP in 2019. Current governmental R&D funding amounts to about US$200-300 billion per year. Private R&D funding, predominantly driven by the business sector, is crucial for translating research findings into marketable products and services. The private sector accounts for approximately two-thirds of global R&D spending, with significant investments in fields such as information and communication technologies, biotechnology, and clean energy. However, private R&D funding is often concentrated in areas with higher commercial potential, potentially overlooking research areas with broader societal benefits.

### *The pandemic - a stress test for science & technology systems and the science-policy interface*

The pandemic and the world's response to it has been a stress test for science, technology and innovation capabilities, the science-policy interface at all levels, our national institutions, and the multilateral system as a whole.

By some measures, our world has spectacularly failed the stress test. Indeed, a former 10-Member, Bill Colglazier, in *Science & Diplomacy* diagnosed "catastrophic failures of the science-policy-interface in many countries and globally" in 2020.[6] Indeed, the world witnessed a "parallel epidemic" of misinformation and

[6] https://www.sciencediplomacy.org/editorial/2020/response-covid-19-pandemic-catastrophic-failures-science-policy-interface

political polarization that greatly reduced what could have been done based on scientific insights and technological possibilities alone.

The pandemic highlighted our global interconnectedness and shared vulnerability, and it also led to massive loss of lives, livelihoods, and rights. The UN has documented in detail the significant reversal of development gains due to the immediate and longer-term impacts of the pandemic. Most concerning ate the exacerbation of inequalities and truly devastating impacts on some of the poorest of the poor.

Yet, the pandemic also highlighted the power of new technologies for diagnostics, vaccinations, therapeutics and rapid prototyping, and sharing of latest scientific insights, which arguably has saved billions of lives. Indeed, science in the form of vaccines and treatment moved us from fear, anxiety and uncertainty to living positively with the virus. Digital technology helped us stay connected and continue to be productive socially and economically. Rapid access to knowledge through open science has helped the world to develop vaccines and medical treatments in record times. The world's scientific and technological capabilities for gene editing and wider synthetic biology and directed evolution have progress exponentially – not only in leading national labs but all the way in community and DIY biolabs. A biohacker scene has emerged that includes groups in developed and developing countries alike.

And it has become clear how essential previous public and private investments in fundamental and applied research have been for building these capabilities. For example, government-funded research of hundreds of scientists since the 1960s laid the groundwork for mRNA vaccines.[7] So, we need to look back and appreciate the benefits of long-term commitment to fundamental research, but we also need to look ahead and anticipate challenges and possibilities. Many of the recent changes have been spurred – directly or indirectly - by rapidly advancing science and technologies. They have significantly changed the conditions for achieving the SDGs, compared to when they were adopted in 2015. Hence, it is insufficient to look at only past and current trends, but it has become increasingly important to anticipate future opportunities and challenges related to science and technology. Scenarios, tech futures, and STI roadmaps for the SDGs, and related capacity building have therefore become essential means for all countries – developing and developed - to make sense of the ongoing, disruptive changes.

The prevailing forms of science communications and education have proven insufficient to counter random and deliberate disinformation compaigns fueled by social media disinformation bubbles and fake news. It is a paradox of our times that digital technologies have greatly amplified existing inequalities and perspectives and exacerbated political polarization rather than brought together different viewpoints. It is clear that new governance, tech architecture and ethical codes are needed to steer these developments in a positive direction.

The pandemic will likely have longer term impacts, in terms of supply chains, the geographic orientation of manufacturing and production, the process of knowledge generation beyond science in general, to name just a few. Many of these impacts will only become clear in years to come. The same will apply to future pandemics which are expected to become more frequent the more environmental habitats are disturbed by humans.

[7] Dolgin, E. (2021). The tangled history of mRNA vaccines- Hundreds of scientists had worked on mRNA vaccines for decades before the coronavirus pandemic brought a breakthrough, Nature 597, 318-324 (2021), doi: https://doi.org/10.1038/d41586-021-02483-w

***Insights for effective science-policy advice***

The Covid 19-pandemic has brought the science-policy interface into sharper focus than ever before. The recent experiences both illustrate the value of formal science advisory mechanisms and raise important questions.

Science advice is never a linear process from evidence to policy: it requires reciprocal iteration between the policy and the science communities. Science advice has two main components: evidence synthesis and evidence brokerage. The former is the need to review evidence from all the disciplines relevant to an issue to summarize what is known and the uncertainties. Brokerage is the matter of appropriate communication of that synthesis to the policy maker in a way that is understood. Brokerage is also the process of ensuring that the evidence provided meets the needs of the policy maker. Central to brokerage is clearly describing what is known and the underpinning assumptions, and importantly, what is not known – this is particularly important in crises when there will be many uncertainties early on and this certainly was the case in the pandemic. Science advice seeks to provide information and an analysis of the options for a policy issue but the choice of options by the policy community is dependent on many non-scientific factors including fiscal, political, public opinion, political and diplomatic considerations. Thus, science advice cannot be separated fully from science communication to society.

In both emergencies and non-crisis situations, performing effective science advice requires a trusted interface between the policy community and the science community, generally in the form of an established brokerage mechanism. Ultimately good science advice is thus dependent on an ecosystem of knowledge generators such as universities and government laboratories, knowledge synthesizers such as academies, think tanks and research institutes, and effective processes for brokerage via science advisors, sometimes academies and advisory boards.

A core part of science advice is risk assessment and communication. There is an urgent need to understand how to ensure that assessments of major and even existential risks such as pandemics and climate change lead to more timely attention from the policy community. We must learn from the pandemic so that we do not fail to do better in the next crises.

There are also important learnings for how science and policy work in concert in the multilateral space. The scientific inputs to global policy should follow the same principles of synthesis - ensuring appropriate plurality by discipline, geography, and development state - and brokerage. The challenge of plurality extends to where multiple agencies have a lens on the same issue and here mechanisms for integration are critical.

***Rapid scientific and technological changes – an enormous challenge for vulnerable countries and communities***

The conditions for achieving the SDGs have significantly changed since they were adopted in 2015. Many of the changes have been – directly or indirectly - by the rapidly advancing science and technology and their implications including in institutional terms.

Rapid changes can be seen in technology development, demonstration and diffusion with increasingly significant impacts on countries at all levels of development. In fact, almost all countries that are not at the technology frontiers with respect to these new technology clusters face increasing disadvantages, as the export-oriented development model based on technological upgrading that had been extremely successful in recent decades is becoming increasingly difficult to follow or some argue it is becoming infeasible. “Premature de-industrialization” in developing countries is but one of the more often noted phenomena in this regard.

At the same time, the STI communities are undergoing major institutional and organizational changes. In fact, their societal and economic roles are shifting. The emergence of sustainability science as a fully integrated, practical kind of science that links with many different disciplines across natural and social sciences is a case in point.

More worryingly, highly regarded scientists expressed doubts about our knowledge-based ability to effectively address major global sustainable development challenges.[8] This points to more fundamental issues in linking science with practical policy and problem solving.

The global perspectives on “STI for SDGs”, “SDGs for STI”, and “STI for climate change mitigation and adaption” have increasingly converged. There are, for example, major overlaps between STI for climate and sustainable development debates.

***Towards a sustainable innovation culture and system***

In the current disruptive global dynamics, innovation is of growing strategic importance to navigate the great technological transition. But unfortunately, the ingredients to foster a strong and sustainable innovation culture and system towards the SDGs still need to be discovered for most countries in the Global South, particularly for disadvantaged and vulnerable people in all countries. A growing disparity in STI capabilities between countries and within societies threatens to rapidly increase socioeconomic disparities and cancel the possibility of equal opportunities for all.

Most countries in the Global South are ill-equipped to face and to benefit from technological acceleration and could easily fall into international irrelevance. Only a few countries possess powerful and far-reaching innovation ecosystems that can determine the world's fate. The competition will speed up innovation. They will probably seek geopolitical supremacy, market predominance, and economic gain. They have easy access to political, legal, and financial resources that protect and promote all stages of their innovation processes, which often do not translate into greater well-being, social inclusion, and positive environmental impact. Public policies tend to socialize the risks of innovation but not the benefits.

Furthermore, the rapid emergence of frontier technologies and innovations prevents most governments, businesses, and social groups, especially in developing countries, from keeping up and benefitting while averting negative impacts.

[8] Examples include James Lovelock, Vaclav Smil, Roger Pielke Jr, and Susan Solomon.

Most companies and individuals need help assessing risks, receiving expert advice, implementing best practices, and accessing crucial financing. They rightly fear that their ideas will be ignored, stolen, sabotaged, or exploited by more powerful or cunning third parties and that the ability to innovate will continue to be found elsewhere. But crucially, they need more capacity and support to implement their ideas effectively.

After decades of the dichotomy and dispute between laissez-faire and state-led (government intervention) economics, we could be at the dawn of a third option of direct bottom-up creative innovation and economic planning. This implies that governments go beyond mainly stabilising markets or centrally choosing winners towards a development driven by innovation and creative socioeconomic dynamics. The role of governments would include coordinating knowledge sharing, helping identify opportunities to commercialise inventions, and funding innovative solutions.

Nonetheless, crises are cradles of significant transformations. STI4SDG roadmaps elaborated by the TFM can offer countries and communities effective ways to enhance their economic competitiveness in a globalised context. More broadly, they can provide the most viable route towards the type of sustainable development and global solutions expressed in the SDGs and collaborate on equal footing to work out and test answers that bring them closer to the SDGs.

A thriving, accessible, harmonious and transparent ecosystem for innovation can bring together public, business, financial and academic/R&D stakeholders in virtuous cycles of exchange. However, there is no universal formula for creating a flourishing ecosystem and no guarantee that it will produce practical, responsible, ethical, inclusive, and sustainable results or can contribute to addressing global problems. Therefore, these parameters must be embedded in a globally coherent and collaborative SDG innovation network.

***Lessons from recent science and technology futures and scenarios for the SDGs and beyond***

Ever since the Rio+20 Conference in 2012, many scenario modelers have developed global sustainable development scenarios. Since 2015, they have also developed more specifically SDG scenarios emphasizing economic, technological, or political approaches. However, in the past eight years, unabated global increases in energy, materials and land use, together with their associated environmental, social and health consequences, have required analysts to make ever more ambitious assumptions to arrive at scenarios where the SDGs are achieved in the remaining fewer and fewer years.

Recent sustainable development scenarios show pathways towards ensuring decent living standards for all. The concept of decent living standards goes well beyond basic services and eradication of poverty. It addresses nutrition (food, preparation and conservation), shelter (housing, thermal comfort), health (health care, water and sanitation), socialization (education, communication and information), and mobility (motorized transport). Less than one third of the current global average annual final energy consumption per capita is needed to provide decent living standards. The largest per capita gaps are in Sub-Saharan Africa, South Asia and Latin America, but regional differences are sizable

Energy gaps to ensure decent living are biggest in terms of transport across regions, but there are also sizable gaps in clean cooking cold storage, sanitation and cooling. The cooling gap is especially large in

South Asia. In many parts of the Global South, cooling is among the fastest growing energy use in buildings, yet only rarely the focus of sustainability. Heat stress affects health and productivity of billions of people.

Without a successful rapid global sustainable energy transition, most of the other SDG ambitions will also remain out of reach. Clean energy solutions also have the potential to deliver universal energy access in a way that is safe and powers economic development for everyone

Despite continued unsustainable trends, recent sustainable development scenarios show that the SDGS and our climate targets are still within reach. We can still ensure decent living standards for all, including in developing countries. We can halve malnourishment by 2030, achieve zero hunger by 2050, reduce extreme poverty to 180 million people by 2050 and ensure rapid income growth in developing countries. For this to happen, we need to adopt the right policies as well as step up investments, research and sharing of technology with sustainable development as our ultimate objective. Effective governance and institutions are critical as is peace, international cooperation and solidarity. The energy transition is a powerful enabler for realizing all these advances, and the SDGs. In all areas, there is need for political will, focus, continuing research and development, and international cooperation and solidarity.

Decision-makers need a clear and evidence-based view of potential technological change in the very long-term as well. Science and technology have led us to new understandings of how our world functions and could be made to function, but it has also had adverse consequences. Science and technology in and of themselves are not virtuous or viscous pursuits. The suitability of scientific and technological processes and outcomes for helping us meet the SDGs will largely rely on the intentions, ambitions, and integrity of all nations, companies, and publics who engage in them. Underlying the whole discussion is acknowledgement that our perception of what is possible in what time frame is informed by the implicit and explicit futures we imagine.

## b) On specific issues and technologies

***The green economy – a technology revolution challenging development models***

Rapidly emerging scientific breakthroughs and technologies are upending old development models, offering new opportunities but also enormous challenges to institutions in all countries. This includes clusters of technologies, such as advanced digital production technologies, green and low-carbon technologies, electrified transport, solar photovoltaics, hydrogen, smart grids, and digital consumer technologies. They are part of a technology revolution also referred to as the "*green economy*".[9] Here we illustrate just a few examples of what this new green economy entails.

Digitalisation has become a pervasive force across all sectors and countries, promising new opportunities for leapfrogging. Yet, billions of people across the world remain excluded from the benefits due to lack of basic Internet connectivity, technology skills and access. While great progress has been made in closing digital gaps in terms of simple Internet and Web access in many parts of the world, new digital gaps have opened up as new technology infrastructures (e.g., generative AI) are being built on top of basic connectivity infrastructure. Fintech in particular has been leading the way in digitalisation and has the potential to greatly increase financial inclusion, including in the poorest parts of the world.

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[9] UN (2023). Chapter III.G in: Financing for Sustainable Development Report, Inter-agency Task Force on Financing for Development, March 2023

Digitalization is reshaping production processes. By 2021, there were 3.5 million industrial robots installed in the world. Industrial robot installations have surged at compound rates of over 30% per year, primarily in China where now more robots are installed annually than the stock of robots in Europe and the Americas combined. While the current boom in industrial robots remains highly concentrated in a few countries and in the electronics and vehicles sectors, the projected cost advantages will greatly challenge the labour cost advantage of developing countries in one sector after another in this decade.

The green economy has been very rapidly emerging since 2018. It has become the fifth largest industrial sector by market value at US$7.2 trillion, larger than retail, financial services, or oil & gas.

Global investments into the energy transition alone rose to a new record of US$1.1 trillion in 2022, especially due to electric transport and solar PV. In fact, for the first time ever, energy transition investments slightly surpassed fossil fuel investments in 2022. However, China alone accounted for 49% of this total and for 91% of global investments into clean energy manufacturing. Many developing countries other than China, however, have large shortfalls in sustainable energy investments. Targeted policy strategies drive technology adoption, and indeed, zero-emissions vehicle targets now cover 40% of the global automobiles market.

The primary question is whether these trends offer “green windows of opportunity” for developing countries, as suggested by the latest UN Technology and Innovation report 2023. Whether they will in large part also depend on the degree of openness of our science and technology system in the coming years, despite the prevailing geopolitics and competitive issues. While the technology revolution elements of the green economy hold much promise in terms of opportunities for new kinds of development pathways, advances may also ‘raise the bar’ for firms in developing countries and thus foreclose traditional development pathways.

These technologies will increase productivity, energy efficiency and provide solutions to major sustainability challenges. But they can also increase the risk of widening income gaps between and within countries. Sustainable industrial policies can be a useful strategic approach to building technological capabilities and directed structural change. The Technology Facilitation Mechanism has led to many new UN system STI activities that can help governments making sense of and benefiting from these trends. We need much more real-time access to information on STI trends and policies, especially with respect to the green economy.

***Emerging carbon dioxide removal technologies for addressing climate change***

According to the IPCC 1.5°C report of 2018, without increased and urgent mitigation ambition in the coming years, leading to a sharp decline in greenhouse gas emissions by 2030, global warming will surpass 1.5°C in the following decades, leading to irreversible loss of the most fragile ecosystems, and crises for the most vulnerable people and societies. In the context of systemic transitions across energy, land, urban and industrial systems, the Special Report assesses adaptation and mitigation options, including carbon dioxide removal (CDR) measures, as well as the enabling conditions that would facilitate implementing the rapid and far-reaching global response. In the context of 1.5°C-consistent pathways, CDR measures serve to offset residual emissions and, in most cases, achieve net negative emissions to return to 1.5°C from an overshoot. Over the last decade the scientific community has considered the possibility of using CDR Technologies such as direct air carbon capture and storage (DACCS) or Bioenergy with carbon capture and storage (BECCS) as emissions mitigation mechanisms and these technologies are currently in practice at small (single industrial plant) scale.

In the last five years there has been keen interest in emerging CDR technologies, National Academies studies, national field demonstrations, extensive reviews, both government and NGO funders and companies formed to do field demonstrations and scale up. Corporations are incorporating CDR technologies into their plans. The IPCC's 6$^{th}$ Assessment Report of 2022 assessed the utilization of a range of emerging negative emissions technologies such as nature-based solutions like afforestation and soil enhancement, both for climate mitigation and adaptation, in synergy with mitigating biodiversity loss. Many different CDR technologies are being explored and are already contained in over 100 updated NDCs. The various choices of CGR technologies that will actually be deployed in the coming years will have different implications for the achievement of other SDGs, in particular SDG14 on oceans and SDG15 on terrestrial ecosystems.

*Indicative implications for oceans (SDG14).* The ocean plays a major role in buffering the global climate system by capturing and storing $CO_2$ away from the atmosphere. It acts globally as a net sink for anthropogenic $CO_2$ and significantly reduces the rate of global warming. The organic carbon that is captured and stored by the ocean is often referred to as "blue carbon". Coastal vegetated ecosystems (CVE), such as seagrass meadows, tidal marshes and mangrove forests accumulate and store large stocks of organic carbon in their sediment, with rates of burial per hectare that are estimated to be an order of magnitude greater than those of terrestrial forests. Therefore, they are considered major players in nature-based solutions to climate change adaption strategies. In addition, the current magnitude of sedimentary carbon losses resulting from widespread habitat degradation calls for coordinated actions to create and restore habitats and to implement creative eco-engineering solutions.

While a number of studies have been conducted on blue carbon in CVE during the last decade, many questions still remain unanswered. These encompass aspects such as: the evaluation of global hotspots that are largely understudied (i.e. Central and South America, Asia); how climate change and other disturbances will impact blue carbon systems; the role of macroalgae and seaweed farming; or the best management actions to maintain and enhance carbon sequestration in blue carbon habitats. Also, advancing the scientific understanding of impacts of proposed large-scale farming and sinking seaweed in the oceans is imperative. The evaluation of the capacity of coastal ecosystems or seaweed farming to sequester carbon from atmospheric $CO_2$ (as Blue Carbon) is done using nuclear technologies.[10]

*Implications for terrestrial ecosystems (SDG15)*. Agricultural production plays a key role in climate change, which underlines the need to reduce greenhouse gas (GHG) emissions and to increase carbon sequestration in soil. The high variability of C footprints across different types of agricultural products, pedoclimatic conditions and management practices implies that climate change mitigation measures in agriculture need to be tailored to each specific situation. Agricultural production is responsible of direct emissions of GHG, such as N2O, from synthetic and organic N fertilization, and CH4 from rice paddies. However, indirect emissions taking place outside the agroecosystem also play a key role. In addition, soil and biomass C sequestration can have a major role in the GHG budget of agroecosystems. The life cycle assessment methodology allows the integrated assessment of all these components of the GHG budget in a an internationally standardized way.

[10] C14 dating, estimation of carbon fluxes with isotopic ratios

It is urgent to develop the necessary knowledge base and institutions to manage, fund and deploy CDR in a sustainable way that take account of these complexities of CDR.

***Rapid advances in biotech and synthetic biology***

Besides governance, management, large-scale production and distribution elements, biotechnology, biological sciences and epidemiology have an important role to play for addressing a multitude of current and future biorisks (well beyond the COVID pandemic). International cooperation on R&DD and the open nature of science where adding knowledge will benefit all of a human mankind play an essential role. Similarly, the access to and capacities to scale-up and deploy technologies and innovations of major public health benefits are key in this regard.

Public health and related technologies have been on the agenda of the TFM and its STI Forum since the very beginning. All TFM 10-Member Groups of high-level representatives have included one or two public health experts.[11]

A repeated topic has been anti-biotic resistance – a likely source of future pandemics - as well as a range of biotechnology issues. The TFM provides evidence-based information and discussion. The summary of the STI Forum is a mandated input to the HLPF and its review of science and technology related SDGs and its targets.

Recent developments in biotechnology and synthetic biology have dramatically reduced the cost of DNA sequencing and also of DNA synthesis, ultimately allowing the "programming" of new organism. As a result of ever cheaper high-tech equipment, "Do-it-yourself" biology labs, biohacker spaces, makerspaces and fablabs have emerged around the world – first in Europe and North America, but now they can be found in a majority of countries in the world. Levels of equipment, expertise, and biosafety regulations vary greatly, though. These "citizen scientist" movements might be a boon for development. Much of their work is practical and aimed at solving everyday problems, as opposed to commercial operations of large-scale biotech companies. However, little to my knowledge little to no UN support and guidance exists for governments to safely promote these labs.

Trends towards lab automation and minituarization are rapidly leading to the realization of "labs-in-a-chip". This trend is just one of many resulting from the convergence of biotech, IT and artificial intelligence. It points to ever easier and decentralized access to DNA sequencing and DNA synthesis undertaken "citizen scientists" in their homes or simple community labs.

Any biorisk assessment should be grounded in and supported by efforts to build much better science-policy interfaces at all levels. The current pandemic is a stark reminder that without it, biorisk prevention and responses may not be effective in the face of ever new challenges.

***Emerging health technologies and scientific innovations: a new era of global public health***

In early 2023, the World Health Organization's Global Health Foresight function conducted a horizon scan exercise to identify innovative science and technology developments that could significantly impact global health in the next 5-10 years.[12] In their preview of the results, they present the top five most promising

[11] Nobel Prize winner in medicine, Prof. Ada Yonath, the former president of the health agency of Brazil Fiocruz, Dr. Paulo Gadelha, and infectious diseases epidemiologist, Dr. Quarraisha Abdool Karim.

[12] 2023 emerging technologies and scientific innovations: a global public health perspective — preview of horizon scan results , 26 April 2023, Technical document, World health Organization, https://www.who.int/publications/i/item/WHO-SCI-RFH-2023.05

innovations and discuss the enablers and risks associated with them. The 10-Member-Group considers the finding and excellent account of current and future trends in health-related technologies. Selected findings of the WHO report are summarized in this section. The top-5 health innovations:

- *Genomics for early diagnosis and pre-diagnosis of diseases:* The application of genomics, starting from universal genomic prenatal screening, will allow us to identify metabolic and congenital disorders pre-symptomatically. This early detection will enable precise diagnoses and guide management and treatment strategies.
- *Improved vaccine production and global distribution:* Better coordinated and more effective systems of vaccine production and global distribution will be crucial in addressing future pandemics and endemic diseases.
- *Low-cost viral diagnostics:* Novel CRISPR/Cas techniques will allow for the rapid design and construction of cost-effective point-of-care diagnostics for HIV and hepatitis B virus load testing, increasing accessibility to vital healthcare services.
- *Broad-spectrum antimicrobial drugs:* The development of antimicrobial drugs that do not cause resistance or tolerance will revolutionize the treatment of bacterial infections. These drugs may adapt their conformation to target structural changes and mutations, addressing the growing issue of antibiotic resistance.
- *Rapid remote diagnostics:* By connecting people through cell phones, watches, and other devices (such as smart implants, prostheses, and wearable sensors), real-time health information will be available for clinicians and public health entities. This will support individual health promotion, disease prevention and management, and provide real-world data for public health management and health economics.

To realize the full potential of these innovations, various enablers are necessary, including technological advancements (Big Data, AI, and machine learning), skilled health professionals and technicians, leadership and good governance, and a supportive regulatory and policy framework. Additionally, cultural enablers such as building trust in science, disabling the spread of misinformation, and promoting health and digital literacy will be crucial.

However, these innovations also carry inherent risks. They may potentially accentuate health inequity, have issues with reliability and accuracy, face challenges with access and affordability, or pose threats to data privacy. Furthermore, there may be difficulties in understanding and interpreting results, maintaining manufacturing standards, managing potential toxicity and safety concerns, and preventing misuse of technology. To mitigate these risks and maximize the benefits of emerging health technologies, it is essential to establish a robust regulatory and policy framework, prioritize universal primary health care, build and sustain broad health infrastructure, invest in skills and capacity-building, and foster public-private partnerships for research and development. By acknowledging and addressing these risks and enablers, we can harness the potential of these promising innovations to revolutionize global public health and improve the lives of millions of people worldwide.

***From digital development divides to digital transformation***

Digital technologies and networks have an outsized role in shaping overall progress in STI in terms of speed and scale, and equally important our ways of collaborations.

The pace of diffusion of digital technologies has exceeded that of any prior innovation in human history, covering over 50% of the developing world's population in just two decades.[13] The acceleration of digitalization of economic activity, governance, and public service delivery systems in the post-pandemic period has demonstrated beyond doubt the pivotal role of data and AI technologies in transforming economies. Increasingly, it is also clear that the attainment of the SDGs depends on shaping the pathways of technological innovation in ways that contribute to social equity and human well-being.[14]

With every major new digital innovation, new kinds of digital gaps have emerged - not only between countries, but equally within countries, between regions, social groups and between the genders. Here we look first at the between country gaps and in the next section the gender gap.

Unfortunately, the countries that can take advantage of the long-term productivity prospects of the digital revolution continue to lag behind. UNCTAD's Frontier Technology Readiness Index – 2023,[15] which measures the capacities of countries to use, adopt, and adapt to new digital technologies – on the five point axis of ICT deployment, skills, R&D activity, industry activity, and access to finance – has found that though the global average technology readiness has improved over the past five years, a stark disparity across countries remains, with Least Developed Countries (LDCs) requiring to cover much ground. Countries in North America, Europe and North-East Asia are currently the best prepared for an equitable development of these technologies while the least prepared countries are located in sub-Saharan Africa.

How can the AI revolution raise the bar for competitiveness of developing countries? This is both a question for prioritising investments in digital and traditional infrastructure, as well as urgently investing in human capabilities. In the current global economic scenario where over 60% of low-income countries are at high risk of debt distress, national capacities to invest in infrastructural and human capabilities remain severely limited.[16] Traditional barriers for market-based technology transfer are only intensifying in the digital epoch, as the patent thickets and patent fencing erected by transnational digital corporations render the transition to a knowledge economy a truly uphill task for most countries.[17] Prohibitions on source code disclosure in trade agreements, further restrict technology transfer.[18] The inability to have access to the wherewithal for digital innovation has direct implications for digitalisation of core sectors such as health and agriculture, and consequently, the achievement of SDGs.

What this implies is that the onus to plug the investment gap falls on the multilateral system. Yet, the share of ODA flows to LDCs has decreased from 70% to 60% over the period from 2000-01 to 2018-19, with private flows from DAC countries representing merely 1% of the total financing.[19] Initiatives such as the Tech Access Partnership implemented by the UN Technology Bank have thus not taken off despite their ambition.[20]

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13 https://www.un.org/en/un75/impact-digital-technologies

14 https://press.un.org/en/2022/sgsm21105.doc.htm

15 UNCTAD Technology and Innovation Report 2023. cited in https://developmentfinance.un.org/fsdr2023

16 https://developmentfinance.un.org/fsdr2023

17 UNCTAD. (2018). Trade and Development Report 2018 – Power, platforms and the free trade delusion. United Nations. Retrieved February 20,2023, from https://unctad.org/system/files/official-document/tdr2018_en.pdf

18 https://www.cepr.net/report/digital-trade-rules-a-disastrous-new-constitutionfor-the-global-economy-written-by-and-for-big-tech/

19 OECD. (2022). External finance to least developed countries (LDCs): A snapshot. OECD Publishing. Paris. Retrieved February 17, 2023, from https://www.oecd.org/dac/LDCs_external_finance_2022.pdf

20 Gombe, Spring. (2021, May 04). An introduction to the UN Technology Bank for the least developed countries. South Views. No. 216. South Centre. Retrieved March 03, 2023 from https://www.southcentre.int/wp-content/uploads/2021/05/SouthViews-Gombe.pdf

As the UN High Level Advisory Board on Effective Multilateralism has observed, the multilateral system's current responses towards effectively harnessing the AI revolution are slow.[21] In the absence of dedicated funding, the Technology Facilitation Mechanism has not been able to effectively generate a system-wide response to equalize the gains of technology.[22] Leapfrogging the digital divide requires attention to the wider digital infrastructural ecosystems so that STI roadmaps are designed to tackle structural issues in developing countries. A yawning gap in public financing has unfortunately led to sub-optimal and short-lived impacts in the ad hoc and case specific methods of technology deployment.[23]

As data and AI technologies bring unprecedented complexity to the policy arena, including ethical dilemmas, the need for concerted effort at the multilateral level to evolve normative benchmarks is gaining urgency. The digital transition is also deeply intertwined with the climate transition. Research suggests that network-data hardware development has increased greenhouse gas emissions, while mining for minerals in electronics has led to ecological destruction, including potential for extreme biodiversity loss[24], in some of the poorest parts of the planet, furthering a production and consumption model of digital commerce that is unsustainable.[25] Unless the runaway power of large, monopolistic corporations in the AI economy is checked, a digital future that upholds human rights, including the right to development for all, and ecological sustainability, is not possible.

Evidently, digital transformation to meet the SDGs needs to go beyond a purely technical approach. What is needed is for strategic roadmaps to envision the role of innovation and infrastructure as enablers of human capabilities that generate adaptive capacity in the economy.[26] This approach has two prongs: (a) investment in digital public goods; and (b) human-centred futures of work.

Investment in digital public goods is needed to build the basic building blocks of platform, data and AI infrastructures, together with appropriate governance that aims at democratizing the marketplace of innovation preventing private capture. Digital public goods could range from platform protocols to common pool data sources and open AI algorithms. For example, the public digital payments interface that Brazil has developed to boost digital financial transactions – Pix – has a differentiated transaction fee structure: end users are not charged in order to incentivize digital financial inclusion, but private payment service providers are charged a minimal fee to help the central bank recover the cost of maintaining this infrastructure.[27] The Pix case illustrates an ecosystem model built on a semi-commons approach,[28] where the base infrastructure layer is provisioned publicly, and the innovation layer then runs on top. Rule-based guardrails (differentiated pricing, in this case) can create virtuous cycles between public investment, private enterprise and human capability in the digital economy.

Human-centred futures of work need to ensure decent work opportunities for all, and a policy environment to facilitate the transition from education and training to work as well as linkages to social

21 https://highleveladvisoryboard.org/breakthrough/
22 https://www.2030spotlight.org/en/book/1883/chapter/sdg-17-can-technology-facilitation-mechanism-help-deliver-sdgs-era-rapid
23 https://www.t20italy.org/wp-content/uploads/2021/09/TF5_PB08_LM02.pdf
24 Levin, L.A., et al. (2023). Deep-sea impacts of climate interventions Ocean manipulation to mitigate climate change may harm deep-sea ecosystems, SCIENCE, 9 Mar 2023, Vol 379, Issue 6636, pp. 978-981, https://www.science.org/doi/10.1126/science.ade7521
25 Gurumurthy, A. & Chami, N. (2022, August). Taming the intelligent corporation - Why the data paradigm necessitates a re-think of responsible business conduct obligations of MNEs. IT for Change. Retrieved March 03, 2023, from https://itforchange.net/sites/default/files/add/ITFC_TheIntelligentCorporation.pdf
26 'A human-centred approach to promote Science, technology and innovation for Sustainable Development Goals', Irmgard Nübler, International Labour Organisation (ILO), April 2023
27 https://www.bis.org/publ/bisbull52.pdf
28 https://itforchange.net/sites/default/files/1741/WP23-Governing-the-Resource-of-Data-AG-NC.pdf

security.[29] A human capability approach needs wide ranging policy interventions to reboot institutions that can encourage a culture of innovation. This would include critical and creative digital literacy, especially for children and youth; active support for small enterprises; lifelong learning opportunities for all; public-community collaborations; and attention to inclusive economic development.[30]

Deployment of public digital infrastructures can promote job opportunities and learning, bridging information gaps and connecting various stakeholders. For instance, the Digital Workforce Management System (DWMS) – an initiative of the state government of Kerala, in India – conceptualized as a platform of platforms, integrates many features like onboarding, profiling, curation of job seekers, skill assessment, and matching. The platform offers job aspirants the opportunity to fine-tune their career preferences and profiles through knowledge assessment, e-learning, career counseling and guidance, among others. A mobile app - DWMS Connect – has been developed to introduce all the features into one app. The ambition of the project is to provide employment to 2 million people in the state by 2026.[31] With a focus on the empowerment of women, the initiative also enables those registered on the portal to access hyper-local information such as about job fairs. Plans are afoot to effectively utilize data analytics to guide job matching and identify enskillment and social security needs and match them with appropriate local services.

We are in the middle of the digital revolution. We believe it is a major inflection point. Without a vision that can guide its force-field with new norms, policies, and institutional arrangements, we are unlikely to see a just future for people and planet. The question for the multilateral system is one of ecosystem building – how financing for infrastructure and new public goods can be mobilized and how capabilities can be built to prioritize human-centred, ecologically sensitive transformation pathways.

In the lead up to the Addis Ababa Action Agenda in 2015, the Technology Facilitation Mechanism was born to fill the gap for a dedicated institution at the UN to help developing countries address the challenges and obstacles to access technologies for sustainable development. Today, in the era of generative AI and automated supply chains, a new reality confronts us – and the hype and hope need to be clearly parsed. The development divide can be bridged only if the spotlight is on reaping the social and public value of digitalisation. In this regard, the process initiated by UN Secretary General for a Global Digital Compact (GDC) has ushered in a much-needed space to pause and examine the digital juggernaut and facilitate a back-to-basics stocktaking across stakeholders.

Digital policy issues need a dedicated home in the UN with a new work programme on digitalization backed by dedicated public funding. The GDC process presents an opportunity to galvanize consensus for this.[32] Resourced adequately to execute a comprehensive set of actions, the dedicated home should strive to ensure that:[33]

- The digital commons, including data, have appropriate guardrails nationally and globally; and market dynamics in the digital economy are in alignment with a bold vision for our common futures.

29 Work for a brighter future – Global Commission on the Future of Work. (2019). ILO. Retrieved. February 22, 2023, from https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_662410.pdf
30 https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/ldc_report-web-15_04_.pdf
31 https://knowledgemission.kerala.gov.in/
32 Relatedly, the UN High Level Advisory Board on Effective Multilateralism has proposed a Global Commission on Just and Sustainable Digitalization.
33 https://www.highleveladvisoryboard.org/breakthrough/pdf/56892_UNU_HLAB_report_Final_LOWRES.pdf

- Public innovation infrastructure in developing countries is doubled by 2030, and 50% value from the digital economy accrues to the bottom 50% nationally and globally by 2030.
- A normative framework for frontier AI innovation embodying values of a humane and transformative paradigm based on democratic and distributive integrity[34] is developed and adopted at the multilateral level.
- A dedicated, multilateral hub – linked to regional and national nodes and mechanisms – where frontier technology and sustainability science researchers and innovators from developing and developed countries can come together on equal footing to jointly work out and test solutions for the global challenges the world faces is established.
- Effective system-wide coordination is made possible across all relevant UN entities (e.g., ITU, UNESCO, UNCTAD, etc.)

***Gender equity in science and technology, research and AI***

One key trend over the SDG time frame have been continued and high-profile efforts to promote gender equity in all aspects of science and technology fields, especially in research and more recently artificial intelligence fields and activities. One example is of course, the high priority attached by the United Nations and its Secretariat to promoting gender equity, especially in previously male-dominated areas. In 2023, for example, the UN Commission on the Status of Women's priority theme was "Innovation and technological change, and education in the digital age for achieving gender equality and the empowerment of all women and girls."[35]

Sustainable development itself requires more science and more scientists, including women. The 2030 Agenda and its 17 Sustainable Development Goals recognize this explicitly. If the world needs more scientists, it cannot afford having half of its population missing from the scientific workforce. Enhancing female participation in STEM fields requires increasing the number of women entering college, reducing dropouts, and promoting equal treatment at the next step. Change needs to happen in all these fields and at all levels. Among others, suitable sex-disaggregated data and useful indicators on women's participation have been important for achieving the SDGs. UNESCO's STEM and Gender Advancement (SAGA) initiative has helped improving measurement and policies for gender equality.[36]

Gender has been acknowledged as a cross-cutting issue for all research fields. From the perspective of promoting science and technology, the importance of gender equality has come to be recognized in recent years. For example, the European Commission has incorporated gender perspectives into research and development (R&D), and this is being reflected in policy. Its R&D programme, Horizon Europe, launched in 2021, regards gender as a cross-cutting issue for all research fields, emphasizing gender balance and incorporating gender analysis into all R&D.[37,38] In its predecessor program, Horizon2020 (seven years from 2014), it was only recommended to consider gender balance in research and incorporate gender analysis [8]. Based on the results that these recommendations are effective in improving the quality of research,

34 https://parispeaceforum.org/wp-content/uploads/2022/03/Initiate-PPF-Global-South-AI-Report-EN.pdf

35 https://www.unwomen.org/en/csw/csw67-2023

36 STEM and Gender Advancement (SAGA), Improving Measurement and Policies for Gender Equality in Science, Technology and Innovation, UNESCO, 2018.

37 European Commission (2020) Gendered Innovations 2: How Inclusive Analysis Contributes to Research and Innovation.

38 Londa Shiebinger (2008) Gendered Innovations in Science and Engineering, Stanford University Press.

Horizon Europe has made great progress in gender mainstreaming, which requires gender analysis in all research related to humans and living organisms.[37,39]

Equity concerns have emerged as rapidly as AI technologies in recent years, and gender is one of the unresolved issues. AI that is trained with by humans or data that reflect social discrimination and prejudice leads to create discriminatory and unequal systems. It is difficult to eradicate this type of implicit discrimination in AI systems unless the discriminatory consciousness of individuals is eliminated. Since AI predicts the future based on past cases, the future predicted based on the biased past becomes biased. Human-centered AI should be seen as a social principle. One example is face recognition where the recognition rate differs depending on race, gender, and age.[40]

***Innovations in education***

Quality education, including early childhood education, is a fundamental human right; it is a prerequisite for many long-term opportunities, and can serve as a societal equalizer. At the same time, progress in this area has been lagging. Even before the pandemic, the world was not on track to achieve SDG targets for school enrollment and literacy by 2030. The pandemic has been the single largest disruptor to education systems in history, impacting over 90% of students globally with school closures.[41] One year into the pandemic, close to half of all students were still affected by partial or total school closures. As a result, it is estimated that more than 1 billion children are at risk of falling behind, while over 100 million additional children will fall below the minimum proficiency level for reading.[42,43] The World Bank estimates that students currently in school stand to lose a cumulative $17 trillion in lost labor earnings over their work life due to school closures.[44] Some estimates suggest that COVID-19 has wiped out 20 years of education gains. Many children also suffer from mental health issues due to increasing isolation. These negative impacts have disproportionately affected vulnerable communities including developing countries, low-income households, women and girls, persons with disabilities, migrants, and refugees.

To mitigate the impact of the pandemic, many countries used new information and communication technologies (ICTs) to continue education through home schooling. The latest digital education technology solutions (edtech) disseminated via phone applications, TV and radio have expanded in many countries to support distance learning. These technologies have the potential to make education more interactive with more hands-on experience, for example through the Virtually Integrated Projects (VIP) model.[45] They can also enhance tailored, personalized teaching as seen with Khan academy.[46] Such technologies enable students to learn essential 21st century skills including creativity, collaboration, communication, technology literacy and flexibility.

On the other hand, while technologies can facilitate interactive learning and help ameliorate the impacts of school disruptions, they often leave behind households with limited technology access and low-income countries, which struggle with lower digital connectivity overall. UNESCO estimates that half of all global

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[39] European Commission (2013) Gendered Innovations: How Gender Analysis Contributes to Research.
[40] https://gender-summit.com/
[41] Our Common Agenda
[42] UNICEF (2020). Education and COVID-19. https://data.unicef.org/topic/education/covid-19/
[43] UNESCO (2021). 100 million more children under minimum reading proficiency level due to COVID-19. https://en.unesco.org/news/100-million-more-children-under-minimum-reading-proficiency-level-due-covid-19-unesco-convenes
[44] World Bank (2022). The global education crisis – even more severe than previously estimated. https://blogs.worldbank.org/education/global-education-crisis-even-more-severe-previously-estimated
[45] https://www.vip.gatech.edu/
[46] https://www.khanacademy.org

learners do not have a household computer and 43% have no household internet access.[47] Furthermore, 37% of the world's population – or 2.9 billion people – have never used the Internet; 96% live in developing countries, highlighting the critical impacts of the digital divide. School closures are particularly problematic in places where students are unable to continue their studies virtually, not only because students stop learning, but because they tend to forget some of what they had learned previously. Dropout rates are likely to increase particularly among vulnerable populations including girls and marginalized communities.[48]

Despite recent advances in edtech and distance learning, there is no empirical evidence that digital solutions can replace traditional education, teachers, and practical skills training.[49] There is an urgent need to bolster global education systems through human-centered approaches, improved teaching methods and formative assessments. Improving the efficacy of digital solutions will require better digital infrastructure, particularly in developing countries, and support of private sector initiatives to build human-centered and inclusive ed-tech solutions and other innovations.

This calls for innovations not only in content or digital provision, but also in the learning models and learning ecosystems. The system needs to be able to impart not only technical and core skills needed in labour markets, but also to impart competences, attitudes, values, and personal traits which, among others, nurture creativity, discovery, and innovation. Education systems should promote human agency to shape the future and make humans resilient and able to cope with crisis.[50]

To transform education systems in a way that helps enable opportunities and balance inequalities, new technologies should strive to narrow, and not widen disparities. Curricula can be designed to prepare students and youth for future market needs in a changing global economy, including by emphasizing STEM education, especially among women and girls. Innovations in teaching and learning, such as active learning and the use of artificial intelligence can help tailor online learning, especially for underserved children and adults to address a range of equity and equality issues. In the context of digitalization, strategic pedagogical approaches can enable teachers to improve learning models, for example by emphasizing theory of knowledge, and teaching students how to filter materials and recognize misinformation. Collaborative approaches and inclusive methods can help prepare the next generation to innovate solutions for addressing social and economic challenges and inequalities to build a more sustainable future.

## c) Progress towards tech-related SDG targets and the UN Technology Facilitation Mechanism

***STI-related SDG targets – tech performance, universal access, and innovation systems***

The 2030 Agenda recognizes the importance of technology for the achievement of the SDGs. Technology is not only captured in SDG17 as a key "means of implementation". As explained in detail in the Global Sustainable Development Report 2016[51], among the 169 targets, 14 targets explicitly refer to "technology"

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[47] UNESCO (April 2020). Startling digital divides in distance learning emerge. https://en.unesco.org/news/startling-digital-divides-distance-learning-emerge#:~:text=Half%20of%20the%20total%20number,continuity%20in%20the%20vast%20majority

[48] Center for Global Development (July 2020). Six ways COVID-19 will shape the future of education. https://www.cgdev.org/blog/six-ways-covid-19-will-shape-future-education.

[49] Center for Global Development (July 2020). Six ways COVID-19 will shape the future of education. https://www.cgdev.org/blog/six-ways-covid-19-will-shape-future-education.

[50] Richard Sennet 2008 The Craftsman; Literature on humanistic education.

[51] Table 3-1, https://sustainabledevelopment.un.org/content/documents/2328Global%20Sustainable%20development%20report%202016%20(final).pdf

and another 34 targets relate to issues that are most often largely discussed in technology terms. There are also certain technology dimensions to the other remaining 121 targets, in which case, however, technology is only one of many means for their implementation. Those 48 targets that are most closely related to technology can be categorized along three targets: (a) significant overall technology performance improvement; (b) universal access to sustainable technology; and (c) global effective innovation system for sustainable development. The remaining 121 targets fall primarily into the equity and institutional categories. In this format, it translates the complex list of SDG targets into a form that can readily be related to existing scientific literature and assessments. Technology-related targets have also been proposed in the scientific literature, and they are usually much more quantitative than the agreed SDG targets. Hence, while the creators of the SDGs overwhelmingly focused on the objective to "leave no-one behind" in all its dimensions, when it came to technology, they included a significant number of overall technology performance targets. This is very much in line with scientific findings that point to a need for making simultaneous progress in equity, overall technology performance and institutions, as well as in both radical and incremental technology change. It is also important to note that the SDG agenda highlights the value of include multistakeholder inputs and indigenous knowledge, as well as systems thinking to foresee synergies and unintended trade-offs between actions to achieve the SDGs

We provide a broad assessment of progress in these 48 STI-related SDG indicators since 2015. This is based on the data in the latest UN progress report on the SDGs, other science and engineering sources, and our own judgement on some of the qualitative targets. The broad picture is that of progress in most STI aspects, a progress that is, however, too slow to achieve the SDG aspirations by 2030. Major renewed efforts would be needed across the board. To be realistic, they will require institutional and governance innovation, some of which we proposed in our recommendations below.

| Principle & overall goals | Technology-related SDG targets (48 of 169 targets) | Global Progress 2015-2023 in selected STI areas |
|---|---|---|
| **Significant overall technology performance improvement (19 targets)** | **General technology performance targets for 2030** (targets 8.4, 8.2, 9.4)<br>**Issue-specific, quantitative technology performance targets for 2030** (targets 2.3, 3.3, 3.6, 6.3, 7.3, 12.3)<br>**Issue-specific, qualitative technology performance targets for 2030** (targets 3.9, 6.3, 6.4, 7.2, 7.b, 12.3, 12.5, 14.1, 14.3, 2.5) | Slow progress in global resource efficiency (no "decoupling"), increasing material footprint, but slight reductions per capita and per unit of GDP.<br>Moderate progress in technological and infrastructure upgrading but accelerated adoption of green technologies. No significant global progress on GHG emissions reduction.<br>Too slow progress in agricultural productivity, food waste, wastewater, energy efficiency, and on diseases. Comparatively good progress on road safety.<br>Too slow progress on water quality and efficiency, chemical pollution, and recycling. |
| **Universal access to sustainable technology (12 targets)** | **Access to basic services by 2030** (targets 1.4, 6.1, 6.2, 7.1, 11.1, 11.2)<br>**Access to technology** (targets 3.b, 9.1, 9.c, 16.10)<br>**Technology use** (targets 5.b, 11.2) | Very good progress on mobile network access.<br>Good progress on universal access to electricity.<br>Moderate and uneven progress on access for women and girls.<br>Deterioration on slums, on addressing malaria and on increasing vaccine coverage (e.g., DTP) and certain medications, especially among the poor. |
| **Global effective innovation system for sustainable development (17 targets)** | **Research, development and demonstration** (targets 3.b, 9.5, 9.b, 14.a)<br>**Technology transfer and diffusion** (targets 17.7, 17.8)<br>**Higher education and STI capacity building** (targets 4.b, 13.3)<br>**STI policy environment and market incentives** (targets 8.3, 9.b, 12.c)<br>**International cooperation on STI capacity, technology access and transfer** (targets 2.a, 6.a, 7.a, 9.a, 12.a, 17.6) | Very good progress on basic access to the Internet and in broadband access, but new gaps in terms of quality and new related infrastructures have emerged.<br>Very good progress on ODA for scholarships. Reduction in ODA for water and sanitation to Sub-Saharan Africa.<br>Moderate but highly uneven progress on R&D expenditure.<br>Little to no global progress on increasing the share of medium and high-tech manufacturing in total value added, with large disparities among countries.<br>Rapid global progress on deployment of renewable electricity, but large differences among countries. |

*Data sources:* UNSDG database as of April 2023[52], the SDG progress chart 2022[53], and a range of academic sources.

### *Progress of the UN Technology Facilitation Mechanism*

The UN Technology Facilitation Mechanism (TFM) has made significant strides in promoting science-based, solution-oriented, multi-stakeholder, and collaborative approaches to address the global challenges outlined in the SDGs. It has become an unprecedented new UN entry point for science and technology communities. But there also remain significant areas for improvement of this new science-policy interface, especially in terms of effectiveness, reach, and scale.

As envisaged by Member States that created the TFM in 2015, it has led to an increasing number of complementary partnerships and activities spearheaded by UN Member States, the UN system,

[52] https://unstats.un.org/sdgs/dataportal/analytics/GlobalRegionalTrends
[53] https://unstats.un.org/sdgs/report/2022/Progress-Chart-2022.pdf

development partners, organized science and engineering communities, academics, private sector entities, NGOs, individual scientists and engineers. This is evident by the “mapping” of UN activities on STI for sustainable development which have been undertaken by the Interagency Task Team on Science, Technology and Innovation for the SDGs (and its informal predecessor) since 2012.

Undoubtedly, science, technology and innovation issues are firmly back on the agenda at UN headquarters, which has spurred a lot of STI activities across the UN system. Yet, political sensitivities around IPR and new technologies remain. While the TFM has made laudable inroads towards much greater UN system cooperation, it remains a very fragmented system. This is despite having achieved the highest level of cooperation on STI at the working level in 40 years. It should be noted that the TFM’s Interagency Task Team on STI for the SDGs (IATT) now comprises 48 UN entities and engages more than 100 expert staff who are active in various IATT subgroups.

As in previous years, there is a lot of talk about “one-UN” approaches, but little incentives and active support for it. In this context, it has been noted that there is no UN Chief Scientist who could drive support for coherent STI work across the system and among UN senior leadership.

There is great willingness from stakeholders, including academia, NGOs and government officials to get engaged, but avenues for engagement are somewhat limited compared to the high levels of interest. Despite these limitations, to-date thousands of participants have made voluntary contributions.

It is important to note that the wide range of participation has not only been a matter of choice, but that it has become increasingly essential, in view of the complexity of new technology issues for achieving the SDGs.

In particular, with respect to the far-reaching implications of new and emerging technologies, it has been noted that these technologies have progressed much faster than the TFM has been capable to respond or merely document the changes. The TFM’s work on STI for SDGs roadmaps have been promising, but the rapidly changing environment has been noted.

Most importantly, the TFM remains an almost entirely unfunded General Assembly mandate within the UN Secretariat. This is greatly at odds with the rising expectations for the TFM to facilitate STI for the SDGs worldwide. One important practical step would be to formally integrate the TFM work into the work programmes of all IATT members and thus to ensure adequate funding

Goodwill by all experts involved will likely not be enough for the TFM to master the future challenges and opportunities towards fulfilling its role. Structural considerations will also need to be seriously considered. They relate to the implementation approach; governance; the means and ways of engaging of volunteers; funding; geopolitics; and how to operationalize interlinkages with partners within and beyond the UN. The creation of a Science Advisory Council could play a dual role of high-level oversight and state of the art input into ongoing and emerging challenges.

In devising a plan for the future work of the TFM, it is insufficient to look at past trends and TFM performance, since the overall environment has changed exponentially in recent years. Hence, what worked well in the past might not work as well in the future. Against such background, General Assembly resolutions on the impacts of rapid technological change on the SDGs have focused the TFM on this rapidly emerging changes. Responding to such challenges in a timely manner will be essential for the continued relevance of the TFM in the future. The rapid emergence of generative AI even in the general public in 2022 is just one case in point.

## 3. Recommendations

Based on our work and deliberations within the Group, we have five major proposals and eleven recommendations for policies, political commitments, and high-impact initiatives (see table). We consider them very important for achieving our vision for STI in 2030.

- *Proposal A: Sustainability Science and Technology Cooperation Package for Future Generations*
- *Proposal B: Building the next generation Web 3.0 distributed system for all by 2027*
- *Proposal C: Capacity building for generative AI for the SDGs*
- *Proposal D: One-UN programme on digitalisation in support of developing countries*
- *Proposal E: Global CDR fund and market*
- *Proposal F: Funding global public goods*

| 10-Member-Group Recommendations of policies, commitments and high-impact initiatives | | | |
|---|---|---|---|
| | **Proposal** | **Category** | **Recommendations** |
| **Sustainability science & technology** | **A. Sustainability Science and Technology Cooperation Package for Future Generations** | STI Funding for SDGs | **Recommendation 1:** Global governmental research funders boost spending on SDGs by 20% over the next two years (by 2025) |
| | | Institutions and cooperation | **Recommendation 2:** US$1 billion per year for a collaborative, global sustainability science centre and training network across geopolitical divides (with demonstration projects at scale in energy, food, climate, biodiversity, health, water and sanitation) |
| | | | **Recommendation 3:** Global network of banks of ideas, funds for innovation, and ethical councils for innovation |
| | | | **Recommendation 4:** Develop and implement national STI4SDG roadmaps, as strategic guideposts for all stakeholders |
| | | Example commitments – health science and technology | **Recommendation 5:** Prioritize investing in the first 1,000 days of a child's life particularly in the poorest settings within and between countries (providing modern medical and nutritional support for all children and their mothers before 2030) |
| | | | **Recommendation 6:** Share technologies and skills to solve the basic human rights issues of water, health, quality education, sanitation and food security. |
| **Digital technologies and networks** | **B. Building the next generation Web 3.0 distributed system for all by 2027** | Technology deployment, training, and cooperation | **Recommendation 7:** Governments commit to put in place policies, regulations, initiatives and funding to build the next generation Web 3.0 distributed system and make it work for all by 2027.<br>This would include the following democratization of the Web, capacity building, the creation of a collaborative, global, public-private UN school/centre on Web 3.0 and related tools, more effective international multistakeholder cooperation, agreement on minimum socio-economic, environmental and ethical standards, and funding commensurate with the challenge. |
| | **C. Capacity building on generative AI for the SDGs** | Training, cooperation, and governance | **Recommendation 8:** Build worldwide capacity for using, developing, and understanding the impacts of generative AI.<br>The initiative would include massive upscaling of collaborative training on generative AI and related emerging tools, including significant commitment of governmental funds complemented by other sources; effective international multi-stakeholder cooperation; sharing access to relevant fundamental research technology infrastructures; and agreement on global minimum socio-economic, environmental and ethical standards on generative AI. |
| | **D. One-UN programme on digitalisation** | UN programme for developing countries | **Recommendation 9:** Create a One-UN programme on digitalisation and sustainability in support of developing countries.<br>This programme would include the following tracks: democratic global digital cooperation and principles development; innovation and development; technical and policy capabilities for future-ready innovation ecosystems; and integration with the Technology Bank for LDCs. |
| **Other** | **E. Global CDR fund and market** | Fund and market creation | **Recommendation 10:** Create a global carbon dioxide removal (CDR) fund and market to facilitate the sustainable deployment of CDR technology options.<br>This includes: (a) fund CDR research and demonstration projects and share their lessons worldwide; create coherent and consistent international rules for CDR deployment assuring the sustainability and permanence of the sequestration and storage activities; provide financial incentive for RD&D for CDR at the required scale; create a CDR market that is not competing (or crowding out) emissions mitigation. |
| | **F. Funding global public goods** | Funding, principles and networking | **Recommendation 11:** Boost global public investment in global public goods to reach (0.2% of GNI), and consider implementing the recommendations of the Expert Working Group on Global Public Investment ("Building a better system: Making Global Public Investment a reality" of July 2022) |

*Source: 10-Member-Group 2021-2023. Status: April 2023*

## a) Proposal A: Sustainability Science and Technology Cooperation Package for the SDGs

We propose the consideration of six recommendations as part of a *Sustainability Science and Technology Cooperation Package for Future Generations*. It is important to note that while the various recommendations could be pursued separately, they would be most effective if implemented together as a package.

| **Proposal A for Leaders** |
|---|
| **Sustainability Science and Technology Cooperation Package for Future Generations**<br>Governments to commit to a systematic global package to greatly expand national efforts and international cooperation on sustainability science and technology, with a clear focus on capabilities of future generations. Countries to commit putting in place national policies to support and align their efforts with the global effort at a scale commensurate with the pressing challenge.<br>1. Increased and targeted funding commensurate with the great potential of sustainable science and technology for the SDGs:<br>    a. Governmental research funders across the world to boost spending on SDGs by 20% over the next two years (by 2025), complemented by other sources **(Recommendation 1)** [as part of a wider initiative to boost global public investment in global public goods to reach (0.2% of GNI)].<br>2. US$1 billion per year for a collaborative, global sustainability science centre and training network that is based on existing institutions but crosses geopolitical divides **(Recommendation 2)**<br>    a. Undertake a series of high-impact initiatives, training and technology *demonstration projects at scale, enabling technological learning for all*, in the following focus areas: *energy, food, climate, biodiversity, health, water and sanitation*<br>    b. Access to fundamental research infrastructures through the centre<br>    c. Monitoring in real-time progress in sustainable development<br>3. Greatly expanded international cooperation on sustainability science and technology<br>    a. Cooperation between governments, private sector, and academic institutions to pool resources, share knowledge, and collaborate on high-impact initiatives<br>    b. Support a network of bank of ideas, funds for innovation, and the ethical councils for innovation **(Recommendation 3)**.<br>    c. Develop, support and fully implement national STI4SDG roadmaps in all interested countries and key regions or municipalities, as appropriate **(Recommendation 4)**.<br>4. STI4SDG government commitments in key areas. Examples:<br>    a. Prioritizing investing in the first 1,000 days of a child's life particularly in the poorest settings within and between countries (providing modern medical and nutritional support for all children and their mothers before 2030) **(Recommendation 5)**<br>    b. Sharing of technologies and skills to solve the basic human rights issues of water, health, quality education, sanitation and food security **(Recommendation 6)**. |

Sustainability science emerged as a new pragmatic and applications-and problem-focused science a quarter century ago. It has since led to a growing number of technology applications and innovations and a systems thinking approach that have become increasingly essential for making any systematic, integrated progress towards the SDGs. Indeed, their widespread deployment at a scale commensurate with the SDG aspirations appears the only solution to the world's most pressing challenges in the key sectors of energy, food, climate, biodiversity, health and sanitations that is capable – by definition – to fall into repeated traps of unforeseen consequences and trade-offs where progress in one area jeopardizes progress in another SDG area.

So, while the solutions are emerging, the development, know-how and related collaboration networks are extremely fragmented and suboptimal, both across disciplines and national borders, and between science and technology. Governments' public investments in R&D and in the much costlier incentives for deployment of sustainable technologies would potentially become much more effective, if governments across the world agreed on key cooperation policies and actions, as outlined in this proposal.

However, government support for R&D while essential will not be enough. Capacity building is needed and integrated solutions must be demonstrated in practice and at increasing scales, as it is this kind of learning-by-doing that is essential for successful deployment and transfer of technologies. Multistakeholder-generated roadmaps and local solutions for particular local communities, cities and rapidly urbanizing areas can be useful guiding posts to provide a lose-type of cooperation with room for exploration and try-and-error. From global to local levels, systems thinking, including scenario analysis and tech futures can provide essential information on future possibilities allowing for local innovations in line with national, regional and global sustainability goals.

***Governmental funding for STI***

In addition, we also propose commitment by *governmental* research funders across the world to boost spending on SDGs by 20% over the next two years (by 2025), complemented by other sources, possibly as part of a wider initiative to boost global public investment in global public goods to reach (0.2% of GNI), see below. This would not only be a wise global investment, finally providing more adequate resources to what may define the livelihoods of future generations, but it would also provide much needed transparency and help reconciling policy objectives with actual R&D investments. The SG's 10-Member-Group of High-level Representatives estimates current governmental R&D funding to amount to US$200-300 billion per year, compared to total &D funding from all sources which reached US$2.5 trillion in 2022. Hence, the proposal implies roughly an additional US$20 billion to support the discovering of new science and tech solutions available to all countries for accelerating SDG progress.

<u>**Recommendation 1:**</u> **Governmental research funders across the world to boost spending on SDGs by 20% over the next two years (by 2025), complemented by other sources.**

***Collaborative, global sustainability science centre and training network***

In a world that has become increasingly divided by geopolitics, unequal wealth, and access to science and technology, a dedicated, neutral space is very much needed where sustainability researchers, engineers and innovators from developing and developed countries alike can come together on a more equal footing to jointly work out and test solutions for the global challenges the world faces. Researchers would have access to *fundamental research* infrastructures that would be out of reach for most countries on their own. The new centre would build on existing institutions but ensure access for researchers worldwide and could strengthen science communications and building trust in science. Hence, we propose the creation of a collaborative, global sustainability science centre and training network comprising a main hub and various spokes. Researchers would have access to tools and scientific communities to share their ideas and test them at scale (with public and private partners) – a model that is and/or has been long used by the EU, USA and Japan in other areas of concern.

Currently, the world spends about US$1 billion for the high-energy physics lab CERN – a wise investment which not only led to scientific advances but to many new technologies, including the creation of the World Wide Web which has transformed the world. A similar level of funding is suggested for the proposed centre to build the capabilities of current and future generations to jointly find solutions to the most pressing global challenges. Such investment will almost certainly lead to additional, unexpected technological benefits similar to CERN. Another relevant example to build on and to learn from is the International Institute for Applied Systems Analysis (IIASA) set-up in the early 1970s that allowed scientific cooperation across the cold-war geopolitical divides on global issues and projects of great relevance.

| |
|---|
| **Recommendation 2: US$1 billion per year for a collaborative, global sustainability science centre and training network that is based on existing institutions but crosses geopolitical divides** |

Technology demonstration projects of high-impact solutions in energy, food, climate, biodiversity, health, and sanitation are key. They will allow hands-on, technological learning in real-life conditions that brings in public and private research and engineering expertise, building the skills of a new generation of experts working together and bringing those skills back to their home countries replicating what has been learned. IPR issues would be managed in the same way as is current practice in existing programmes that follow this institutional model in the developed countries. Public and private funders alike would save significant amounts of money simply by working together on joint projects.

The centre could also play a main role in monitoring in real-time global progress on sustainable development, using the latest scientific insights and technologies for collection and analysis of a wide variety of data.

***Example commitments on health science and technology to be spearheaded by the centre***

Beyond demonstration projects, the proposal asks governments to commit to prioritizing investments in key programmatic areas and support each other in the implementation. For example, governments might want to prioritize investing in the first 1,000 days of a child's life particularly in the poorest settings within and between countries, by providing modern medical and nutritional support for all children before 2030, in line with the scientific evidence which highlights the outsized benefits of such programme. There are a number of best-known investment cases for the first 1000 days, such as the work of the Strong Foundation and a World Bank consortium. Another important example of a potential high-priority commitment would be to sharing of technologies and skills to solve the basic human rights issues of health, water, sanitation, quality education, and food security.

| |
|---|
| **Recommendation 5: Prioritizing investing in the first 1,000 days of a child's life particularly in the poorest settings within and between countries (providing modern medical and nutritional support for all children and their mothers before 2030)** |
| **Recommendation 6: Sharing of technologies and skills to solve the basic human rights issues of health, water, sanitation, quality education, and food security.** |

***Rationale for prioritizing the first 1,000 days of a child's life for social & economic benefit***

Investing in the first 1,000 days of a child's life, from conception to age two, is critical for social and economic benefits due to the period's maximum developmental plasticity, establishing the foundations of optimum health, growth, and neurodevelopment. Experiences during this time have long-term consequences for health, wellbeing, learning, and development, affecting public health problems and broader social issues such as criminality and economic participation. Economic analysis shows large societal benefits from investing in this crucial developmental period.

A holistic approach is necessary, focusing on the whole child and integrating policies, programs, and services aimed at the first thousand days and early childhood. This includes supporting better relationships between parents and antenatal care providers, ensuring a universal platform of support for parents, children, and families, and providing targeted support to those with greater or more complex needs. Strengthening community relationships, promoting safe, nurturing environments, and using evidence to inform policies and initiatives are also essential. Policymakers should conduct independent evaluations to assess implementation and outcomes, and long-term funding for effective services and programs is required.

Achieving these outcomes involves raising awareness of the first thousand days' importance, investing in environmental determinants of health and disease, improving and targeting services to the earliest stages of childhood and conception, and focusing on the most impactful interventions. Additionally, investing in research to map current investments and gauge their success is crucial for understanding what works and identifying innovative ideas for the future.

Stable and adequate housing has a significant impact on families and children, affecting health and wellbeing and enabling full participation in social, educational, economic, and community life. Physical environments have direct and indirect impacts on children's development. Negative home environments during the first thousand days are linked to developmental issues, including inferior language development, behavioral problems, insufficient school readiness, aggression, anxiety, depression, and impaired cognitive development. Long-term effects include decreased likelihood of high school graduation, increased likelihood of teen parenthood, adult unemployment, decreased income, and higher rates of poverty.

***Institutions and strategic approaches for greater STI cooperation and coordination***

Complementary commitments to greatly expanded system of international cooperation at multiple levels - among governments, private sector, and academic institutions - will be essential and could pool resources, share knowledge, and collaborate on high-impact initiatives. For example, it could include a commitment by governments to develop, support and fully implement national STI4SDG roadmaps in all interested countries and key regions or municipalities, as appropriate, and to systematically cooperate and support each other in this regard. Other commitments suggested to make international cooperation more effective, include, for example, supporting a network of banks of ideas, funds for innovation, and the ethical councils for innovation.

***Building Sustainable Innovation Systems: Bank of Ideas, Fund for Innovation, and Ethical Council for Innovation***

One of us developed a specific proposal for a UN-backed network of Banks of Ideas and innovation funds, led by autonomous ethical councils, to advance the Sustainable Development Goals (SDGs) by strategically supporting innovation ecosystems and providing long-term funding for creative ideas, research, development, and deployment.[54]

**Recommendation 3: Support a network of bank of ideas, funds for innovation, and the ethical councils for innovation**

A robust innovation ecosystem requires accessible and affordable electricity, internet, education, and technical skill development. Involving technology parks, universities, research centers, incubators, and entrepreneurs is crucial to promote creativity, diversity, sustainability, equity, and inclusion.

Innovation strategies should focus on communication, collaboration, learning, and adaptation within an interconnected ecosystem that emphasizes value creation and collaboration within a quadruple helix model (science, policy, industry, and society). Banks of Ideas should identify specific SDG-related problems and support innovation through standardized digital platforms with scalability, expert input, and access to best practices. They should provide services such as online digital registry, consultation expert registry, problem registry, mentorship, and project evaluation.

A massive, SDG-relevant database would provide insights into various innovation ecosystems. Criteria for registering ideas in the Bank of Ideas include SDG alignment, addressing real needs, sustainability, technical feasibility, profitability, collaboration potential, and market creation. The Bank should promote funding and ensure successful execution of ideas.

A Fund for Innovation could pool resources from governmental, charitable, and private sectors, administering national budgetary funds, multilateral financial programs, and dispersed private financial support. The Fund would attract national and international risk investors, providing seed capital to projects selected by the Bank in exchange for profit participation or company shares.

The Fund for Innovation could offer multi-purpose financial instruments in line with the objectives of the Banks of Ideas, promoting ideas and innovations compatible with the SDGs. Alternative financing schemes may include fintech industry, non-profit sector, and specialized funding sources. The goal is to give economic value to those who do not have it, generate incentives towards innovative ideas that lack market value, and invest financial resources in communities and individuals that are not economically viable.

The Bank of Ideas and the Fund for Innovation could make people financially viable and create value where there was none. By attracting and coordinating existing charities, the non-profit sector, national and international aid organizations, national development banks, and other public or private organizations' funds, the Fund for Innovation could effectively fund middle-low-income environments within the SDG framework.

[54] Building Ecosystems for Innovation towards the SDG, by José Ramón López-Portillo Romano (Q Element), https://sdgs.un.org/sites/default/files/2022-05/1.1.2-24-Portillo-Building%20Ecosystems%20for%20Innovation%20towards%20the%20SDGs.pdf

Collaborative schemes in binational/multinational contexts can be pursued, mapping complementary capacities and needs between countries. Possible structures for the Bank of Ideas and Fund for Innovation include public-private partnerships or private companies financed by national and international funds. An Ethical Council for Creative Ideas would ensure trustworthiness, transparency, and accountability in the innovation ecosystems for the SDGs.

The Bank of Ideas and Fund for Innovation would draw from private sector expertise to incubate, accelerate, and commercialize selected innovation projects. Public policies would be reoriented to offer strategic financial support for innovation, while markets for improved products and services would be developed. The Fund for Innovation would explore national and international financial support, adjusting its structure to be more receptive to economic development programs and social/environmental impact entrepreneurship. The risk-capital design would be channeled to support the innovation process.

***Developing and adopting national roadmaps for harnessing science, technology and innovation for the SDGs and sustainable development beyond 2030***

Roadmaps can be a powerful, strategic tool to provide a common direction for researchers, developers, government entities, private sector and civil society. Roadmaps create common future timelines and milestones on STI until 2030 and beyond. They aim for coherent actions among all parties involved at the intersection of development, STI and SDG plans.

We recommend that all UN Member States – developed and developing – consider developing and adopting national STI4SDG roadmaps based on broad stakeholder consultations, and to support their timely implementation through funding and partnerships at national and global levels. They should support and complement the Voluntary National Reviews presented by UN Member States at the HLPF each year, and they could be a good vehicle to mobilize scientific and technological expertise from across the world to where it is needed most.

**Recommendation 4: Develop, support and fully implement national STI4SDG roadmaps in all interested countries and key regions or municipalities, as appropriate.**

Since 2019, IATT has spearheaded a global pilot programme on STI4SDG roadmaps. A network of TFM multi-stakeholder partners has been supporting the elaboration of STI roadmaps and action plans for the SDGs. Partners have jointly developed technical guidebooks for sharing experience in the STI4SDG process. It has been supported by a “Partnership in Action”. STI4SDG Road maps are currently being developed in six pilot countries, namely, Ethiopia, Ghana, India, Kenya, Serbia and Ukraine. To date, more than 20 countries have expressed interest in joining the programme, but funding and staff commitments have been the major constraint. The programme was also included in the outcome doc of the G7 in Japan.

We recommend adequately resourcing and greatly expanding this one-UN, multi-stakeholder pilot programme, so that all interested countries and key regions or municipalities can develop and implement locally relevant and appropriate STI4SDG roadmaps. As exponential technologies progress and have increasingly rapid impacts, future-oriented scenarios and roadmaps will become increasingly important to anticipate rather than react to developments, some of which increasingly overwhelm the capabilities of traditional institutions. These scenarios should go beyond the current mainstream and consider the impacts of global shocks, such as future pandemics and disasters, as well as the full range of expected climate change impacts.

## b) Proposal B: Building the next generation Web 3.0 distributed system for all by 2027

The World Wide Web has transformed societies and economies like few other technologies since its creation in 1993. The first-generation Web 1.0 consisted primarily of static Web pages with limited interactivity and most users only accessed information but did not actively participate in or contribute content. The second-generation Web 2.0 shifted towards a much more dynamic, interactive and participatory Web, with social media, blogs, wikis, and other user-generated content. It led to the rise of online platforms, cloud computing and a handful of multinational tech companies that have been dominating the Web and its evolution. Ownership, expertise and access to the key tech infrastructures have become extremely concentrated among a handful of countries, corporations, universities, and individuals. In fact, more than 90% of the market capitalization of major digital platforms are in the USA and China alone. This concentration has led to discussions on competition, data governance, ownership and privacy, the spread of misinformation and political polarization. And even as impressive progress has been made in terms of closing the basic digital gap of access to the Internet and related services, many people and entire world regions have been excluded and left behind.

Today, we are again at the cusp of the emergence of the third generation Web 3.0. It aims to usher a more open, democratic, entrepreneurial Web and digital economy by replacing today's corporate mega-platforms with blockchain-based decentralized networks. The integration of advanced technologies would allow for better interactions between humans and machines, enabling new possibilities for automation, prediction, and decision-making. And minimum socio-economic, environmental (incl. GHG emissions) and ethical standards will be needed to ensure that these decentralized networks due not exacerbate other sustainability issues.

| **Proposal B for Leaders** |
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| **Governments commit to put in place policies, regulations, initiatives and funding to build the next generation Web 3.0 distributed system and make it work for all by 2027**<br>Governments to put in place all necessary policies, regulations, initiatives and funding to build and interconnect the next generation Web3.0 from the nascent existing pockets of Web 3.0, with a view to make it accessible and beneficial for all of humanity **(Recommendation 7)**. This could be a global solution a whole range of burning issues in digital cooperation, including digital ID, privacy, security, accessibility, data governance, and trust. It will aim to:<br>• *Make sure that data itself is not generally shared, but machines can query it*, e.g., through federated AI and attestations) to ensure privacy but break data silos in the age of emerging generative AI.<br>• *Transactions are secure, legally enforceable and auditable*, e.g., through distributed leger (blockchain), smart contracts and enabling law.<br>• *Fraud and cyberattacks should be difficult*, e.g., by supporting encryption distributed digital identity, and private data stores.<br><br>1. Support democratization of the Web, through data trusts and data cooperatives.<br>2. Capacity building for developing, using, and understanding the impacts of rapidly emerging Web 3.0 technologies<br>3. Create a collaborative, global, public-private UN school/centre on Web 3.0 and related tools – working across the geopolitical divides for the benefit of humanity – and commit to access to fundamental research infrastructures through the school / centre |

4. Promote effective international cooperation between governments, private sector, and academic institutions to pool resources, share knowledge, and collaborate on Web 3.0 projects.
5. Agree on minimum socio-economic, environmental (incl. GHG emissions) and ethical standards on the Web 3.0 and related data governance to achieve a truly just digital transformation.
6. Commit funding commensurate with the challenge.

Countries to put in place national policies to support and align national efforts with this effort at a scale commensurate with the pressing challenge.

The potential benefits of Web 3.0 are clear. It provides workable solutions to ensure privacy yet breaks down data silos. The idea is that people and machines/AI can query vast data stores without generally sharing the data, by using federated AI and attestation. It allows using data without actually handling them. The benefits of such approach are vast. For example, it would allow making vast stores of the current health data silos available for analysis leading to better medicines and better medical trials. It could also be a solution to massive privacy and potential IPR issues related to generative AI's use of vast stores of online data. Online transactions would be much more secure, legally enforceable and auditable, e.g., through distributed ledger (blockchain), smart contracts and enabling law. Also, online fraud and cyberattacks would become much more difficult, by supporting encryption distributed digital identity (digital ID), and private data stores. This could lead to anywhere between +3 to 13% in GDP by 2030, according to McKinsey.

Web 3.0 is nascent, even the majority of the current web still resembles Web 2.0. Today it exists in a few pockets that are being spearheaded by governments, the private sector, academia and civil society. Examples include the Swiss Trust Chain (SwissPost, SwissCom) and Akoya. A big push commitment from governments around the world to work together and with academia, private sector and civil society could go a long way in accelerating and bringing together these initiatives, making them consistent, and above all in supporting them in poorer countries and for serving poorer populations within all countries.

**Recommendation 7: Governments commit to put in place policies, regulations, initiatives and funding to build the next generation Web 3.0 distributed system and make it work for all by 2027**

Putting in place policies, regulations, initiatives, and funding to build Web3 and to make it work for all by 2027 appears a key imperative to avoid leaving billions of people and entire world regions even further behind. Now maybe a once in a lifetime opportunity to steer this technological revolution into a direction that will benefit all and above all put people back into charge of their own digital identities.

## c) Proposal C: Capacity building on generative AI for the SDGs

| **Proposal C for Leaders** |
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| **Generative Artificial Intelligence for the SDGs - securing a global commitment to rapidly build worldwide capacity for using, developing, and understanding the impacts of this rapidly emerging technology**<br>Build worldwide capacity for using, developing, and understanding the impacts of generative AI **(Recommendation 8)**. This initiative might include:<br>1. Create a collaborative, global, public-private UN school/centre on generative AI and related emerging tools – working across the geopolitical divides for the benefit of humanity<br>2. Promote effective international cooperation between governments, private sector, and academic institutions to pool resources, share knowledge, and collaborate on projects related to generative AI.<br>3. Commit significant governmental funds (as part of a commitment of national research funders to increase their funding for SDGs by 20%) complemented by other sources<br>4. Share access to relevant *fundamental research* technology infrastructures through the new UN school/centre<br>5. Agree on minimum socio-economic, environmental (incl. GHG emissions) and ethical standards on generative AI and related data governance to achieve a truly just digital transformation.<br><br>Countries to put in place national policies to support and align national efforts with this effort at a scale commensurate with the pressing challenge. |

Generative artificial intelligence (AI) has been a rapidly emerging new type of technology widely heralded as a "game-changer" that societies and industry need to be ready for and a big step towards generalized and human-level AI. Generative AI is trained on very large amounts of data and self-generates new content, such as images, text, video, computer code, music or art. OpenAI's chatgpt and DALL-E are just one of hundreds such tools. And many new applications and apps are emerging that build on this pioneering new tech infrastructure. It is an exciting new area that has the potential to revolutionize the science, technology, and entire economies and societies. And the current revolution is expected to just the first, necessary step towards generative AI generating its own code to continuously improve itself.

These technologies and their capabilities are progressing so rapidly that we have no time to lose. Timely action is needed now – hence the high priority for this "ask" for leaders. Just to give one example of the rapid exponential change, computational requirements for these successively new AI models are doubling every 2.5 months – a rate 10 times faster than at height of the ICT revolution, and chatGPT reached one million users within 5 days only. Decision-makers and institutions in developed and developing countries alike have a very hard time to even understand what is going on, let alone how to shape these developments, participate in and benefit from them. This ranges from schools, to companies, governments, from young people wondering about their future and workers wondering whether their jobs will soon be replaced, or businesses wondering how they can find ways to integrate these new tools to complementing human skill. For example, schools and universities even in the technologically advanced countries grapple with how to best respond and adapt their work and ensure that young people become shapers rather than only consumers of generative AI.

Furthermore, ownership, expertise and access to the key tech infrastructures are extremely concentrated among a handful of countries, corporations, universities, and individuals. More than 90% of the market capitalization of major digital platforms are in the USA and China alone. And despite hundreds of generative AI start-ups in the USA, China and Europe in 2022 alone show great promise, geopolitics and dual use issue increasingly limit global cooperation to harness this technology for the SDGs and humanity's big global challenges.

Only together could the world possibly address this challenge in a timely way, ensure that the number of people left behind will be limited to the extent possible, and make this technology contribute rather than derail the world's sustainable development aspirations.

**Recommendation 8: Build worldwide capacity for using, developing, and understanding the impacts of generative AI.**

A global commitment is thus needed to support access to infrastructure and capacity for developing, using, and understanding the impacts of generative AI and to make it work for our SDG aspirations. A collaborative, global, public-private UN school/centre on generative AI and related emerging tools which would work across the geopolitical and developmental divides for the benefit of humanity could prove a most effective response to these challenges. Such a centre could provide a wide range of capacity building and serve as entry point for researchers, users and innovators to gain access to relevant tech infrastructures which otherwise would remain outside of the reach of any one country or institution. The infrastructure would also support wider capacity building, including governmental decision-makers and regulators. The school/centre would facilitate international cooperation between governments, private sector, and academic institutions to pool resources, share knowledge, and collaborate on projects related to generative AI. It could also serve as platform for discussing minimum socio-economic, environmental and ethical standards on generative AI and related data governance to achieve a truly just digital transformation. UN Member States should commit significant public funds to this initiative which would be complemented by other sources. Funds could be secured as part of a wider commitment of national research funders to increase their funding for SDGs by 20% (see related "ask" on sustainability science and technology). Countries to put in place national policies to support and align national efforts with this effort at a scale commensurate with the pressing challenge.

## d) Proposal D: One-UN programme on digitalization in support of developing countries

| **Proposal D for Leaders** |
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| **Create a One-UN programme on digitalization for developing countries (Recommendation 9)**<br><br>The programme would include the following tracks:<br>1. Democratic global digital cooperation and principles development;<br>2. Innovation and development;<br>3. Technical and policy capabilities for future-ready innovation ecosystems; and<br>4. Integration with the Technology Bank for LDCs. |

In order to democratize STI and its benefits for public and social value, we believe that a dedicated home is needed in the UN to develop and refine appropriate norms, policies and pilots; promote future-ready human capabilities; and mobilize financing for public innovation ecosystems. Such an institutional home in the form of a one-UN joint programme - that fully builds on existing UN system work and expertise -

could give important impetus to a digital transformation pathway for a sustainable, just and equal future. It could aim for the following targets:

- Public innovation infrastructure in developing countries doubled by 2030;
- 50% value from the digital economy accrues to the bottom 50% nationally and globally by 2030;
- Data and digital commons nationally and globally have appropriate guardrails; and market dynamics in the digital economy and society are in alignment with a bold vision for our common futures.

**Recommendation 9: Create a One-UN programme on digitalisation and sustainability in support of developing countries.**

The programme would work on the following tracks.

*Track on democratic global digital cooperation and principles development:* While generative AI has caught everyone's imagination, we need to explore how digital intelligence and data models stand the test of abiding social and institutional ethics. Today, the AI paradigm reinforces geo-political and geoeconomic fault lines. Its trajectory is based on an undermining of next-generation jobs in the global South. An invisible army of youth from developing countries perform painstaking, low paid work for AI value chains (in annotation, content moderation, testing, (clickfarms) etc). It is unclear how such AI can be truly regenerative for the global South without efforts to preserve and strengthen local knowledge and local economic capacity/local pockets of entrepreneurship and innovation. We need an ethical, and transformative framework for generative AI that is not extractive, exploitative, centralised or corporatised, but embodying values of a humane and transformative paradigm based on democratic and distributive integrity. The Global Digital Compact is likely to flag the need for a rights-enabling data and AI framework. This track on principles and democratic cooperation can undertake research for policy development with contributions from a range of actors across the world and come up with flagship reports.

*Track on innovation and development*: A dedicated, multilateral hub - linked to regional and national nodes and mechanisms – where frontier tech and sustainability science researchers and innovators from developing and developed countries can come together on equal footing to jointly work out and test solutions for the global challenges the world faces.

*Track on Technical and Policy capabilities for future-ready innovation ecosystems:* For any programme to produce robust public digital innovation ecosystems in the global South, policy support is essential. This track can work closely with UNCTAD on issues such as digitalization and intellectual property. For e.g. UNCTAD has recommended free online access to information on patent-free technologies that are readily available for firms in developing countries. Training policy makers on an ongoing basis is crucial. Regenerative tech innovation also depends on capacity building programmes that go beyond typically assimilating young people in exploitative AI value chains towards creating local human capabilities and infrastructures.

*Track integrated with the Technology Bank for LDCs*: There are lessons to be learned from the shortcomings of the Technology Access Programme of the Technology Bank for LDCs.[55] Without a dedicated line of financing and secretarial support to policymakers in developing countries, national roadmaps for local AI infrastructural development cannot take off. To overturn the status quo in the AI

[55] https://www.southcentre.int/wp-content/uploads/2021/05/SouthViews-Gombe.pdf

international political economy that condemns much of the population of the global South to remain 'AI laggards', public financing mechanisms are vital. The financing track for innovation and frontier tech and science can give impetus to the technology bank.

## e) Proposal E: CDR Fund and market creation

We propose the creation of a global CDR fund to facilitate the sustainable deployment of carbon dioxide removal technology options.

| **Proposal E for Leaders** |
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| **Create a global carbon dioxide removal (CDR) fund to facilitate the sustainable deployment of CDR technology options (Recommendation 10)**<br><br>1. Fund CDR research and demonstration projects and share their lessons worldwide<br>2. Create coherent and consistent international rules for CDR deployment assuring the sustainability and permanence of the sequestration and storage activities. This should consider questions of environmental justice and mitigation of biodiversity loss.<br>3. Provide financial incentive for RD&D for CDR at the required scale<br>4. Create a CDR market that is not competing (or crowding out) emissions mitigation. |

IPCC reports show that carbon dioxide removal from the atmosphere (CDR) is necessary in order to achieve net zero $CO_2$ emissions and to halt climate change. Many of the CDR options are in early demonstration stages and still require research and up-front investments to achieve proof of concept at large scale. While some countries and philanthropic funders are moving ahead with local-scale implementation, there is only little attention on legal aspects, including certified methods of measuring, monitoring, verification, and reporting.

A globally coordinated fund for CDR research and demonstration projects are needed in order to establish: (a) coherent and consistent international rules for CDR deployment assuring the sustainability and permanence of the sequestration and storage activities; (b) the required financial incentive for RD&D (research, development, and deployment) for CDR at the scale that it is needed ; and (c) a CDR market that is not competing (or crowding out) mitigation activities at the national level to reduce emissions.

The fund could be financed by countries that have contributed to the burden of $CO_2$ in the atmosphere, and thus have the obligation to remove the part of the pollution that they have caused. Allocation of funds by different countries to the overall budget could be thus proportional to the $CO_2$ in the atmosphere that each country has contributed to. A global auctioning system (or similar) system could incentivize projects all over the world (including in developing countries, where the potential for CDR is significant). These should also include consideration of environmental justice and mitigation of biodiversity loss.

## f) Proposal F: Funding global public goods

The proposal implies a new social contract and is based on the principle of “all contribute, all participate, all benefit”. It aims for an international target commitment to dedicate 0.2% of gross national income to secure global public goods and make them accessible worldwide. The proposal builds on the current (unfulfilled) international commitment for rich countries to commit 0.7% of their GNI to ODA. The proposal is essentially an endorsement of the findings of the Expert Working Group on Global Public Investment.

| Proposal F for Leaders |
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| **Boost global public investment in global public goods to reach (0.2% of GNI)**<br><br>We suggest the target of 0.2% of GNI for public investment in global public goods and implementation of the recommendations of the Expert Working Group on Global Public Investment (GPI): "Building a better system: Making Global Public Investment a reality" of July 2022 **(Recommendation 11)**, including:<br>1. Adopt GPI principles into all new and existing global funds and initiatives. Put them at the core of global health financing.<br>2. Establish GPI budget lines in government spending plans, including in efforts to reinvigorate climate finance. Evolve Regional Public Investment mechanisms to complement GPI<br>3. Build an inclusive GPI Network to enable cocreation.<br>4. Link to other global, regional and national campaigns, especially on inequality. Engage in major UN (and other) processes on the road to 2030. |

***The Present International Public Finance System***

International public finance has a critical role to play in advancing towards Global Public Goods (GPG) and financing the SDGs. Nonetheless, the international community is increasingly struggling to finance global strategies that help generate those goods and goals, and to induce all countries and their populations to have equitable access to them. Most current structures and approaches are unsustainable, inefficient, insufficient, patronizing and unidirectional (from the global North to the global South). They confront measurement challenges, scale of need and governance issues related to global problems or crises (e.g. climate change and the Covid-19 pandemic).

In the current environment, profits are concentrated in a few countries and corporations (as we could learn from the Covid-19 pandemic), while inclusive and sustainable impact investment is not. In large part, this is due to the process of increasing financialisation that is overwhelming the world (more than US$5 trillion has been allocated to the buyback of shares of large companies and banks during the last decade: most of the private funds available are allocated to finance, insurance or real estate and not to productive, inclusive and sustainable activities).

Governments have many tools – dynamic procurement methods, grants, loans and regulations – to drive investment aligned with strategically important objectives and to ensure that business profits are reinvested in socially and environmentally beneficial ways. This is the case with the recent excess profits of fossil fuel-based companies resulting from the war in Ukraine. Many have justly claimed that these profits should be taxed and subsidies to the fossil fuel industry eliminated.

More generally, many argue that global challenges and emergencies should receive part of funds like these, as part of a new international public finance system. Until decision-making power is more representative, decisions will continue to be made that favour a small number of countries over broader global interests.

***A New Proposal: Global Public Investment (GPI)***

For some time, a multi-disciplinary group of experts and practitioners have been developing the concept of Global Public Investment (GPI) through global multi-sector consultations that have included United Nations agencies.[56] They concluded that we need a long-term representative decision-making system where all contribute and all benefit. We need a new system that offers reliable access to and use of international public money, in order to invest in what is required to achieve the SDGs and to tackle global challenges like inequality and climate change. Any new approach must ensure that the efforts, risks and rewards associated with it are socialized.

In recent years the concept of Global Public Investment (GPI) has emerged as a proposal and a formula to address the fight against global challenges and crises.[57] GPI is not an income redistribution scheme, or another form of on-going international public finance managed, for the most part, through existing fiscal organisations. Instead of donor-recipient and replenishment-based approaches, GPI proposes universal contributions from all countries, under a fair and equitable sharing agreement, according to geography and problem; the sharing and co-responsibility in the decision-making process and the equitable and meaningful sharing of the benefits achieved. In contrast with aid systems and cumbersome country-level contributions, GPI incentives are the main driver, while sanctions help deal with non-compliance issues.

GPI seeks to overcome the problems faced in international governance derived from inequitable country and sectorial representation by ensuring a more representative decision-making procedure that includes all stakeholders. It is a new approach to diversify decision-making and create mutual accountability for how international public finance is mobilised and allocated for sustainable development. Everyone is involved in decision-making under equal governance on policy prioritization and with citizen participation. This includes physical infrastructure; capital goods; common normativity/regulation schemes; strategic investments in research and development; training and skill building; creation of a legitimate governance schemes for the allocation of common funds.

GPI facilitates the generation of Global and Regional Public Goods that take into account the particular characteristics and needs of each region and nation. Growing global challenges and emergencies call for a new sustainability agreement, emphasizing both the issues agreed upon in multiple international and regional instances, as well as country-specific sustainability issues. All countries benefit from GPI, but the poorest countries receive the most support. It is a more appropriate means of allocating international public finance, prioritising the poorest people, wherever they are, fighting against inequality and discrimination in all its definitions, and fomenting sustainability in all its forms (environmental, economic and social).

In sum, GPI means a new social contract where "*all contribute, all decide and all benefit*".[58]

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[56] Expert Working Group on Global Public Investment: "Building a better system: Making Global Public Investment a reality, July 2022; see also https://globalpublicinvestment.net/what-is-gpi/

[57] For example, as a means to execute an effective production and distribution of vaccines against Covid-19

[58] Global Public Investment Network: "Global Public Investment: A Transformation in International Cooperation", 2021 (https://globalpublicinvestment.net/what-is-gpi/)

### *Global Public Investment and "Cocreation"*[59]

The international finance system needs to "cocreate" a better definition of the problems that it seeks to address and the principles that it sets out as a solution. It must take advantage of the experience, knowledge and legitimacy of all stakeholders, by building an interconnected and equitable decision-making system in the collection and application of contributions. This GPI network can better reflect the interests and peculiarities of all countries and of the relevant stakeholders. It can make it easier to work out the technical details and trigger processes to build political support by making the respective benefits more obvious to everyone.

According to the expert group that has developed the idea of GPI, "Co-creation is at the heart of the GPI approach and must remain central as we continue to build the concept."[60] It requires co-designing, consulting, co-creating, co-producing, and cooperating to build a solution that all participants can accept and co-validate, as a result of their design intent, process ownership, and outcome value.

GPI needs to be global, with all countries contributing, deciding and benefiting.[61] It must respond to the public will and therefore be built with public money, while being supported by private resources, in order to generate Global Public Goods and to maximise social and economic benefits. The experts group propose that a more adequate allocation of public finances and private contributions would better respond to the SDGs. It would also allow for greater transparency, accountability, collaboration, evaluation-validation, effective representation of countries and sectors, and active participation of civil society.

Global Public Goods could be better achieved through the GPI network. Some existing examples of common funds can help as guidelines. The EU has shown how political cooperation can lead to the coherent and effective management of interregional financial resources in order to achieve regional public goals and interests, like reducing inequality. The poorer EU countries contribute the same proportion of their national income as richer countries, but in return receive a larger share of the common pool and an equal share of resource allocation.

### *Advantages of a GPI Network*

The GPI network would introduce important advantages for achieving the SDGs and deliver Global Public Goods through a public-interest mechanism. It can become a more effective and equitable way to prioritise international objectives, revitalise multilateralism and generate an empowering new narrative of what is important for the greater good of humanity. It has the potential to bring additional (grant) finance; more sustainable and intentional/strategic financing; greater co-investments over a longer period of time; higher quality investments when all stakeholders are fully involved in managing it.

The GPI can generate regional infrastructures to address issues like cross-border problems.[62] This can, over time, contribute to convergence between countries and the creation of more efficient cross-border

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[59] Expert Working Group on Global Public Investment: "Cocreation and Consultation for Global Public Investment, Best Practices and Principles", Equal International / Queen Mary University of London (Global Policy Institute), July-November 2021

[60] Expert Working Group on Global Public Investment: "Building a better system: Making Global Public Investment a reality, July 2022; see also https://globalpublicinvestment.net/what-is-gpi/

[61] ibid, "Global Public Investment is firmly based on the human rights principle that every human being must have a say in decisions that affect their lives, and that governments have a duty to meet the needs of all people, without any discrimination.", p. 11.

[62] For example, tracking migratory flows, legal and illegal products, capital; create digital identities preparation and mitigation of risk of natural disasters, attention to health emergencies; defense of human rights; facilitating the energy transition and combating climate change.

markets. GPI can prioritise and incentivise areas for public and private investment and become an agent for shaping and scaling the market that fosters the growth of companies.

An important advantage of GPI is that everyone benefits from the results achieved (although not necessarily in the same way, since national needs will always be partly aligned and partly differentiated), while generating incentives for an equitable economic development through the principle of economic 'convergence'. GPI enables cooperation in a way that harnesses the capacity of the largest and most powerful players, but incorporates the contributions that smaller countries can make, often through their particular comparative advantages in a participative and equitable decision-making process.

***Recommendations by the Expert Working Group include:***

“1. Adopt GPI principles into all new and existing global funds and initiatives

2. Establish GPI budget lines in government spending plans

3. Establish GPI principles at the core of global health financing

4. Incorporate GPI into efforts to reinvigorate climate finance

5. Evolve Regional Public Investment mechanisms to complement GPI

6. Link to other global, regional and national campaigns, especially on inequality

7. Build an inclusive GPI Network to enable cocreation

8. Engage in major UN (and other) processes on the road to 2030”[63]

## 4. Conclusion

We appreciate the UN Secretary General’s trust in us as high-level representatives of scientific community, private sector and civil society. We hope that our assessment, future vision and specific proposals and recommendations will be of interest and considered seriously. Rest assured that even after the end of our present term, we stand ready to further explain, support and engage with any of our suggested initiatives. Indeed, we have learned that most of the members of previous 10-Member-Groups remain active and engaged in the TFM and related UN discussions. They have mobilised thousands of scientific and engineering stakeholders for the UN and facilitated direct access to highly specialized expertise. As we transition to this eminent “alumni-group” of 10-Members, we would encourage the UN to formalise the role of this alumni group. Last but not least, we would like thank the UN Secretariat and in particular the Secretary to our Group, Mr. Roehrl, for his support and guidance.

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[63] Expert Working Group on Global Public Investment: "Building a better system: Making Global Public Investment a reality, July 2022, p. 4

## Annex 1: Our eleven recommendations in more detail

Our proposals and recommendations are at various stages of development, with some of rather advanced in a form that is ready for implementation. The Group is still working on outlining all our eleven recommendations in full details. This Annex will be appended at a later stage.

## Annex 2: Bios of the 10-Member-Group 2021-2023

**Ms. Cherry Murray [Co-chair] (USA), Professor of Physics and Deputy Director for Research, Biosphere 2, University of Arizona**

Cherry Murray, Professor of Physics at the University of Arizona, is Deputy Director of Research at Biosphere2 focusing on environment, water, food, energy, and sustainable development. She obtained B.S. and Ph.D., degrees in physics from the Massachusetts Institute of Technology. Her research interests evolved from experimental condensed matter and surface physics to nanotechnology, innovation, R&D of telecommunications networks, to science, technology, national security and energy policy, science diplomacy and global sustainable development. From 1978 to 2004, Murray held a number of research and executive positions at Bell Laboratories, eventually becoming Senior Vice President for Physical Sciences and Wireless Research. She then served at Lawrence Livermore National Laboratory as Deputy Director and Principal Associate Director for Science and Technology from 2004 to 2009. She was dean of Harvard University's School of Engineering and Applied Sciences from 2009 until 2014. Murray served as the Director of the US Department of Energy Office of Science, from 2015 until 2017, overseeing $6 billion in competitive scientific research as well as the management of 10 national laboratories. She then became Benjamin Peirce Professor of Technology and Public Policy and Professor of Physics at Harvard until her retirement in 2019. A member of the National Academy of Sciences, the National Academy of Engineering, and the American Academy of Arts and Sciences, and treasurer and past co-chair of the InterAcademy Partnership, Murray has received the US National Medal of Technology and Innovation as well as the American Physical Society Maria Goeppert-Mayer Award and George E. Pake Prize.

**Ms. Quarraisha Abdool Karim [Co-Chair], an infectious diseases epidemiologist, Associate Scientific Director of CAPRISA; Professor in Clinical Epidemiology, Columbia University, New York, Pro-Vice Chancellor for African Health, University of KwaZulu-Natal, South Africa, President of The World Academy of Sciences and UNAIDS Special Ambassador for Adolescents and HIV.**

Her research has focused on the evolving HIV epidemic, preventing HIV infection in young women, and deaths in HIV-TB co-infected patients and more recently on Covid-19. Abdool Karim has over 300 peer reviewed publications; edited several books and contributed to several book chapters and has played a central role in building the science base in southern Africa through the Columbia University - Southern African Fogarty AIDS International Training and Research Programme. She holds Fellowships at The World Academy of Science, the Royal Society of South Africa, the Academy of Science of South Africa and the African Academy of Science and is a member of the USA National Academy of Medicine. Her contributions has been recognized by more than 40 local and international prestigious awards including: the African Union's Kwame Nkrumah Prize for Science and Technology; the TWAS-Lenovo Prize from The World Academy of Sciences (TWAS); the ASSAf Science-for-Society Gold Medal; the South African Medical Research Council Gold Medal; the L'Oréal-UNESCO Women in Science Laureate award for Africa and the Arab States; the Christophe Merieux Award from the French Academies of Medicine and the John Dirks-Canadian Gairdner Global Public Health Laureate Award. She is a member of the WHO Alliance for Sexual and Reproductive Health; and Scientific Advisory Board of the United States President's Emergency Plan for AIDS Relief (PEPFAR); co-chair of the UN SDG Technology Facilitation Mechanism and co-chair to the UNAIDS Executive Director's Advisory Board. She is a Living Legend for the City of Durban and has been inducted to the Order of Mapungubwe (the highest citizen recognition bestowed by the State President of South Africa).


**Mr. Carlos Henrique de Brito Cruz (Brazil), Member of the Brazilian Academy of Sciences, Senior Vice President (Elsevier), and Professor Emeritus; Elsevier Research Networks; Physics Institute, University of Campinas**

Brito Cruz is a Professor Emeritus at the University of Campinas (Unicamp), Brazil, and a Senior Vice-President, Research Networks at Elsevier, UK.

He has been as a Professor at the Physics Institute, Unicamp, Brazil, directed the Physics Institute, and was the VP Research at Unicamp. He worked as a scientist at AT&T Bell Laboratories, at the Université Pierre et Marie Curie, and at the University of Rome La Sapienza. He served as the President of the São Paulo Research Foundation, FAPESP and the President of Unicamp. From 2005 to 2020 he has been the Science Director at FAPESP. He presided the Council for Technology and Competitiveness at the Federation of Industries of the State of São Paulo (FIESP), has been a member of industrial advisory boards, as well as high-level academic committees and boards. He is a member of the Council of the United Nations University and of the judging panel for the Queen Elizabeth Prize for Engineering.

Brito Cruz is a member of the Brazilian Academy of Sciences (ABC), the Academy of Sciences of the State of São Paulo (ACIESP), the World Academy of Sciences (TWAS), and is a Fellow of the American Association for the Advancement of Science (AAAS), and of the American Physical Society. He received the Order of Scientific Merit (Brazil), the Ordre des Palmes Académiques (France), and the Order of the British Empire (OBE).

**Ms. Maki Kawai (Japan), President, National Institutes of Natural Sciences, Japan**

Ms. Maki Kawai (Japan) is the President of the National Institutes of Natural Sciences in Japan. Previously, she serves as the Director General, Institute for Molecular Science, Professor Emeritus, The University of Tokyo Prof. Maki Kawai is the Director-General of the Institute for Molecular Science and Professor Emeritus of the University of Tokyo. She has been serving as a member of the Japanese government's committee on science & technology policy planning, and contributed to the drafting of a model plan for intellectual property strategy (2003-2007), as well as for a new system for education as a member of the Prime Minister's Education Rebuilding Implementation Council (2013- 2021). As a scientist, she has been working on interdisciplinary research in the fields of surface science, physical chemistry, condensed matter physics, materials science and nanoscience. Her research has been highly evaluated by many academic societies, and she has been the recipient of various awards, including the Chemical Society of Japan (CSJ) Award (2008), the Gerhard Ertl Lecture Award from the Fritz-Haber Institute of the Max Plank Society (2015), the Medard W. Welch Award of AVS, U.S.A (2016), and the L'Oreal-UNESCO Women in Science Award (2019). In addition to her fundamental scientific research, she is a widely respected leader in scientific management. This activity, involving science in the USA, Germany, the United Kingdom, and Japan, has made her a highly valued member of the international scientific community, culminating with her former position as the RIKEN Executive Director in charge of research affairs (2010-2015) and former president of the Chemical Society of Japan (2019-2020). She is Fellow of the American Physical Society, and Honorary Fellow of the Royal Society of Chemistry.

**Mr. Keywan Riahi (Austria), Director, Energy, Climate and Environment Program (ECE), International Institute for Applied Systems Analysis (IIASA)**

Keywan Riahi is the Director of the Energy Program at the International Institute for Applied Systems Analysis (IIASA). He is lecturing as a Visiting Professor of Energy Systems Analysis at the Graz University of Technology and has recently also joined the Payne Institute of the Colorado School of Mines as a Fellow and serves as an External Faculty Member at the Institute for Advanced Study (IAS) at the University of Amsterdam. In 2021, Mr Riahi was appointed to the 10-Member Group by the United Nations Secretary-General Guterres to advise on Science, Technology and Innovation for the implementation of the Agenda 2030. Mr Riahi ranks first in the recent list of 1000 most influential climate scientists by Reuters and has been selected as Highly Cited Researcher worldwide by the Web of Science/Clarivate Analytics (2016-2020). In 2015 he also received the IAMC award for extraordinary contributions to the field of integrated assessment modelling. His publications receive more than 10.00

**Mr. José Ramón López-Portillo Romano, Chairman, Q Element Ltd.**

Mr. José Ramón López-Portillo Romano is an academic, entrepreneur, diplomat, consultant and public servant of Mexico. Economist of origin, he has a DPhil (Ph.D.) in Political Science from the University of Oxford, where he cofounded and coordinated the Center for Mexican Studies. He was Undersecretary of State in México, Permanent Representative and independent Chairman of Council of the FAO. His multifaceted professional experience allows him to address the problems of the socioeconomic impact of accelerating scientific-technological change from different angles. He has written articles and a book, and advices the Mexican Government about science and innovation diplomacy. He has cofounded and chairs several think- and action-tanks, like Q Element. He was nominated by the Secretary General member of the 10-Member Group for the TFM.

**Ms. Anita Gurumurthy (India), Founding member and Executive Director, IT for Change, Bangalore**

Anita Gurumurthy is a founding member and executive director of IT for Change (ITfC) where she leads research on the platform economy, data and AI governance, democracy in the digital age and feminist frameworks on digital justice. Anita actively engages in national and international advocacy on digital rights and contributes regularly to academic and media spaces. She serves as advisor on various bodies including Save the Children's ICT4D Brain Trust, Minderoo Tech & Policy Lab 's Board, and the United Nations Secretary-General's 10-Member Group in support of the Technology Facilitation Mechanism (TFM).
Anita leads a range of research projects: Unskewing the Data Value Chain, a policy research project for equitable platform economies; Centering Women in India's Digitalizing Economy, a policy research and learning exchange project spanning India, Africa and the EU on women and the future of work; Recognise-Resist-Remedy, a project to address gender-based hate speech in the online public sphere.
She also contributes to policy forums and academic spaces: She was Part of the expert group set up by UN Women towards CSW 64. She contributes regularly to policy related processes in global policy arenas, such as the WTO Public Forum, UN Human Rights Council, UN-CEDAW, UN-CSW UNCTAD, UN Women, UNESCO and other venues, and the work of Special Rapporteurs of the UN. She Has represented civil society positions in global events on many occasions including the UN Internet Governance Forum (plenary session on cybersecurity at IGF 2017, opening session and main session on human rights and the Internet at IGF 2016 and closing session at IGF 2008). She was invited to deliver a keynote at the B'AI Global Forum launch event at the University of Tokyo in March 2021. She was plenary speaker at the IAMCR's 2020 conference (online). Also spoke at IAMCR main plenaries - 2016 conference in Leicester, UK, and 2014 conference in Hyderabad, India. She has contributed to global civil society discussions on the post-Covid digital context including at the Women's Working Group on Financing for Development; the Transnational Institute's webinar series 'Taking on the Tech Titans', and FES' discussions on Gender and the Digital Economy in Asia. Lastly, she was a Keynote speaker at the AAAI/ACM conference on Artificial Intelligence, Ethics and Society in February 2020.

**Mr. Tālis Juhna (Latvia), Vice-Rector for Research and Professor; Chairman of Advisory Board of the Latvian Council of Science, Riga Technical University**

Talis Juhna is the professor and vice-rector for research at Riga Technical University (RTU). He has more than 15 years' experience in science and innovation management both at the university and the national level. He has introduced the technology transfer strategy that allowed RTU to become an innovative university in the region. He has received Ph.D. in Environmental Engineering with a focus on water and wastewater biology and has established the Water and Biotechnology laboratory at RTU in 2002. He is the director of the study program in Biotechnology and Bioengineering. His research is focusing on the application of biotechnologies in drinking water, wastewater systems and renewable energy production. Juhna has received several awards including a full member of the Latvian Academy of Sciences. He represents the expert group of engineering sciences at the Latvian Council of Science where he also serves as the Chairman of the Advisory Board. Juhna is involved in several research boards in industry-academia clusters including climate technologies, biotechnology, and material science. He is a board member of Riga Water Company and co-founder of a high-tech biotech start-up.

**Dr. Yonglong Lu (China), Chair Professor of Xiamen University and Dean of College of the Environment and Ecology, and Distinguished Professor of the Chinese Academy of Sciences (CAS).**

Dr. Lu is an elected Fellow of TWAS (The World Academy of Sciences); a foreign member of Academia Europaea (AE), a foreign member of Russian Academy of Science; a Fellow of International Science Council; UN 10-Member Group Technology Facilitation Mechanism for the SDGs; past President of Scientific Committee on Problems of the Environment (SCOPE); President of Pacific Science Association (PSA); Member of International Resource Panel, United Nations Environment Program (UNEP/IRP); Science Advisor of International Union for Conservation of Nature (IUCN); former member of Committee on Scientific Planning and Review, International Council for Sciences (ICSU/CSPR); Vice President of Ecological Society of China; Chair of Committee on Ecology and Environmental Sciences, Chinese Society for Sustainable Development. He used to be Director General for CAS International Cooperation (2007-2012), and Deputy Director General for CAS Comprehensive Planning (2001-2007). He was an international review panelist for both Future Earth and UN Sustainable Development Goals (SDGs).

As an active sustainability and environmental ecologist, he has published 360 papers in peer reviewed journals such as Science, Nature, Science Advances, PNAS, Nature Sustainability, Nature Comm., and authored or co-authored 17 books. He is a highly cited scientist in the field of ecology and environmental sciences. He is the founding Editor-in-Chief of Ecosystem Health and Sustainability - a Science partner journal, an Associate Editor of Science Advances, the founder and Associate Editor of Environmental Development, Associate Editor of Acta Ecologica Sinica, and other peer-reviewed journals.

He has obtained various awards and honors from the State Council of China, Chinese Academy of Sciences and other national or international organizations, including the 2nd Prize of National Award for Advancement of Science and Technology, 1st Prize in Science and Technology for Promoting Development by the Chinese Academy of Sciences, 2nd Prize and 3rd Prize for Advancement of Science and Technology by the Chinese Academy of Sciences, National Outstanding Young and Middle-aged Scientist, Green Design International Contribution Award, SCOPE Distinguished Achievement Award, and Scientific Chinese 2019 Outstanding Contribution Award**.**

**Ms. Salome Guchu (Kenya), Principal Innovation and Outreach Officer, Inter-University Council for East Africa (IUCEA)**

Dr. Salome Guchu is a Principal Innovation and Outreach Officer, Inter-University Council for East Africa (IUCEA). She previously was Deputy Director of Research at the State Department of University Education and Research, Ministry of Education, in Kenya. She is responsible for developing, coordinating, and implementing programmes that support and strengthen the national research and innovation ecosystem.

For four years (2016-2020) Salome built the Kenya National Innovation Agency (KeNIA) as its first CEO by spearheading its operations, developing capacity and support for commercializing innovation and implementing key programmes for nurturing Kenyan innovators. She negotiated and implemented international collaborative initiatives, implemented Global Innovation Policy Accelerator programme for Kenya, and drafted a framework for national innovation policy. In her leadership capacity at KeNIA, Salome served as a Board member of National Research Fund and National Commission for Science, Technology and Innovation. Prior to that she was part of a team that carried out and produced the first reports for national innovation survey and national research & development survey. She also served as the national contact desk person handling regional Science, Technology, and Innovation (STI) programmes.

Salome holds a PhD in Chemistry from the University of Nairobi. She has also pursued professional development programmes on STI policy development and management, strategic leadership, corporate governance, amongst others. She is keen on making effective contributions to the STI sector by enhancing productive STI collaborations at local and international levels.

When not addressing matters related to research and innovation, Salome likes to spend time in schools mentoring and encouraging youth, especially girls, not to shy away from pursuing science, technology, engineering and mathematics (STEM) careers.