SCIENCE, TECHNOLOGY, INNOVATION, AND DIPLOMACY FOR SUSTAINABLE DEVELOPMENT: SUCCESSES AND CHALLENGES

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Abstract

Science diplomacy and international scientific engagement are essential for rapidly advancing scientific knowledge and mobilizing science, technology, and innovation to make progress on the seventeen Sustainable Development Goals of the UN2030 Agenda. The new era of competition and conflict of the 2020s has created great uncertainty about the future, but science diplomacy can help if humanity is to regain the will to create a sustainable world for the benefit of all people and the planet.

Keywords

Sustainable, Development, Science, Technology, Diplomacy

Sustainable Development

Sustainable development grew in popular usage with the environmental movement in the 1970s. It was often associated with concern about environmental degradation with concepts like "limits to growth" and "tragedy of the commons" (Meadows et al., 1972; Hardin, 1968). The most widely used definition came from the 1987 United Nations report *Our Common Future*, colloquially known as the Brundtland report: "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The report emphasized three components of sustainable development: environmental protection, economic growth, and social equity.

In 1992, the United Nations Conference on Environment and Development in Rio de Janeiro, the Earth Summit, promoted sustainable development with its Rio Declaration of Principles as a guide for countries (United Nations, 1992). The Earth Summit also led to the Climate Change Convention and opened for signature the Convention for Biological Diversity. Eight years later in the year 2000, all member states of the UN agreed on the Millennium Development Goals for making progress over fifteen years to help developing countries (United Nations, n.d.). The eight goals with their targets focused on eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality; improving maternal health; combating HIV/AIDS and other diseases; ensuring environmental sustainability; and building new partnerships for development. Progress on many of these goals occurred over the following decade but much more remained to be done when the member states began negotiations on what new goals might follow.

In September of 2015, one hundred and ninety-three member states adopted seventeen Sustainable Development Goals (SDGs) as the key elements of what would become the UN 2030 agenda (UN-SDGs, n.d.). The goals encompassed a broad social, economic, environmental agenda serving the five P's: PEOPLE (no poverty, zero hunger, good health and well-being, quality education, gender equality); PROSPERITY (clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation, and infrastructure, reduced inequalities); PLANET (sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land); PEACE (peace, justice, and accountable institutions); and PARTNERSHIPS. Several advanced countries, including the United States, advocated for a small number of goals saying too many would lead to no priorities. Their concern may have been motivated in part to avoid more financial aid demanded by developing countries. The large number of goals, however, prevailed. As one observer from the business sector said, the seventeen SDGs approved by the UN in 2015 should be seen as a significant gift to humanity, similar to what can be said about the Universal Declaration of Human Rights proclaimed by the UN in 1948 (Bakker, 2016).

The SDGs are an aspirational, practical, and political definition of sustainable development applying to all countries. The goals have longevity to 2030, and they reflect value judgments made specific with 169 targets and 248 indicators for gauging

progress. They aim to advance all the SDGs together by maximizing synergies and minimizing tradeoffs. They call for "no one to be left behind" and for mobilizing stakeholder engagement. The sixteenth goal focuses on peace, justice, and accountable institutions and the seventeenth on partnerships, but there is no goal for democratic governance.

While I was serving as the Science and Technology Adviser to the U.S. Secretary of State (2011-14) during much of the period when the SDGs were being negotiated, I was not directly involved in the negotiations. However, I was contacted by professional staff at the UN to be involved in expert meetings regarding the role of science, technology, and innovation (STI) for sustainable development. They had been directed to investigate this topic because it had become likely that the UN 2030 Agenda would contain a component focused on STI for the SDGs. The real reason I was asked was because they had read a report from the U.S. National Academies of Sciences, Engineering, and Medicine entitled *Our Common Journey: A Transition Toward Sustainability* (The National Research Council, 1999). It was produced in 1999 when I was executive officer of the National Academy of Sciences. The title was a play on words of *Our Common Future* to indicate that achieving a more sustainable world would be a journey. Recognizing that science, technology, and innovation must have an important role, the report emphasized creating a partnership between scientific communities and societies that would engender a journey of learning and doing, adaptive management and social learning, in addressing global goals. As the report said, "Any successful quest for sustainability will be a collective, uncertain, and adaptive endeavor in which society's discovering of where it wants to go is intertwined with how it might get there." It reinforced using knowledge "intelligently in setting goals, providing needed indicators and incentives, capturing and diffusing innovation, carefully examining alternatives, establishing effective institutions, and, more generally, encouraging good decisions and taking appropriate actions" (The National Research Council, 1999, p. 3).

The part of the UN 2030 agenda focused on science, technology, and innovation was called the Technology Facilitation Mechanism (TFM). The diplomats who created it did not know how best to harness STI, but knew that it was important if sustainable development was to be achieved. The TFM was charged to make progress, and it had three components: an annual multi-stakeholder STI Forum held annually at the UN, a Ten Member Group (TMG) of advisors appointed by the UN Secretary General for two-year terms, and an Inter-Agency Task Team (IATT) with one representative from each of more than forty international agencies. I was co-chair of the 10MG from 2016-18. In the 2017 STI Forum, we emphasized five actions: (i) using system analysis to help maximize synergies and minimize tradeoffs among the independent SDGs, (ii) emphasizing STI capacity building in each country including building human capacity and strengthening the science advisory ecosystem, (iii) creating action plans and roadmaps that incorporate STI into national planning efforts, (iv) expanding involvement through public-private partnerships and efforts that help create business opportunities in pursuing the SDGs, and (v) conducting "deep dives" on every SDG because only a comprehensive approach with stakeholder participation can yield realistic roadmaps at the global, regional, national, local, and institutional levels.

One initiative that the 10MG championed was the creation of STI for SDGs roadmaps at the national level. The idea of the STI for the SDGs roadmap was to focus on the intersection of three plans often produced independently in countries. One was the national plan of the country emphasized by political leaders, another was the STI capacity building plan often championed by science and technology agencies, and the third was the fledgling national plan for making progress on selected SDGs. To advance this initiative, an IATT workgroup on roadmaps was created in 2017, and a guidebook preparation was begun in 2018 (UN-IATT & EC–JRC, 2021). Five pilot countries were announced in 2018 to prepare their STI for SDGs roadmaps. These countries had approval at the highest level of their governments and assistance with funding promised by several developed countries and international agencies. In 2021, the pilot countries expanded to six, including Ethiopia, Ghana, India, Kenya, Serbia, and Ukraine.

Several global reports were produced by groups of scientists focusing on how to make progress on STI for the SDGs. They included the *World in 2050* reports emphasizing six big areas where transformations were needed: human capacity and demography; consumption and production; de-carbonization and energy; food, biosphere and water; smart cities; and the digital revolution (IIASA, 2019). Another was the *Global Sustainable Development Reports* that would be produced every four years by fifteen independent scientists appointed by the UN Secretary General. The first GSDR appeared in 2019 entitled "The Future is Now: Science for Achieving Sustainable Development" (Independent Group of Scientists appointed by the Secretary-General, 2019).

Even during those early years of the UN2030 Agenda, it was recognized that there are many challenges to making progress on the SDGs. Aspirational rhetoric is inspiring, but effective policies, real action, and adequate funding are hard to implement and sustain. The targets do not cover all the essential elements. Many key indicators are either missing or lack adequate data. The voluntary national reviews submitted by member states to the UN High-Level Political Forum are useful, but not real action plans. And these challenges are minor compared to the enormous political challenges at the national and global level that create roadblocks to progress for every one of the SDGs. Even the incredibly rapid progress of the science and technology revolution, yielding a growing number of emerging technologies, is seen not only for creating potential new opportunities but also for creating powerful disruptions and security threats to societies.

The UN Secretary General's speech to world leaders at COP26 in November 2021 laid out the stark choices regarding climate change (Guterres, 2021). The challenges of the COVID pandemic, the Russian invasion of Ukraine, the worsening relations between the U.S. and China, the retreat from globalization, and the impending economic recession worldwide also created heavy headwinds for making progress on the SDGs. Two of the pilot countries for STI for SDGs roadmaps, Ethiopia and Ukraine, were involved in conflicts that disrupted their plans for making progress on sustainable development, illustrating once again that wars may be the greatest threat to the UN 2030 agenda.

Yet, efforts on the SDGs continued with some of the most promising initiatives at the subnational and local level. Although the U.S. never produced a Voluntary National Review (VNR), Brookings and the UN Foundation produced in 2022 *The State of Sustainable Development Goals in the U.S.* as a shadow VNR (International Institute for Sustainable Development, 2021). The National Academies of Sciences, Engineering, and Medicine undertook a study on "Operationalizing Sustainable Development" highlighting some of the constructive initiatives at the local and global level (National Academies of Sciences, 2022). The U.S. rejoined the Paris Climate Agreement at that time, and many countries emphasized their commitment to reducing greenhouse gas emissions. The STI Forums continued. Influential public communicators such as the young activist Greta Thunberg and the science fiction writer Kim Stanley Robinson reached out to young people around the world. Yet the global conflicts continued to hurt progress towards the UN2030 Agenda in the early 2020's.

Science Diplomacy

I take a practical, pragmatic view of science diplomacy: what are the goals of a given endeavor, who are the actors, what is the strategy or roadmap, and what are the actions to be undertaken (Colglazier, September 2024). It certainly includes all aspects of the three components laid out in 2010 by the American Association for the Advancement (AAAS) and the Royal Society: science in diplomacy, science for diplomacy, and diplomacy for science (The Royal Society, 2010; 2025). Yet an initiative in science diplomacy can involve all three components, the critical elements are the goals, actors, strategy, and actions.

Science diplomacy typically encompasses more than just fundamental science, many aspects of STI often come into play. Initiatives have been undertaken by national governments, international organizations, non-governmental institutions, individual scientists, and by collaborations among many actors. When practiced by governments, science diplomacy often depends upon scientific and technical experts being involved in international scientific engagements to achieve diplomatic goals for the national interest. National goals can overlap with global goals, but that is not always the case and the goals may even conflict. Science diplomacy can be used to gather intelligence and influence foreign governments through their scientific communities as well as to improve diplomatic relations, to advance worldwide science for mutual benefit, and to solve global challenges. Non-governmental scientific organizations can engage in science diplomacy to achieve their own scientific and diplomatic goals, which, again, may not be entirely the same goals as those of their governments. Some of the most important and successful science diplomacy initiatives have involved collaboration among governmental and non-governmental actors.

My involvement in science diplomacy has lasted over forty years across a wide range of countries and issues, serving as researcher, professor, executive officer of the U.S. National Academy of Sciences, science and technology adviser to the Secretary of State, co-chair of the 10-Member-Group advising at the UN on the role of STI in achieving the SDGs, and as a participant in many initiatives of non-governmental scientific

organizations. My views on what can be achieved by science diplomacy have been profoundly influenced by wise mentors and practitioners whom I consider to be great "science diplomats." They include distinguished scientists who had no training in the art of diplomacy or experience working in government. They also include diplomats and politicians who had little or no training in science. Incorporating multidisciplinary expertise and knowledge, not just from science, but also the humanities, professional fields, and practical experience, is invaluable for making progress with science diplomacy.

One aspect of science diplomacy often underappreciated is the possibility of scientific and technological advances to "leap over" diplomatic hurdles that have stymied progress, through devising new pathways and solutions. Some science diplomacy successes have lasted for decades, although some of these have been reversed when geopolitics have taken a drastic turn. While it is painfully clear that politics is a more powerful force than science in the short run, geopolitics can also change in ways that enable science diplomacy initiatives, even those begun in earlier years, to take advantage of a new "window of opportunity."

I was fortunate to have observed and participated in a "golden era" for science diplomacy that lasted several decades. Among great successes for science diplomacy were: the Montreal Protocol ratified in the late 1980s, the nuclear arms control treaties realized in the 1990s, and the Intergovernmental Panel on Climate Change (IPCC) and its "Summaries for Policy Makers" negotiated with governments that were influential in achieving the Paris Climate Agreement signed in 2016. The Montreal Protocol was made possible by three key ingredients: the scientific advances of the three scientists who won the Nobel Prize after alerting the world to the threat of destruction of the ozone layer, the companies that developed new refrigerants that did not use chlorofluorocarbons, and diplomats who persisted in pursuing a treaty. Advances in arms control were accelerated by Soviet leader Mikhail Gorbachev's science advisors being many of the Soviet scientists who had previously engaged in non-governmental "Track II" dialogues with American scientists. The unique collaboration represented by the IPCC may be worth repeating for other global challenges, like dealing with the threats and opportunities presented by emerging technologies.

At the National Academies of Sciences, Engineering, and Medicine, I was a participant and observer in dialogues and studies involving scientists from Russia, China, Japan, Iran, Indonesia, India, Mexico as well as countries in Europe, Africa and the Middle East (including scientific collaboration between Israeli and Palestinian scientists). In the State Department from 2011 to 2014, I saw science and technology as a great asset for American diplomacy. Every country, whether or not they liked the U.S. government, wanted to engage with American universities, research laboratories, and technology companies. At the UN 10-Member-Group advising on STI for advancing the SDGs, I gained enormous respect for the UN professional staff and scientists and diplomats from many countries who wanted to turn the aspirational rhetoric of the SDGs into real actions to advance sustainable development everywhere in the world.

At the World Science Forum in 2019 (WSF, 2019), I laid out five priorities for science diplomacy going forward. They were: (1) controlling new technologies of war that can be used by nation states and terrorists, (2) providing foresight and facilitating dialogue on

the implications of rapid technological developments, (3) maintaining a channel of communication between estranged nations with potential for conflict, (4) accelerating progress on global goals, and (5) building STI capacity in emerging economies to help improve the lives of their citizens.

The New Era of Increased Competition and Conflict

This new era of competition and conflict is quite different from that of the past thirty years. Geopolitical constraints and global disruptions provide a staggering list of challenges: (1) the COVID-19 pandemic and threat of new pandemics, (2) the competition and conflict between the U.S. and China, (3) the Russian invasion of Ukraine, (4) the alliance among Russia, China, Iran, and North Korea, (5) the lapsing of nuclear arms control agreements with nuclear saber-rattling and more nuclear powers, (6) the Middle East war between Israel and Hamas with its potential to expand wider, (7) developing countries having to navigate a multipolar world, (8) economic stresses with high inflation and increased debt, (9) de-globalization and fraying supply chains, (10) the lack of progress on UN2030 SDGs, (11) autocratic leaders even in democracies, (12) political polarization with few avenues for peaceful resolution, (13) allies losing confidence in the U.S. as a reliable partner given the impact of the 2024 U.S. election, (14) uncontrolled migration, (15) the accelerating effects of climate change, (16) emerging technological threats (AI, synthetic biology, robotics, quantum, big data, blockchain, social media, and more), (17) increased mistrust by the public of advice from scientists, and (18) a loss of faith in the ability of science and technology to make the world better. As the UN Secretary General stated at the opening and closing of the UN High-Level Political Forum in September 2023, "Our world is becoming unhinged, tensions are rising, challenges are mounting, we seem incapable of responding." The second UN Sustainable Development Report released in 2023 had a similar urgency in its title: "Times of Crises, Times of Change: Science for Accelerating Transformations to Sustainable Development."

The current geopolitical environment is altering the practice of science diplomacy by governmental and non-governmental organizations in large part because the ability to carry out international scientific and technological collaborations is being affected by security concerns and conflicts. That is especially true in collaborative research on technologies, but it is also true in those areas of fundamental research close to technological advances that have the potential to create significant advantages and threats for a nation state. International scientific and technological collaboration funded by governments is growing among allied countries but decreasing between countries in competition and conflict. That will affect the global advance of science and technology as well as the ability of countries to collaborate to solve global challenges. It is also negatively affecting the ability of the U.S. as well as other countries to attract talent from around the world. The use of science diplomacy as a "window of communication" between estranged countries is disappearing.

International scientific engagement has always been a vital component of science and technology capacity-building and a key ingredient of many science diplomacy initiatives. The new rules and restrictions being developed and implemented by government agencies are being justified by legitimate security concerns arising from patent

infringement, technology theft, malign foreign talent programs, and espionage, as well as cases of serious ethical lapses by scientists. This new regime of research security will potentially affect fundamental research where, in the past, results have been published in the open literature and where much of the work has been conducted at universities and civilian national laboratories as well as at international facilities.

The balance between research openness and security for fundamental research could tip too far towards the security side. That would likely lead to more areas of "controlled unclassified information" (CUI) and significantly decrease international scientific collaboration. That result would harm the ability of democratic countries to advance their national interest and their aspirations to be world leaders in STI and in attracting talented people from around the world to their countries. Research institutions and research funders need to implement rules and procedures that will not eliminate risks but will enable a careful judgment on how to reduce the risks while still achieving the benefits of research. When carried out on a project-by-project basis with engagement by highly knowledgeable scientists inside and outside government, this nuanced process could lead to better judgments on the balance between openness and security for fundamental research. That is essential if humanity is to reap the potential benefits of utilizing artificial intelligence and other new technologies to rapidly advance scientific knowledge.

Predicting the Future

Scientists and technologies are not much better than anyone else in predicting the future, and my track record confirms that. Nevertheless, when I was in the State Department, I was fascinated by the efforts of the intelligence agencies to engage in foresight to try to anticipate possible future worlds. Two of my editorials in *Science & Diplomacy* dealt with these issues: (1) "Science and Technology Foresight" (2017) and (2) "Science Diplomacy and Future Worlds" (2018). Scientific foresight is a worthwhile exercise and may lead to useful insights, but it is also humbling to look back in hindsight. I updated in 2024 my science diplomacy priorities for the U.S. trying to take into account the impact of global changes occurring before the U.S. election (Colglazier, October 2024). The disastrous impacts on American science and world trade caused in 2025 by the new U.S. government, however, were impossible to predict and have created even greater uncertainty about the future.

"Inventing the future" is popular in Silicon Valley. It certainly captures the power of the rapid advance of science and technology to create new possibilities previously unknown. I like a humbler version that emphasizes the importance of history in understanding where we need to go in the future:

"We cannot invent the future without understanding the past, and we cannot cast a critical gaze on society outside our campus without also undertaking a careful examination of our own history and our own imperfections in providing access and opportunity in ways that build a more just and effective society" (Leebron, 2019).

The two most powerful forces affecting the future of humanity are moving at vastly different speeds, creating enormous problems in efforts to make the world better. One is the inability of national and global political leaders to deal on any reasonable timeframe

with our myriad global challenges, including the increasing competition and conflicts that can lead to wars. The other is the rapidly accelerating scientific and technological revolution with its unpredictable impacts appearing quickly, including threats that need to be managed and benefits that need to be secured. We should remember that science diplomacy got its start after World War II with the efforts of non-governmental scientists to reduce the threat of nuclear weapons. Those scientists knew that science alone cannot solve our problems, only people can, but science diplomacy can help.

Our greatest legacy to future generations, besides avoiding wars, terrorism, and conflicts, will be building knowledge-based societies and accelerating the expansion of scientific knowledge and useful technologies. The 1987 Brundtland Report could have highlighted the key role of science, technology, and innovation by defining sustainable development as meeting the needs of the present while expanding the ability of future generations to meet their own needs. We must all remain optimistic that humanity has the power, and hopefully the wisdom, to use science, technology, and innovation to create a more sustainable world for the benefit of all people and the planet.

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