Science and Technology Major Group Position paper - HLPF 2018

From incremental steps to transformations: leveraging interactions across the SDGs to secure long-term sustainable development outcomes

Incremental processes toward sustainable and resilient societies are no longer an option. We need to rethink and reshape development around the fundamental reliance of human wellbeing on the health of the planet. Achieving the SDGs and long-lasting development outcomes require system-wide transformations of our food, energy, consumption and production patterns, and our governance systems. Integrated approaches to policy development, knowledge generation and application provide opportunities to understand the range of options and accelerate the pace of change.

1. Key recommendations for the 2018 HLPF and SDGs implementation

1. **Implementing the SDGs as an integrated set, taking full account of the interdependencies between them, creates opportunities for reframing development around people and the planet, promote policy coherence, create efficiencies, target investments, and promote stronger buy-in. Achieving the SDGs together as an "indivisible whole" is not only possible, but the only way of achieving the SDGs.** The International Council for Science published in 2017 A Guide to SDG interactions: from science to implementation which provides a framework for describing the level of interdependency between goals and targets and developed an analysis of 4 of the 17 goals. It shows that actions under one goal can reinforce progress in other goals, providing opportunities for co-benefits across multiple policy domains. For instance, agroforestry and other sustainable approaches advance the food, water, energy and land biodiversity goals. Similarly, actions taken to achieve an SDG may hinder progress in achieving another and lead to setbacks. Understanding and managing these interactions is key to achieve the SDGs as a whole. This framework is now being further developed in partnership with the International Network of Government Science Advisors to develop national-level interactions map jointly with scientists, policy-makers and stakeholders to understand potential co-benefits and trade-offs that need to be managed in different country contexts, analyse policy and knowledge gaps to inform priority-setting.

2. **There is a special urgency for acting now on SDG interactions as current decisions are locking-in unsustainable pathways that will make it more difficult to attain all the SDGs** as called for by a group of experts who met at a Wilton Park-University of Sussex led event**.** We need a long-term approach to investments in SDG policy-making that fully realizes the opportunities of synergistic actions across SDGs and that is mindful of the potential trade-offs. Current UN and national strategies for

SDG implementation remain largely sectoral and compartimentalised, and are often narrowly focused on individual goals and near-term payoffs.

3. **Wider coordinated efforts are needed to understand the long-term pathways to achieve the SDGs and the potential spill overs across policy domains, and across time and geographical boundaries.** The World in 2050 is a global research initiative launched by the International Institute for Applied Systems Analysis (IIASA), the Sustainable Development Solutions Network (SDSN), and the Stockholm Resilience Center (SRC). Its aim is to develop a broad narrative and quantitative pathways on how the 17 SDGs can be achieved. A report will be launched in 2018: it identifies six key major transformations needed to achieve the 17 SDGs and long-term sustainability: 1. Energy including decarbonization, efficiency, access; 2. Food and biosphere including for example, sustainable intensification, agro-ecology ocean biodiversity, forests and water, healthy diets, nutrients; 3. Cities covering housing, mobility, sustainable infrastructure, water, pollution; 4. Sustainable consumption - resource use, circular economy, sufficiency, pollution; 5. Digital revolution - Artificial intelligence, big data, biotech, nanotech, autonomous systems; 6. Human capacities and demography - education, health, ageing, labor market, gender, inequalities.

4. **The scientific and technology community has a crucial role to play in providing the evidence, expertise and data to inform, measure and monitor the implementation of the SDGs and help deliver solutions.** To inform the SDGs, fundamental as well as interdisciplinary and transdisciplinary science and novel approaches are needed to identify policy options and solutions. Scientific communities are mobilizing widely to respond to the urgency and opportunities to achieve a science-based transition to sustainable development. ICSU and ISSC are merging to form a single International Science Council bringing together the natural and social sciences at the global level. Future Earth is developing knowledge action networks around the SDGs to support stakeholder-engaged and solutions-oriented research and innovation. Many research organisations at national level lead novel research in support of the SDGs, for example the Stockholm Resilience Centre on resilience, Newcastle University on systems thinking for sustainable development, IRD in developing countries scientific cooperation for contextual understanding of sustainability challenges, and many others. Research funders such as the Wellcome Trust increasingly acknowledge that in many cases, a lack of primary research is not the bottleneck to action, and support policy-related activities, encouraging research design with a view towards end users and impact.

5. **The science-policy-society interface need to be strengthened at all levels, from local to global, and mechanisms for the translation of evidence into policy need to be developed that fully take into account social and political contexts.** For the road to 2030 to be evidence-paved, there are crucial elements of a scientific advisory system to support the implementation, delivery and evaluation of the SDGs: develop STI roadmaps that identify knowledge and capacity gaps and orient national systems towards delivering for the SDGs, develop knowledge brokering, build collective intelligence, strengthen the science and practice of scientific advice, foster humility in providing advice.

6. **Business as usual is not option and the window for transforming our modes of development is narrowing as time goes on: "the time for action is now, actually it was yesterday and the day before"** as Sir Robert Watson said when presenting the four regional assessments of biodiversity and its contribution to people that IPBES released on 23 March 2018. We know enough to take action.

7. **Achieving sustainable development requires better integration, more coordination, and cooperation at an unprecedented scale.** To enable societal transformations to, for example, sustainable consumption and production systems, decarbonization, urban sustainability, sustainable natural ecosystems and biodiversity and a healthy biosphere, it is necessary to strengthen collaboration between communities of researchers, practitioners, decision makers and other stakeholders to jointly frame questions that need to be addressed, ensure that knowledge can be taken up in decision-making.

8. **Alongside technology, governance, societal and cultural norms and values, and behavioural change have a huge role in achieving the SDGs.** Globally, values and norms differ across and among diverse societal groups but we all face the common challenge of developing sustainable futures for our societies. A global alignment where common ground is struck on important values and recognition of shared responsibilities that can contribute to a global vision for sustainable futures is an imperative.

9. **Our governance systems need to be changed to enable transformative changes and better manage complex multidimensional challenges.** A shift from sectoral to integrated, systemic perspectives is necessary to account for the complexity of problems that we are facing and realizing the opportunities. For example, in view of the strong public support in many countries for policies that improve health, the achievement of health co-benefits of policies and interventions can help to motivate change and enhance the acceptability of sustainable development policies. This transition will be challenging and will require effort and reflexive learning processes. Systemic shifts will require a focus on human behavior, and issues of environmental and social justice will need to be at the core of the processes and plans for transformations.

10. **The 2030 Agenda is primarily an agreement between national governments, but successfully achieving social transformation means we need to focus on every level of society, i.e. individual to global levels -- and not just the nation state.** In particular, the focus should be in cities, as intermediate governance entities between nation-states and local communities. Governance at the city level has a greater capacity in some cases to interconnect different policy realms such as sustainable livelihoods, job creation, environmental sustainability, sustainable energy, and sustainable consumption.

11. **The HLPF offers a crucial opportunity for participants to reflect not only on successes but importantly, also on challenges in the implementation of the SDGs. A better understanding of implementation challenges and gaps would allow for better learning process, and more effective engagement of scientists, practitioners, and civil society for supporting effective implementation.** However,

for the lessons learned at the HLPF to truly influence policy and funding decisions requires appropriate follow-up processes at all levels to ensure that lessons learned and challenges identified during processes such as the VNRs can inform policy changes at the national, regional and local level.

12. **The 2030 Agenda emphasises that the SDGs are integrated and indivisible. However, the Thematic Reviews and VNRs currently provide insufficient space for reflection on interactions between SDGs and targets.** When discussing interlinkages, the Thematic Reviews should go beyond merely highlighting that a particular SDG is connected to other SDGs, towards identifying specific manners in which SDGs and/or agendas reinforce or undermine each other.

2. Key insights and messages related to the SDGs under review

SDG 6. Ensure availability and sustainable management of water and sanitation for all

Water is central to the 17 Sustainable Development Goals (SDGs), and essential to human health and wellbeing and global prosperity as a whole. There is an estimated four billion people facing problems of insufficient access to clean water (Mekonnen and Hoekstra 2016)[1]. **There are three, partially related, issues that need to be managed to meet SDG 6 and the SDGs as a portfolio: access to water, water quality and water quantity**. This requires a good understanding of the socio-economic dimensions of access to this natural resource, as well as the way water flows (surface, groundwater and atmospheric) are influenced by forests and tree cover, interacting with the hydroclimatic cycle and human land use (Creed and Noordwijk 2018)[2]. Forested landscapes are essential for various water-related ecosystem services such as water provision and filtering, conservation of soils, and climate regulation. Forests and trees are important modulators of water flows, with water flows being among the most prominent determinants of human health and wellbeing (Rockström et al 2014)[3].

The ambition of SDG6 to provide access to reliable water for all requires a balancing of regulating water demands for extractive and primary industries, protecting the sources of water and, one step further, the sources of rainfall, and enhancing the social fabric and transparent governance of natural resource management. The IUFRO-led Global Forest Expert Panel (GFEP) on Forests and Water assessed these relations recently. IUFRO will launch its report "Forests and Water on a Changing Planet: Vulnerabilities, Adaptation Options and Governance Opportunities" at the meeting of the High Level Political Forum in July 2018. The publication will constitute the most comprehensive systematic scientific syntheses on the interactions between forests and water on the global level to date.

Water (and sanitation) systems require integrated and multi-scalar management that is dynamic and changes over time according to environmental and social pressures. The linkages between cities and their larger regions (lands) should be considered when designing

1 Mekonnen MM, Hoekstra AY (2016) Four billion people facing severe water scarcity. Sci Adv 2(2): p.e1500323.
2 Irena F. Creed & Meine van Noordwijk (eds.), 2018. Forest and Water on a Changing Planet: Vulnerability, Adaptation and Governance Opportunities. A Global Assessment Report. IUFRO World Series Volume 38. Vienna. (forthcoming).
3 Rockström, J., M. Falkenmark, T. Allan, C. Folke, L. Gordon, A. Jägerskog, M. Kummu, M. Lannerstad, et al. 2014. The unfolding water drama in the Anthropocene: Towards a resilience-based perspective on water for global sustainability. Ecohydrology 7: 1249–1261.

responses to water stresses. Static governance structures that focus on one scale (e.g. city scale) undermine attempts at planning that integrate the vast array of pressures. Effort should therefore be focused towards exploring innovative governance mechanisms that account for this complexity and are informed by bottom-up as well as top-down perspectives.

Cities rely on water supply and sanitation services to survive, often transporting large quantities of water large distances[4]. This water relies on security of supply, provision of infrastructure for treatment and transport, and suitable facilities for treatment of waste. The locations of these activities are often outside the urban area, often many tens or hundreds of kilometres distant and over international boundaries. The threat of climate change will reduce the availability of water in many regions[5], with some parts of Europe potentially experiencing an entirely different climatic regime in future years[6]. Access to water resources in urban areas is also a social and political issue, with socio-economic change and rapid urbanisation adding to the pressures of a changing climate[7]. Rainwater harvesting, particularly in developing nations, could enable the domestication of water supply and thus reduce pressure on scarce resources[8]. Thus, packages of measures must be implemented to both improve supply and reduce demand for water to ensure future sustainability and achievement of target 6.1[9].

In addition to the problem of too little water in cities, there is also a problem with too much water; extreme rainfall events, driven by changes in climate, are intersecting with impermeable surfaces, increasing due to urbanisation, to cause floods. The interconnected nature of urban systems shows that flooding caused by extreme rainfall can cause large-scale social and economic impacts, both in terms of direct damage to human life and property and indirect economic impacts[10]. Such flooding problems are not limited to the urban boundary, with cities connected through river catchments to distant regions and many floods caused by management of land and resources elsewhere in the catchment. A 'catchment systems engineering' approach can mitigate flood water and associated pollution in rural areas, improving the resilience of urban areas whilst managing the natural landscape[11]. Such approaches can assist in both improving urban resilience and preserving natural environments and biodiversity (Target 15.9). In the urban environment, the use of greenspace can mitigate against flood risk and increase resilience whilst also improving urban ecosystems, although the effectiveness such green adaptation requires further study[9].

Urban sanitation, particularly under Target 6.2, also requires systems thinking. Access to sanitation is a social and political issue as well as a technical issue, with small-scale community dynamics affecting access[12]. In developing nations, and particularly in informal settlements, alternative methods of sanitation (such as faecal sludge management) may need to be considered and optimised to achieve Target 6.2[13]. The provision of sanitation infrastructure must be considered in its broader social context to ensure that it is widely used and practical[14]. Thus, policies to enable progress towards targets under Goal 6 require a system approach that includes a broad analysis of environmental, technical, social, and natural factors.

[4] https://www.sciencedirect.com/science/article/pii/S0959378014000880
[5] https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.5140
[6] http://iopscience.iop.org/article/10.1088/1748-9326/aaaad3/meta
[7] https://link.springer.com/article/10.1007%2Fs11269-017-1734-2
[8] https://www.tandfonline.com/doi/abs/10.1080/13552074.2017.1339949
[9] https://www.hydrol-earth-syst-sci.net/20/1869/2016/
[10] https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29IS.1943-555X.0000372
[11] https://www.sciencedirect.com/science/article/pii/S0048969713008231
[12] https://www.sciencedirect.com/science/article/pii/S0197397515001939
[13] http://pubs.rsc.org/en/Content/ArticleLanding/2016/EW/C5EW00179J#!divAbstract
[14] https://onlinelibrary.wiley.com/doi/abs/10.1111/anti.12117

A deficit in climate information is perceived as a barrier to planning resilient development, including access to water and proper sanitation services; but in many places information has been produced but, for some reason, has not been integrated into planning processes. We should focus efforts on building a deeper understanding of the role of governance, ethics, perceptions and values during the processes of producing and integrating scientific information into planning and implementation processes and responding to climate change. There is much to learn from water management processes across the globe, particularly in areas of water-related stress. Initial conversations with government staff in the City of Cape Town have indicated that their responses have been informed by lessons documented in grey literature that has been developed by city, project or resource managers who have faced similar challenges (e.g. in Melbourne, Australia). These lessons should be systematically documented and shared as such literature is currently not readily available.

One way to support and strengthen the participation of local communities in improving water and sanitation management (SDG 6.b) will be through their widespread involvement in citizen science. Interested citizens and even school children are able to carry out water quality monitoring in local streams and waterbodies using indicator species (for example https://www.streamwatch.org.au/ ; http://brodheadwatershed.org/streamwatchers.html), learning at the same time about the importance of pollution control and watershed protection.

Additional resources on this topic:

National science academy networks in Africa (NASAC) and the Americas (IANAS) have published comprehensive regional perspectives on water security:

- Water security in Africa recommendations to policymakers (2014) is an integrated account for the continent which explores the water-food-energy nexus; safe water and sanitation; water resources and infrastructure for economic growth; managing transboundary systems; global change and risk management; water governance and management; financing; and capacity development. It provides recommendations for policymakers for each of these.
- Urban water challenges in the Americas (2015) is a compilation of national perspectives and case studies on the continent. With 120 authors from 20 countries, it provides a synthesis of common urban problems and management strategies to combat these, spanning the wide geographical and economic diversity of the Americas.

SDG 7. Ensure access to affordable, reliable, sustainable and modern energy for all

Access to modern energy is fundamental to human development. The services that energy makes possible – from mobility to manufacturing, agriculture to heating and lighting – are ubiquitous and yet not everyone has enjoyed the benefits that access to modern energy can provide. Energy extraction, conversion and consumption also has major impacts on other sectors, be they economic, social, and environmental.

There are also important interlinkages to note among the targets of SDG7. For example, distributed sources of renewable energy (solar, biogas), could help rural communities achieve energy access. While doing this via a more centralized, infrastructure heavy approach is also

possible but would risk that elevated prices could be a barrier for poor households. The energy efficiency target, meanwhile, is a 'win-win' strategy on all accounts as every unit of energy saved is a unit that does not need to be produced, thereby making it easier to achieve the targets on renewable expansion and universal access provision[15] [16].

Urban areas are key drivers of energy demand, but also offer opportunities for efficiencies of scale. Energy systems are intrinsically linked to the economy, society, and the environment and urban policy-makers face a trilemma of tackling simultaneously energy security, sustainability (carbon reduction) and affordability. In order to ensure sustainable and resilient energy for all, systems thinking must also be applied to energy demand and supply in cities[17]. The urban characteristics, such as development density, transport policies, and building codes, which define a city have profound impacts on the energy demand[18]. Meeting climate change targets by reducing energy use will also require extensive retrofitting of existing buildings to reduce energy demand, and consideration of the interactions between social and technological aspects[19]. Waste generated in urban areas, including food waste, also has the potential to feed into energy generation. Pilot-scale experiments are currently being undertaken to demonstrate the practicality of producing biogas through the use of anaerobic digestion)[20] and hydrogen from fuel cells powered by domestic wastewater[21].

The sustainability and resilience of the urban energy system is dependent on a mix of renewable supply, energy storage, and a reduction in energy demand (including domestic, industrial, and transportation uses). Energy storage is an important tool to meet Targets 7.1 and 7.2, so the integration of this storage into energy infrastructure is of particular importance[2223]. In addition, new methods of generating and distributing energy, e.g. through 'mini-grids' from photovoltaic generation, will be increasingly important in developing nation cities and rural areas. Tools are needed to help manage these mini-grids and potentially enable provision of energy to the 17% of the world's population that are currently unserved[24].

There are obvious interlinkages between Goal 7 and other goals under review at this year's HLPF. Work at Newcastle University has shown the reliance of resilient energy supply on the provision of water, particularly the need for water supply for future carbon capture and storage generation[25]. This highlights the conflict between the need for water for energy production and water for other uses, suggesting that there may be risks to the energy sector from climate change by as soon as 2030[26] and that resilient water and energy supplies will require careful management and balancing between competing demands.

Modern energy systems and the transition away from environmentally-damaging and unsustainable energy sources rely on advances in science and technology. Meeting the targets for SDG7 will require major advances in energy transmission and storage, improved efficiency in energy use, and technologies appropriate to all users, particularly the poor and those in rural areas without access to modern energy services. There are major benefits from

[15] ICSU 2017 A Guide to SDG interactions: from Science to Implementation. International Council for Science
[16] McCollum, 2018 Connecting the sustainable development goals by their energy inter-linkages. Environment Research Letters 13
[17] https://www.sciencedirect.com/science/article/pii/S030626191401174X
[18] https://www.jtlu.org/index.php/jtlu/article/view/1209
[19] https://www.sciencedirect.com/science/article/pii/S2214629614000371
[20] https://www.sciencedirect.com/science/article/pii/S1876610217357399
[21] https://www.sciencedirect.com/science/article/pii/S096085241401342X
[22] http://ieeexplore.ieee.org/document/7741684/
[23] https://www.sciencedirect.com/science/article/pii/S0360319916309478
[24] http://www.mdpi.com/2071-1050/9/5/738
[25] https://www.icevirtuallibrary.com/doi/10.1680/ener.14.00028
[26] http://iopscience.iop.org/article/10.1088/1748-9326/11/2/024011/meta

achieving SDG 7 across many other goals and targets. About 85% of the fine particulate air pollution is related to the way in which society uses energy. Total deaths annually from a combination of household and ambient air pollution are estimated at 6.5 million (see Lancet Pollution Commission report). The transport sector in particular faces major challenges in adapting its very conception and extensive infrastructure to non-fossil-fuel energy sources. However, an engineering approach by itself will be not be sufficient. Energy system planning needs a major contribution from the social sciences to incorporate non-market approaches, gender equality, and social justice, among other perspectives.

The achievement of SDG7 poses a number of challenges and opportunities that differ across regions. Globally more than two billion people depend on wood energy for cooking and/or heating. In much of sub-Saharan Africa more than 90% of the people rely on fuelwood and charcoal for cooking and heating (Angelsen et al. 2014). Wood-based energy is important in rural areas, but also among urban dwellers in developing countries. While the use of biomass for energy is recognized as often being inefficient, and is often harvested in an unsustainable fashion, it is a renewable energy source, and thus with the introduction of cleaner and more efficient cooking techniques and sustainable management of the forests it has great potential to contribute to SDG 7 on clean, sustainable energy. Besides, the production and distribution of fuelwood and charcoal generate income for tens of millions of households in rural areas. In sub-Saharan Africa alone, the wood fuel sector employs an estimated seven million people (WB 2016).

In Africa, be it for jobs, security, climate change, food production or increasing incomes, access to energy for all in cities is essential. To achieve "transformation towards sustainable and resilient societies", clean energy, like solar energy, will be an opportunity for cities. Massive expansion of solar generation across Africa by mid-century is likely a necessary component of any serious strategy to mitigate climate change but this requires building the foundation for a consistent scale-up of solar generation in Africa by 2030 and taking a long-term approach to technology development in the region. Fortunately, the regional solar resource dwarfs current and projected future electricity demand (708 terawatt-hours by 2030). In recent years, solar costs have fallen substantially, and installed capacity has grown very rapidly. Even so, solar energy today accounts for only about 1% of Africa's and global electricity generation. Particularly if a substantial price is not put on carbon dioxide emissions by actors, expanding solar output to the level appropriate to the climate challenge likely will not be possible at tolerable cost without significant changes in regional and state government policies.

There is a need to focus on improving the performance and costs of existing technologies through R&D, and on the development of new technologies, for instance in thin-film technologies that use Earth-abundant materials. The HLPF should inspire Africa's scientists to focus on new materials and system designs (ex., using Traditional Knowledge, or TK) and should support their testing in pilot-scale facilities, akin to those common in the chemical industry. Support for current solar initiatives in the region will help create the foundation for major scale-up by building experience with manufacturing and deployment and by overcoming institutional barriers.

Additional resources:

National science academy networks in the Americas (IANAS) and Europe (EASAC) have published regional perspectives on aspects of energy security:

- IANAS Guide to sustainable energy in the Americas (2016) provides an analysis and national case studies on energy efficiency; renewable energy; underserved populations; water, energy and gender; bioenergy; and capacity building (designing an investment strategy for skills, technologies and supporting infrastructure). It provides a contribution to the road map for achieving SDG-7 on the continent.
- EASAC Report on Valuing dedicated storage in electricity grids (2017) provides recommendations on large-scale electricity storage in the EU to build in flexibility around balancing reserves, capacity and generation, as well as congestion management. Large-scale electricity storage affords the flexibility that is needed to manage increasing quantities of variable renewable electricity generation on the grid.

SDG 11. Make cities and human settlements inclusive, safe, resilient and sustainable

By 2030 it is expected that 60% of the world's population will live in cities. Cities account for 75% of global GDP and 75% of global carbon emissions, despite occupying less than 2% of the Earth's land surface and are spatial hot-spots of risk from extreme weather and other natural hazards. The design, density, efficiency, and size of cities also governs their consumption of natural resources, their ability to provide secure and healthy lives for their inhabitants, and their impact on the natural environment surrounding them. As a result, cities are both a threat and an opportunity for global efforts towards sustainability and the achievement of the SDGs.

Whilst cities may have political and administrative boundaries, the sustainability of any urban area is dependent on a much wider set of 'catchments' which supply cities with food, water, energy, and consumer goods. Considering the flow of these supplies into and out of cities is vital for planning of a sustainable future[27]. Such large urban hinterlands give cities a much greater 'ecological footprint' than their physical size would suggest. As such, national policy-makers setting urban policies must consider interconnections at a much larger spatial scale. The resilience of cities depends on a much wider area than that controlled directly by the city, with food and energy security, and flood risk being affected by processes at a much larger spatial scale.

Achievement of SDG 11 is therefore reliant on and underpinned by achievement of other SDGs (indivisibility), in particular those being reviewed at this year's HLPF (SDG6n SDG7, SDG12, SDG15). The implementation of SDGs will require national governments to develop national urban strategies to manage and implement infrastructure provision projects; to manage urban growth and their natural ecosystems adequately; to ensure equitable and inclusive urban developments and engage in energy transitions. Without this national strategic planning, territorial urban growth runs the risk of being unbalanced, unsustainable, and to reinforce territorial polarization and inequalities.

Implementation of Goal 11 should begin with efforts focused on the first objective; to make cities inclusive. Urban development processes to date have resulted in condensed areas

[27] https://www.sciencedirect.com/science/article/pii/S2211464516301142?via%3Dihub

of environmental and social injustices. Mature cities, as a result, currently face the challenge of making drastic changes to improve wellbeing, reduce emissions and increase adaptive capacity. Cities in developing countries should not strive for similar development and "lock-in" to similar trajectories.

Inclusivity is only possible if the diversity of perspectives within the city are voiced, issues faced by various groups are heard, and these same groups co-produce a solution. Environmental and social justice should be at the heart of the city governance process. As a first step, effort should be focused on building partnerships and networks across different scales and types of groups within cities. These networks should include representatives from research, practice and policy (e.g. see Ouranoros in Montreal). A more inclusive city will foster relationships across these various groups, which will also contribute to improving safety (See Torolab: Camino Verde "La Granja" example). Participatory decision making is essential where uncertainty and complexity characterize policy problems.

Informality in cities is one of the greatest sustainability challenges for both research and action. Municipal plans need to draw in all key actors, so they come to understand different urban pressures and get agreement on the needed trade-offs. Knowing what matters and what works for urban dwellers especially the vulnerable groups including women, youths and slum dwellers will promote inclusive governance and sustainable city development policies. Reducing inequalities through appropriate local economic empowerment is key to building resilience in medium and large cities.

City level actors including local businesses, city-governments, local NGOs and community groups as well as international organizations and philanthropies involved in urban areas need to be engaged in the implementation and monitoring of the SDGs. For example, engaging with global networks producing comparable urban data in SDG reporting and implementation e.g. City Networks, Philanthropies such as Rockefeller, Bloomberg, Bill and Melinda Gates, International networks of civil society groups such as Slum Dwellers International, and global research networks (e.g Future Earth). City networks like C40 or ICLEI have also been very vocal in putting cities and mayors at the forefront of global conversations, especially around climate change.

Data and tools for decision-making need to be strengthened to address urban sustainability challenges. In particular, the development of and mainstreaming of modelling/forecasting technologies is needed to provide city planners with the ability to access higher-resolution and integrated modelling and forecasting tools and better assess the impacts of, for example, urban growth, climatic changes, future effects of sea-level rise, loss of biodiversity in and around their boundaries. Data availability, coverage, quality, resolution and reliability of data need to be enhanced, and reporting should be standardized and with open access (network of observatories with a joint observation framework could support this aspect).[28]

Additional resources

[28] Bai, Xuemei, et al. 2018. Six research priorities for cities and climate change. *Nature*. Vol 555.

- The IAP statement on Science and Technology for Disaster Risk Reduction (2017), endorsed by the world's science academies, sets out strategies for disaster mitigation (enhancing resilience), disaster management and post-disaster recovery. Recommendations include strengthening local and national stakeholder platforms for DRR; promoting trans-, cross- and inter-disciplinary research and cooperation; and framing good governance around safety and risk management.
- The Global Young Academy published a policy brief on the refugee crisis (2016), following an international workshop exploring complex, interdisciplinary issues around refugee integration in Europe. It identifies priority areas where the global research community can readily contribute (understanding and addressing the root causes, practical actions and interventions, and reframing the refugee debate).

SDG 12. Ensure sustainable consumption and production patterns

A fundamental restructuring of current systems of production, distribution and consumption is indispensable to accommodate world demographic growth and rising consumption while achieving sustainable development. SDG12 has also a cross-cutting relevance to numerous other goals including health and well-being, clean energy, decent work and economic growth and sustainable cities and communities.

Cities are responsible for the majority of global consumption, and large cities will be responsible for over 80% of the growth in consumption up to 2030. Cities are also responsible for around 80% of world energy demand according to the World Bank. The resilience of urban areas is also reliant on the web of supply chains that feed cities' requirements for goods. As these supply chains lengthen, their resilience becomes more difficult to maintain[29].

Cities require water, energy, and food supplies often from a large (sometimes global) area around the city. The sustainability of food supply chains need to be assessed, from agriculture, through to processing, retailing, and catering[30] and consider social and environmental aspects as well as financial sustainability[31].

Urban policies can have direct implications on consumption patterns at a global scale. For example, many cities have policies to increase their use of electric vehicles in order to reduce greenhouse gas emissions and address air pollution problems[32]. These policies clearly require a huge increase in the production of electric vehicles worldwide, and therefore on the consumption of raw materials that are required for their construction. Electric vehicle batteries, for example, require large amounts of cobalt and this demand links cities via supply chains to production of cobalt in countries like the Democratic Republic of Congo[33]. Thus, policies adopted in cities can have global sustainability implications and mining of such resources must be governed to ensure sustainable supply[34]. Electric vehicle adoption policies in cities also have direct links to the energy demand, and thus the ability to achieve the targets in Goal 7[35].

[29] https://www.e3s-conferences.org/articles/e3sconf/abs/2016/02/e3sconf_flood2016_04008/e3sconf_flood2016_04008.html
[30] https://www.tandfonline.com/doi/abs/10.1080/15239080701255005
[31] https://www.tandfonline.com/doi/abs/10.1080/00207543.2011.571926
[32] https://link.springer.com/article/10.1007%2Fs10584-013-0989-8
[33] http://www.ncl.ac.uk/engineering/staff/profile/oliverheidrich.html#215009
[34] https://www.nature.com/articles/nature21359
[35] https://www.sciencedirect.com/science/article/pii/S0040162516305935

Wastes enter into both SDGs 11 and 12. Many forms of waste have been created by science and technology and need new solutions. Information technology (IT) wastes have not been designed for recycling, and are accumulating rapidly with planned obsolescence. Plastics have become a new environmental menace. Many other persistent compounds from innovative chemistry are accumulating around the world with impacts on human health and the environment. Radioactive wastes need new solutions since long-term disposal is problematic. There is potential here for public/private/science partnerships (SDG17) in redesigning technological products for recycling, in developing closed cycles for scarce materials, in reducing the half-life of radioactive wastes, and in finding replacements for plastics, following on the model of the Montreal Protocol that successfully managed the replacement of ozone-depleting substances.

It is necessary to promote a systems approach to Sustainable Consumption and Production and address whole provisioning systems, including consumption practices and production conditions, as well as life-cycle impacts and the economic, political, social and cultural aspects that underpin our lifestyles. There is also, however, a need to understand why sustainable paths in urban areas aren't currently followed[36]. In addition, research on SCP has devoted significant attention to the efficacy of:

- individual behaviour-change premised largely on consumer education and eco-labeling
- the development and use of more efficient and less polluting technologies (typically referred to as weak SCP or "green" consumerism),
- reducing the adverse effects of goods and services on a per unit basis
- improving resource use and product performance.

Radical policy measures that limit volumes of production and consumption and raise critical questions about social and economic equity, continued economic growth and individual and societal well-being will need to be pursued to put us on a transformational path. This includes, identifying conceptual and practice-based spaces where "weak" and "strong" approaches intersect, to forge a more integrated understanding of different pathways to sustainable consumption and sustainable production systems, and to increase the societal/policy relevance of an integrated systems approach of SCP.

Political, economic and social initiatives at various governance scales (national, state, municipal) to incentivize lifestyles behaviours[37] and shifts in societal mindsets should be coupled with effective governance systems and infrastructures to maintain them. This will contribute to facilitating deep simultaneous transformations within interconnected socio-economic domains:[38] Energy, Food and Biosphere, Cities, Human Capacities and Demography, Digital Revolution, Production and Consumption. Examples of actions to promote such lifestyle change include for instance information to consumers: like nutritional facts, labels related to "Earth Facts" and disclosure of information regarding individual carbon footprints and emissions.

There is a need for stronger emphasis on social sciences to understand what underpins our consumption and production patterns, behaviours, and lifestyle choices. For instance,

[36] https://www.sciencedirect.com/science/article/pii/S0921344917300228
37 Bai, Xuemei, et al. 2018. Six research priorities for cities and climate change. Nature. Vol 555.
38 Bhowmik, A.K., McCaffrey, M., Frischmann, C., Gaffney, O., Ruskey, A., 2018. Powers of 10: A framework to optimise implementation of climate action strategies from individual to global scales. in preparation.

the extensive research in marketing and product design to increase consumption is not presently balanced with research to reduce excessive consumption. There are behavioural barriers, mindsets, confirmation biases and ideologies that are resistant to fact-based information. Alongside research on more durable and recyclable products, a major new effort is needed on how to motivate simpler, less material lifestyles. Another example is the impacts of the spread and consumption of IT products and networks, enabled by science and technology. The economic sciences are challenged to design alternative economies that are socially just, altruistic and cooperative, create employment, and reduce poverty and inequality.

Additional resources

The IAP's interregional study on Food and nutrition security and agriculture (FNSA) (2016-2018) takes an integrative food systems approach to encompass growing through to processing, transporting, trading, purchasing, consuming, and disposing of or recycling food waste. Regional reports have been published for Europe (2017), Asia (2018), the Americas (2018) and Africa will follow in September 2018, together with a global synthesis report in late 2018.

The national science academies of EU Member States (EASAC) have published two reports on the Circular Economy (2016). One report looks at indicators for a circular economy and how to measure its performance, factoring in basic drivers for the transition from a linear to a circular economy. The other report explores priorities for critical materials for a circular economy, and how to improve their recycling rates.

The Global Young Academy has published a report on municipal solid waste management and green economy (2016), providing a young scientists' perspective on moving towards a green economy by prioritising waste avoidance, minimisation and promoting the "Three Rs" (Reuse, Recycle, and Recover). It includes examples of successful public policies, business models, green investment opportunities, innovative approaches and case studies.

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Biodiversity and ecosystems are critical for human well-being: they provide our food, water, energy, clean air, they regulate the climate, they provide social cohesion. There cannot be development without protecting biodiversity and ecosystems. But biodiversity continues to be lost, at an alarming rate because of land use change, unsustainable agricultural and forestry practices, urbanization and other drivers. We are taking these benefits at a rate far faster than nature can replace them. Climate change is becoming a major threat to biodiversity and the many contributions of nature to people. In the Americas for instance, there is today 30% less biodiversity than at the time of the European settlement, under business as usual, this could go up to 40% by 2050. In Asia, under a business as usual scenario, 45% of biodiversity could be lost including some extinction by 2050, with no exploitable fish stocks, and up to 90% of coral reefs will be severely degraded.

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Protecting biodiversity and ecosystems is a development issues that need to be mainstreamed in all areas of policy. Opportunities for action include the development of protected areas, and the restoration of degraded lands, behavioral and institutional change to shift our consumption and production patterns, sustainable agriculture and forestry, appropriate use of technology, and a transition to low-carbon economies. These are some of findings of the most comprehensive assessment of the state of knowledge on biodiversity and ecosystems services at regional scale to date released in March 2018 by IPBES, the Intergovernmental Panel on Biodiversity and ecosystems Services, now counting 129 member states, based on the work of 500 experts reviewing more than 10,000 scientific publications.

Achieving SDG 15 is closely linked to achieving other SDGs. There is evidence that achieving targets in SDG 15 is strongly linked to achieving other targets. For example, achieving sustainable management of forests (target 15.2) has strong positive links to ending extreme poverty (target 1.1), sustainable food production systems (target 2.4) and improve water quality (6.3). However, there were many targets for which there is still great uncertainty about the strength of links between different targets. To ensure that SDG 15 can be met, and contribute fully and efficiently towards meeting other Goals, both within the theme of Transformation towards sustainable and resilient societies, and across all Goals, we need to have a much better understanding of how it is actually linked to other goals. This will help to identify targeted actions can address more than one goal where possible, as well as targets that may be difficult to achieve simultaneously.

Rapid urbanisation, particularly in developing nations, and the increase in demand from increasing urban populations have the potential to put considerable pressure on the achievement of Goal 15. The ecological footprint of urban areas extends into terrestrial ecosystems, having profound impacts on natural resources and land degradation. Within cities themselves, biodiversity is under threat from a continued loss of greenspace, air pollution, and increasing human population. As such, urban policies can have direct impacts on the achievement of Goal 15.

The process of urbanisation, happening at great pace in many developing (and some developed) nations has the potential to destroy terrestrial ecosystems as they are displaced with urban land-use. The fragmentation of natural ecosystems can have a great impact on populations of vertebrates (especially near the edges of forests). Even where not directly impacted by urbanisation, increasing consumption of food and agricultural products by increasing urban populations is driving deforestation and placing further pressure on natural ecosystems. Therefore, consideration of the urban metabolism, in an interdisciplinary manner, is essential to ensure future urban sustainability. The provision of urban greenspace has the potential to alleviate flood risk in urban areas, reduce heat stress during extreme temperatures, combat urban air pollution, and also support urban biodiversity. For example, Newcastle University hosts a green infrastructure facility as part of the Urban Water Hub UK's Collaboratorium for Research in Infrastructure and Cities. This integrated urban laboratory allows the examination of the quantified benefits of green infrastructure, measured through a cutting-edge system of sensors, to improve urban resilience, to improve local planning and investment decisions. Such green approaches to reducing risk to future extreme weather events could allow multiple co-benefits, in terms of improved habits for urban ecosystems.

The global supply chains feeding demand in cities have the potential to threaten achievement of Target 15.8, as a large number of invasive species arrive via trade and consumption in urban areas. Global shipments of food and timber products in particular can

lead to an increase in invasive species. Target 15.9 calls for the integration of ecosystem and biodiversity considerations in local planning, something which is crucial in urban areas as well as rural.

Forests cover about one third of the world's total land area and are crucial to the ecological balance of the world and human wellbeing. Forests - and trees outside forests - supply timber, non-timber forests products, fuelwood, medicines, food, and clean water. They sequester and store vast amounts of carbon, influence rainfall, reduce flooding, and prevent soil erosion. Forested landscapes are important for recreation and nature-tourism, for physical and mental well-being, as well as for spiritual and aesthetic pleasure. Forests host a vast majority of the earth's terrestrial biodiversity, which provides genetic materials, potential future crop varieties, and medicines. Forest-related activities also provide employment and income to millions of rural dwellers. Forests are essential to the attainment of SDG 15 and many other SDGs.

According to a recent publication by the International Union of Forest Research Organizations (IUFRO), the long-term sustainable management of forests relies in many cases heavily on the communities and families living in or near forests. Almost a third of all forestland, an estimated 513 million ha of forests, are legally owned or managed by indigenous and local communities (RRI 2016), the majority in Latin America. Furthermore, an important proportion of publicly owned forests in Africa, Asia and Latin America are used and managed by indigenous and local communities without formal government recognition, but held under customary, community-based tenure systems (RRI 2014). There is also compelling evidence about the important role of communities in protecting forests.

Harnessing the full potential of community and smallholder forestry to achieving SDG15 necessitates progress in other SDGs and their targets that relate to the development of a supportive institutional setting, unlocking economic opportunities, the realization of education and capacity building programs and a more systematic monitoring of outcomes. Especially important in this connection are the targets under SDG16 that focus on the development of more effective, inclusive and transparent institutions, and ensuring participatory and representative decision-making at all levels, as well as the targets under SDG1, SDG2 and SDG5 that relate to ownership and secure rights to land and forests and equal rights to land and resources.

Progress towards SDG15 also hinges on the opportunities for local forest stewards to earn a decent living. Increasing incomes from sustainable forest management and protection can be supported by better inclusion of local actors to profitable value chains, support to micro-, small- and medium-sized enterprises, better access to markets for the large diversity of forest and tree-based products and development of markets for forest ecosystem services. These issues are also addressed in the SDGs and specific targets. Progress in them provides opportunities for important synergies supporting the achievement of SDG15. IUFRO's Project on "World Forests, Society and Environment" is currently in the process of conducting a holistic multi-disciplinary scientific assessment of potential and anticipated impacts of efforts to achieve the SDGs on forests and related socio-economic systems. The assessment also considers how the implementation of the SDGs can transform existing forest-related development scenarios and positively affect the roles of forests in sustainable development in the future.

Forests contribute to increasing resilience towards the negative impacts of ecological and economic shocks and building more resilient livelihoods and living environments for both rural and urban populations. With climate change and increasing occurrence of extreme climatic events the importance of these contributions is likely to further increase. Halting forest loss and degradation and strengthening sustainable management of forests and tree resources are essential for ascertaining the continuous provision of forest ecosystem services and for the development towards sustainable and resilient societies.

Addressing competing land and resource uses require landscape approaches and inclusion of the interests of different stakeholders through participatory planning and decision making, including through forest landscape restoration (FLR). With an estimated 25% of the global land surface degraded to some extent, and about 15% considered appropriate for FLR, there is significant potential for restoring forest landscapes at a large scale. However, given the scale and complexity of FLR challenges worldwide, there is a clear need to further enhance the collection and synthesis of scientific knowledge from different regions aimed at gaining new insights and promote interactions.

Other resources

- EASAC's report on Multi-functionality and sustainability in the EU's forests (2017) provides recommendations for sustainable forest management in the EU that deliver optimal social, environmental and economic benefits. The report looks at synergies and trade-offs in the way in which the interaction of forests is managed within climate change mitigation.
- Also pertinent to Goal 15, EASAC's report on Ecosystem services, agriculture and neonicotinoids explores the use of neonicotinoids and their effects on a range of organisms that are important for pollination and natural pest control, as well as on biodiversity. See also IPBES's assessment of pollinators, pollination and food production.

3. The role of science and technology in supporting SDG implementation

The multiple and multidimensional interlinkages and tensions between the SDGs require integrated approaches to identifying these linkages, and stronger collaborations between researchers, policy/decision-makers and practitioners to collectively identify research questions and levers for policy and business action, and incentives that resonate with stakeholders. Integration underlies the SDGs. Integrated actions and solutions are needed now, and we need new approaches to problem solving and new kinds of partnerships to help make these happen.

Implementation of the SDGs requires access to, and the application of, the best available evidence from the global community of knowledge providers and practitioners. Independent expert advice is a vital part of evidence-informed policymaking, at national, regional and global levels of decision-making. So a key recommendation must (continue to) be to strengthen the science-policy interface at all of these levels.

Major advances in science have increased our understanding of the Anthropocene – the age of humans – where, in an interconnected world, escalating environmental changes interact and connect across scales with large social and economic shocks, triggering feedback loops, and increased exposure to new types of risk. This calls for a way to rethink and reshape

development. The Stockholm Resilience Center synthetize insights from resilience science that point to the need to:

1) **Change our approach to change**. Change is everywhere and everything is changing. We cannot control it or withstand it and need to develop through and with change. Change can also be an opportunity for renewal and reshaping development.

2) **Cultivate resilience capacities to develop with change.** Important structures, processes and abilities which exist at multiple scales from individuals to the global economic system, are required for learning, adapting, renewal, re-organization or transformation. Within these a diversity of social, ecological, financial, technical, and institutional components is key in creating and maintaining desired outcomes in the face of change.

3) **Account for systemic shifts and surprises.** There is growing evidence that systems do not always respond in an incremental way to increasing external pressures. Beyond a critical threshold or tipping point, very large and often rapid and irreversible changes occur.

4) **Recognise that people, place and environment are intertwined and determine resilience capacities**. Many of the challenges or failures of development are reinforced by a lack of recognition of the interactions and feedbacks between people and their environment, which undermines resilience capacities to develop with change. Recognising and strengthening these relationships will be key to achieving resilient, sustainable and just futures.

5) **Shift towards transformational change and its specific capacities.** Absorbing or adapting to change is insufficient to achieve the SDGs in the Anthropocene and instead more radical and transformative changes are needed to shift development onto new pathways. Transformation requires new capacities, different to, and sometimes conflicting with absorptive and adaptive capacities.

6) **Recognise and govern global and cross-scale dynamics**. The resilience of individuals, groups and communities is tightly coupled to global and cross-scale drivers and dynamics such as migration, trade and climate change which underlie development challenges and emerging risks, and will shape development interventions and their outcomes.

7) **Reconnect and reconfigure human-environment relationships**. Transforming to sustainable and resilient societies on a resilient planetary life support system will require new and more diverse capacities including social norms, behaviour, markets and value systems underpinning human-environment relations that shape important variables, such as consumption, key to efforts to achieve the SDGs.

8) **Rethink innovation and scaling approaches.** There is a need for new types of social-ecological innovation and scaling approaches that are appropriate for and address key challenges of the Anthropocene.

9) **Design flexible governance systems fit for the Anthropocene**. Current approaches to decentralized, centralized and multi-level approaches have not always lived up to the promise and alternatives are needed that are able to influence cross-scale dynamics of the Anthropocene, not just react to them.

10) **Emphasise local contexts and their cross-scale intersections to ensure transformations that are equitable, sustainable and just**. Approaches for responding to the ways different social-ecological contexts and factors, power dynamics and lived experiences intersect with and are constituted by one another across scales are important for identifying opportunity contexts for transformation. These approaches consider both how to empower those that are marginalized, while also considering the structures and power relationships that create marginalization.

Science and research will need to become increasingly solutions-oriented to support SDG implementation. Being solutions-oriented means working on specific challenges at the local level through place-based initiatives and, at the same time, generating comprehensive approaches and methodologies, putting local solutions within the context of the global challenges and anticipating the tradeoffs that local solutions may have on other locations through displacement or spill-over processes. Successful implementation of the SDGs requires local results to be upscaled by drawing commonalities between the diversity of local challenges and connecting spatial scales, as trade-offs and synergies between SDGs occur across different spatial scales.

Although technology, information and tools are required to improve efficiency in most fields and practices, human behavior is an essential barrier to and opportunity for realizing SDGs. Ethics, perspectives and values plays a major role in decisions that are taken and actions that are implemented. However, for these research processes to be meaningful, effort should be focused on implementing truly transdisciplinary processes, during which representatives from a variety of disciplines and societal groups come together to exchange knowledge. The power dynamics of this research are challenging and should be recognized so that appropriate research processes can be designed. Importantly, academics need to realise that the knowledge they hold is one piece of the larger "knowledge puzzle", and not necessarily the answer.

The challenges that we face are complex and cut across scales, perspectives and processes. The research community is lagging in developing effective research methods for systems that capture relational (and some causal) linkages between physical and social variables of systems. Effort should therefore be focused on developing and testing research methods that support management of complex systems in an integrated manner. Some universities are very well connected with their local environment and local stakeholders and could play a key role in the localization of SDGs (e.g. African Center for Cities work with the municipality of Cape Town to co-create solutions for the implementation of SDGs).

Health is a compelling example. Global and local environmental changes (e.g. climate change, land use change, urbanization) are major drivers of human health. Based on the strong

scientific evidence characterising environmental change-health relationships (Whitmee et al. 2015), the scientific community needs to collaborate in new ways with the policymaking community to apply evidence-based strategies to reduce, and prevent, risks to human health. To facilitate this collaboration, there is a need **to develop and test methodologies/tools which enable the integration of environment and health data for the purposes of** (1) monitoring; (2) assessment; (3) modeling to inform near- and mid-term policy planning ; (4) identifying trade-offs and unintended consequences of decisions to help mitigate possible adverse health impacts from the outset, rather than respond to consequences alone; and, (5) quantifying health impacts of changing environmental conditions for policymakers to prioritize and internalize health in decision-making. One opportunity to implement such collaboration could be for the scientific and policy communities to co-design and execute together demonstration projects at the country and/or subnational levels, also engaging private sector and civil society actors for directly applying environmental change-health understanding into real-world practice.

Funders of research are increasingly aware of the need to develop new models that match the problems that need to be addressed. For example, the Wellcome Trust which encourages research design with a view towards end users and potential impact, stakeholder involvement throughout the projects, and an awareness of relevant social and political contexts (see for example the Our Planet, Our Health programme which supports interdisciplinary projects tackling urban health that engage not just epidemiologists, but city planners, architects etc – contributing to a solid understanding of research questions that need to be tackled and the evidence that will be relevant and have uptake).

Funders should consider models that support the following research and science:

- Research for solving Global Environmental Change (GEC) problems; not heavily grounded in theory, and integrates multiple perspectives including non-scientific.
- Projects that enable emergence and experimentation; these should be governed by flexible learning and reporting processes, instead of annual milestones that might, in fact, be inappropriate as the project and issue at hand evolves.
- Learning processes that capture ongoing changes, instead of checking milestones. Project management is often driven by logframes and reporting processes to funders, measuring progress on an annual or biannual basis. By focusing on these larger milestones, other important changes might go unnoticed. Funders should seek to develop innovative, reflexive learning and reporting processes that capture the spectrum and scale of changes.

Long-term investment in observation and information systems needs to be enhanced if we want to better understand long-term phenomena (vegetation dynamics, water cycle and their interactions with the climate, terrestrial and marine ecosystems, etc.) and design robust knowledge-based policy options and resilient policies. Initiatives are developing in this regard. For example, the AMMA-CATCH observatory, a national observation service dedicated to long-term monitoring of climatological, hydrological and ecological changes in West Africa. It provides simultaneous monitoring of the vegetation cover, the phenology and the various terms of the water balance (rainfall, infiltration, groundwater recharge, surface runoff) at various regional sites.

Scientific cooperation and research capacity building with developing countries needs continuous nurturing and address both the need for enhancing international

collaboration to support data, information, and experience sharing but also respond to local, national and regional needs and specific challenges. For example, the French Institute of Research for Development has identified a need for enhancing cooperation and capacity building in the inter-tropical regions as sustainability hotspots given the uniqueness of its climate determined by specific drivers such as the monsoon systems, the high sensitivity of its land-atmosphere interactions to climatic perturbations and their impact on several SDGs and issues such as food production, biodiversity protection, water security, etc., population movements, as well as demographic pressure couples with ecosystem degradation due to anthropogenic and climate change.

Looking ahead to the 2019 HLPF where inequality (SDG10) will be on the agenda, it is important to address inequality in access to and the use of science, in addition to the obvious concern about inequality in the distribution of wealth. Science and knowledge should be accessible to everyone, in ways that new information technologies are only now making possible. This requires an open source approach. The scientific and technological community needs to explore alternative models for funding scientific publications to replace the present intellectual property approach that excludes the poor and those outside academic institutions from access. Leaving no one behind should apply to science and technology as well as to all the other aspects of the SDGs. Besides, certain cutting-edge areas of research in science and technology are becoming so complex and expensive that only the largest and richest countries can still pursue them. Such science needs to become more international so that scientists from all countries can contribute and benefit.

The InterAcademy Partnership (IAP) – the global network of 138 academies of science, engineering and medicine - has a project "Improving scientific input to global policymaking" which focuses on how the global science community, and national science academies and their regional networks in particular, can better engage on the SDGs. On the basis of a survey of the academies, a key issue is bridging the gap between knowledge supply and knowledge demand. There is a lot of existing knowledge that is simply not being applied to the SDGs, for several reasons including (1) it precedes the SDGs; (2) it is not explicitly framed around the SDGs; (3) it is not reaching the target user – emphasizing both the lack of co-design and co-production in the system, as well as the lack of platforms for scientists and policymakers to interact (including through brokers or intermediaries).

In response, IAP has published a simple Guide to the SDGs for academies and for the growing number of national young academies to help them identify entry points within the UN system supporting the SDGs. It is also developing an online database of recent (inter)academy reports relevant to the SDGs, which it anticipates will be of benefit to the UN and development agencies.

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