United Nations Food Systems Summit 2021
Scientific Group
https://sc-fss2021.org/

Food Systems Summit Brief
Prepared by Research Partners of the Scientific Group for the Food Systems Summit, May 14th, 2021.

How could science–policy interfaces boost food system transformation?

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Executive Summary

The world's food systems must be transformed to make healthier diets more accessible for all, while increasing the sustainability and resilience of these systems, as clearly called for in the 2030 Agenda for Sustainable Development. Scientists and policymakers are among the complex set of actors necessary for this transformation. Working together, they could become a real powerhouse for food system transformation. This brief reviews the importance of the interfaces between science and policy and how these interfaces can become more active and effective. It is based on the synthesis and recommendations of the high-level event Bonding Science and Policy to Accelerate Food Systems Transformation, held on February 4, 2021, to contribute to the upcoming United Nations Food Systems Summit (UNFSS) that made a strong call to action to both the science and policy communities.

On the science side, there is a large diversity of practices and of views regarding the role of science in the food system sector, marked by a polarity, and sometimes tension, between "research-driven" and "demand-driven" research; competition among disciplines and approaches; strong private research, mainly business-focused, alongside public research focused largely on public goods; and an ongoing debate about legitimacy, excellence, and impact.

The world of policy is also diverse, including political actors shaping future visions and competing for governing roles; and public actors and policymakers, at many different territorial levels (including cities, regions, and so on) and sometimes focused on specific sectoral interests (such as education, health, and agriculture). Policy decisions are sometimes based on prevailing science, which serves as a key element of accountability and efficiency, but this is far from being the norm.

Research and policymaking interact in various ways, sometimes intensely, despite differences in the rules of the game and constraints on their respective roles. First, there is an overall relation of supervision between science and policy: research is governed and influenced by the state through continuous negotiation about orientation, budgets, and demand for creativity and freedom to explore new ideas; indeed, identifying priority food system topics for publicly funded research is a critical issue for governments and other stakeholders. Second, numerous initiatives and organizations link governments and scientific institutions at national and local levels. At the international and multilateral level, there is a growing effort to build collective expertise to formulate state-of-the-art scientific knowledge regarding specific global problems. The aim is to identify and build consensus around legitimate and efficient political actions, to be agreed at global level and implemented at all levels. Several mechanisms are at play in these interfaces, and science has provided input for policymaking processes in various domains. On the whole, science has been very influential in forming consensus views on many topics linked to food systems and, from there, the orientation of policies. However, the gap between the scientific process for producing knowledge on a specific question and the complex process of policymaking, which must balance empirical information and scientific results with management of trade-offs, political agendas, and societal acceptability, points to the limitations to evidence-informed policymaking. Furthermore, policymakers and scientists are not the only players in these interfaces; many other stakeholders play an explicit or implicit, visible or invisible role, and power imbalances among them may be strong.

To improve the functioning of these science–policy interfaces, there is a call for both science and policy actors to go beyond their conventional roles. For scientists, the recommendation is to move beyond knowledge supply and alarm-bell ringing to become real knowledge brokers, to engage with policymakers and with key food systems actors, and to promote coalitions for change to co-design the future. For policymakers, the recommendation is to make more effective use of knowledge for decision-making by inviting scientists to deliberative dialogue processes, increasing understanding of uncertainty, complexity, and the limits of evidence, and making their expectations more explicit to the science community. This will require capacity-building for both sides.

There is not one science–policy interface but rather many, at different scales, for different functions, addressing different challenges. Strengthening, connecting, and streamlining these interfaces can ensure the consistency and success of food system transformation. To improve science–policy interfaces, the scientific community should (1) generate actionable knowledge, data, and metrics to move beyond obstacles, and address trade-offs and barriers to change, including power asymmetry, path dependency, conflicts of interest, and risk and uncertainty; (2) articulate models, knowledge, and place-based innovations to design, implement, and assess specific transformative pathways—this requires specific arrangements, dialogues, and approaches, including scientific ones; (3) connect expertise mechanisms, such as scientific committees, to address multisectoral and multiscale processes for sustainable development; and (4) strengthen scientific cooperation through major challenge-oriented alliances and programs. Science–policy interfaces can play a decisive role if they are able to dovetail divergent views and overcome polarized debates and sectoral fragmentation. These interfaces must also help us to look ahead and to bridge local and global processes and actions.

Introduction

There is broad agreement—both among and between researchers and policymakers—on the need to transform food systems to make them more healthy, sustainable, and resilient. Countries have committed to this effort in the declaration on the "Future We Want" and the 2030 Agenda for Sustainable Development. Behind this agreement, however, are disagreements about what exactly needs to be transformed, the pathways of transformation, and the role of technology in the transformation process as we pursue food systems that work for the poor as well as the wealthy. First, although the transformation challenge is global, food systems are hugely diverse, context- and culture-specific, and embedded in a very complex world that is facing growing uncertainties. Thus, a solution that is viable for one context may not work in another; solutions must be custom-fit for specific situations, constraints, and the capacity to change of stakeholders involved. Second, scientists and policymakers are only two groups among a complex set of actors involved in food system transformation. Within and across each set of actors—scientists, policymakers, private sector entities, civil society organizations, and so on—there is a wide diversity of viewpoints and visions as well as diverging values, interests, strategies, and power (Resnick et al. 2018, OECD 2021a). In this complex setting of science–society relations, science–policy interfaces play a key role. Policymakers receive information from different constituencies, scientists being one of them; what distinguishes scientists is that, when they disagree, which is common, they have the capacity to say, from a scientific point of view, what is commonly accepted, what is known, where there is not consensus, and why.

Since the 17th century Age of Enlightenment, science has been viewed as the driver of progress for humanity. Scientists' and policymakers' roles were well defined: scientists would think rationally to understand the world and, in some cases, to define and solve problems and would provide input for decision-makers. Today, however, the dialogue between science and policy has become more complex (Von Braun 2018). First, the categories of actors are not clear-cut. For example, in many advanced countries, private agricultural research (R&D) is preeminent in the food sector; as a result, the private sector is at the same time a strong business stakeholder, a powerful scientific actor, and an active political lobby. Second, in practice, scientists and policymakers have different rules and rhythms, and different kinds of accountability to society. Their roles are evolving rapidly, especially in this era when the credibility and trust in science is subjected to increasing scrutiny by politicians and society as a whole. The participation of both citizens and the private sector further muddle science–policy interfaces. Citizens increasingly question food-system-related science, asking scientists to be accountable, and participate more in governing local food systems (Laforge et al. 2016, Andrée et al. 2019).

In this renewed and pluri-actors context, the roles of scientists and policymakers must evolve to meet expectations for their contribution to food system transformation. Science–policy interfaces are currently both bottlenecks to change, when they do not function well, and potential powerhouses for food system transformation when they are active and effective.

This brief describes the wide diversity within the science and policy spheres and the multifaceted nature of science–policy interfaces. It argues that enhancing the powerful leverage of science–policy interfaces requires that both researchers and policymakers go beyond conventional roles to do "business as **un-**usual." These recommendations draw heavily from the synthesis of the high-level event **Bonding Science and Policy to Accelerate Food Systems Transformation,** held February 4, 2021[1], to contribute to the upcoming United Nations Food Systems Summit (UNFSS), with the participation of the Summit's organizers. With over 40 presenters and 600 delegates from more than 60 countries representing decision- and policymakers, international organizations, civil society, the private sector, think tanks, and academics, this event made a strong call to action for both the science and policy communities (Hainzelin et al. 2021).

1. A wide variety of scientists and policymakers

On the science side

Science is a very broad concept and scientific research, or "science in the making," is one central factor in permanent transformation (Latour 1987). Indeed, scientific institutions have a specific mandate to produce certified knowledge, applying rigorous methods backed by credible theories. Scientists use specific tools (experimental methods, statistical analysis, conceptual modeling, and so on) to establish and test the robustness of their results. However, although scientific researchers follow common rules, the ways in which they work and produce new knowledge are very diverse and embedded in different frameworks. The issues and scientific questions they choose to study are shaped by the objectives of the institutions they work for (public/private research centers, universities), the kind of funding they rely on (public, private), and also their personal values and beliefs. Scientific communities and their priorities are thus shaped by the society they belong to and depend on (Merton 1942).

Moreover, scientific research is not the only source of knowledge and evidence; it is one among various "knowledge producers," and global centers of expertise, such as HLPE/CFS[2] and IPBES[3], now recognize the importance of local and lay knowledge.

Within the scientific world, there is a polarity—and sometimes tension—between "research-driven" (fundamental knowledge, mostly disciplinary approaches, exploration of the unknown, longer-term perspective) and "demand-driven" or "policy-driven" research (applied to problems to be solved, shorter-term perspective, mobilization of available knowledge through expertise). These research approaches relate to the policy

[1] Organized by Montpellier University of Excellence (MUSE, University of Montpellier) and its members (CIRAD, INRAE, IRD) and partners, in particular CGIAR, under the high patronage of the French Government, with the support from the French Development Agency (AFD) and Agropolis International.

[2] High Level Panel of Experts on Food Security and Nutrition of the UN Committee on World Food Security.

[3] Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services.

world in different ways, but they clearly inform each other: the former provides fundamental knowledge and tools and the latter works for their integration across disciplinary communities. To ensure synergy between the two approaches, both science policies and institutional support are needed.

Scientific communities are thriving in both private and public settings, but with different objectives, programming, incentives, and rewards. The private sector is focused on short- and long -term profits and aligns its research accordingly. If profits are affected by how companies conduct their affairs (for example, by possible positive or negative social, nutritional, environmental impacts) due to consumer awareness and response or due to government policy, companies will orient more of their research toward those objectives. But otherwise, sustainable and equitable food systems will likely be neglected by private sector researchers and left to the public sector to address.

Research operates in a very competitive world. Fierce competition between institutions, research units, labs, and countries can be a motor for better science even though cooperation is claimed as a necessity for tackling complex challenges. This competition is not only about funding but also ideas, prestige, and influence, and thus plays an important role in science–policy interactions. The framing of the problems to be solved (Merton 1973) affects the legitimacy of research questions and hence the taxpayer money invested in them. There is rivalry among disciplines; all scientific visions are not equal in terms of legitimacy or political influence (for example, the attention paid to economics- “the science of the princes” - *vs* other social sciences). The same holds true for scientific methods (qualitative vs. quantitative, multidisciplinary vs. transdisciplinary, and so on). There is also competition between public and private research; in agrifood system research where the private sector is significant and sometimes predominant, the question of legitimacy becomes very complex. In a quest for “excellence,” the widespread adoption of bibliometric tools to measure science quality has sometimes generated a bias that affects the integrity, credibility, and legitimacy of scientists, which further muddles science–policy interfaces.

Finally, there is a common, albeit not explicit, theory of change about the role of scientific knowledge or evidence in the emergence of change. Because scientists’ expectations can be naive when disconnected from the policy world, they sometimes expect that outstanding results, high-level publications, or breakthrough technologies should naturally flow to policymakers to shape their decisions. This is clearly not the case.

On the policy side

Of the variety of public actors working at different scales, only a fraction are effectively in charge of “making policies.” Political actors, for example, have a specific and eminent role in shaping a future vision and propositions and eventually governing, with their constituents giving legitimacy to their mandate. Their role is distinct from that of public actors in policymaking. In addition, as emphasized by the concept of governance, policymaking refers to coordination processes that involve a plurality of actors, both public and private, not just a centralized executive authority.

Food system policies are closely linked with health, land, environmental, territorial, and social policies. Their implementation is therefore dispersed across various ministries, government bodies, and administrative levels, and their coordination is an inherent challenge in advancing transformational objectives. In addition, some emerging food system challenges or problems require new thinking. For example, hunger has been understood largely as a phenomenon of poverty and poor productivity (and associated with conflict); but obesity, while also a nutritional problem, is a different issue altogether. Tackling multiple objectives at once, namely making diets and food systems healthy, inclusive, and sustainable, presents an even greater challenge for both scientists and for policymakers.

Many policies are informed to some extent by scientific knowledge, including not only laws, regulations, guidelines, and standards but also incentives for education, research, infrastructure, development, public procurement, and others. Most of these translate into budget allocations. Their scientific basis can be a key element for policy accountability, although policymakers may also have simplistic expectations of science, expecting simple, clear-cut guidance. However, science and policy are not hermetic compartments: some policymakers have a strong scientific education and background, and likewise, some scientists have experience in policymaking. The difficulty of bridging and integrating the two sides may be more about differences in the rules of the game and constraints to research and policymaking worlds than about misunderstanding each other's worlds.

2. Interfacing science and policy at different scales, in different formats

A relation of supervision: Science is governed and influenced by the state

A key science–policy interface is formed by "science policy"—the rules, institutions, and budgets that governments set to govern and shape science and innovation systems. Because of the nature of scientific research, there is constant negotiation between scientific institutions and governments to find an acceptable balance between command, control, necessity of finding solutions, and demand for creativity and freedom to explore new ideas. Balance must also be achieved in science policy among principles of intellectual freedom and property rights, open access, fairness and protection of indigenous knowledge and human subjects, inter alia, while fostering a thriving science system (UNESCO 2018). In addition, scientific advances have opened the possibility of research in contentious areas such as genetic engineering, on which countries must take decisions. Governments have responded with various policies, strategies, plans, directives, institutional arrangements, and budget allocations to address these concerns.

In agrifood innovation systems, the significant and growing role of private sector research must be recognized. Private sector spending on agricultural R&D accounted for 25 percent of all global research spending in 2014 (Beintema et al. 2020); when food research is also considered, the share of the private sector is even greater. In rich countries, private sector R&D accounted for more than half of all agrifood research in 2011, and the share of private sector R&D in middle-income countries doubled (from 19 to 37 percent) between 1980 and 2011 (Pardey et al. 2016). Although much of this growth is self-driven by companies, governments can and have promoted private research through tax rules, patent policies, public–private partnerships, and strategic allocations. Private sector research focuses mainly on development of proprietary technologies, leaving many other key aspects like environmental or social effects of the food system for public researchers. Private foundations, which also provide significant funding for public research institutions, represent a wider range of interests, including social and environmental impacts. Identifying priority food system topics for publicly funded research in this complex environment is a critical issue for governments and other stakeholders.

Public R&D in the agrifood sector is typically carried out by public institutions and universities, funded through autonomous public sources, government ministries and offices, and foundations. However, the increasing competition for funding blurs the distinction between public and private money. The public and private sectors also interface with research organizations and researchers from outside their country; science policy plays a role here as well, for example, in enabling transfer of technology, recognition of testing performed elsewhere, and so on. Smaller states and low-income countries may also find it beneficial to rely heavily on regional or global innovation systems or patent offices (Graff and Pardey 2020) as a more efficient approach to meeting demand for science.

Several key challenges in the governance of science emerge from a set of OECD country reviews of national innovation policies (OECD 2021b): lack of updated overall science, technology, and innovation strategies to guide research and development; high level of fragmentation among both providers of science and sources of funding, rendering coordination around priority research difficult; funding levels and funding models insufficient to maintain high-quality institutions and individuals; and inadequate generation of scientists through national educational systems.

Growing structuration and complexity of science–policy interfaces[4]

At national and local levels, numerous organizations and initiatives link governments and scientific institutions, reflecting a global effort to link science and society (Chabasson 2016, Van der Hove 2007). These include scientific or collective expertise committees on specific issues, tasked with providing knowledge for government policies at the legislative and executive levels. In addition, many countries have installed chief scientists at the cabinet level or have expanded experimental projects involving policymakers and scientists together, such as living labs, sometimes extending to multistakeholder platforms. The increasing number of district- and country-level mechanisms to link science and policy offer a means to share accountability.

At the international and multilateral level, there is a growing effort to build collective expertise to formulate state-of-the-art scientific knowledge in specific global problems in order to identify legitimate, efficient, and consensus-based political actions to be implemented at the global level. As IPCC[5] and IPBES did in the climate and the biodiversity domains, the experience of the HLPE/CFS offers an opportunity to mobilize scientific communities and knowledge to contribute to decision-making. Although each of these panels operates through specific modalities,[6] they are similar in the way they develop negotiation processes about critical, emerging, and controversial issues: they all bring together thousands of

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4 UNEP definition: "Science–policy interfaces can be defined as institutions that aim to improve the identification, formulation, implementation and evaluation of policy to render governance more effective by: defining and providing opportunities for processes which encompass interrelations between science and policy in a range of domains; assigning roles and responsibilities to scientists, policy-makers and other relevant stake- and knowledge-holders within these processes; and guiding and coordinating their interactions." (UNEP 2017).

5 Intergovernmental Panel on Climate Change

6 The HLPE/CFS, for example, exclusively responds to CFS requests. Its reports are not approved by governments, which has both

scientists from different disciplines and regions; they all rely on consultation and peer review processes; and they are all articulated to multilateral political arenas that relate in one form or another to the United Nations. Convening thematic teams of world-class scientists, the HLPE/CFS has been recognized as a fundamental tool for building a scientific consensus on problem formulation and elements of solutions in the food security and nutrition domain (CFS 2018, Gitz 2011). HLPE scientific reports feed into a process of multilateral negotiation led by the CFS and involving different stakeholders, including member-state policymakers, and are eventually reflected in policies. There are also a number of flourishing scientific panels, [7] some of which interact with civil society, that explicitly aim to use scientific knowledge to influence policies, some of them clearly in an advocacy role. With their well-communicated reports and recommendations, these panels are able to shape the public debate on global food system reform.

Mechanisms at play and emerging issues in these interfaces

On the whole, in recent history, science has strongly shaped the way challenges are perceived and understood. This is true in many domains (climate, environment, biodiversity, and more) but particularly true in the food system domain. More specifically, science has informed the process of policymaking through various formal channels including collective expertise, particularly consultation and scientific evaluation mechanisms instituted through legal formulation processes. Informal channels, such as the media and civil society advocacy campaigns, have also played a role when they convey solid scientific diagnostics and results.

For example, research by several scientific teams showed the importance of interventions in domains other than nutrition in reducing the burden of malnutrition. Specifically, the idea of nutrition-sensitive agriculture, promoted by Ruel et al. (2013) in the journal *Lancet*, has been very influential in forming consensus views on this topic. Based on a growing quantity of published scientific evidence, many development agencies, together with governments and NGOs launched new "nutrition-sensitive agriculture" initiatives and redesigned their logical frameworks to take nutrition outcomes into account. In follow-up, researchers tracked these initiatives, documented their outcomes—positive and negative—and raised new questions (Ruel et al. 2018). Outstanding discoveries on the linkage between nutrition and health, intestinal microbiota, the impact of agriculture on biodiversity and soil and water health, the carbon footprint of food, and the quantity of food waste and loss are other examples of the way scientific results drastically change public awareness and, therefore, the orientation of policies.

Yet there is a gap between the rigorous scientific process of producing evidence on a specific question, on the one

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positive and negative consequences, but are the basis for an intergovernmental negotiation process. The level of financial resources differs from one panel to another, as do their political anchorage in UN institutions.

[7] For example, the Global Panel on Agriculture and Food Systems for Nutrition "works with international, multi-sector stakeholders, to help governments in low- and middle-income countries develop evidence-based policies that make high-quality diets safe, affordable and accessible"; the International Panel of Experts on Sustainable Food Systems (IPES-Food) "is an independent panel of experts with a mission to promote transition to sustainable food systems around the world"; and the EAT Forum is "dedicated to transforming our global food system through sound science, impatient disruption and novel partnerships."

hand, and the complex process of policymaking on the other hand, which must balance empirical information and scientific evidence with management of trade-offs, political agendas, and societal acceptability (Gluckman 2016). This points to the limitations of the notion of "evidence"[8] in policymaking (Rycroft-Malone 2004, Saltelli 2015); evidence is not independent of power balances (Loconto et al 2019). Moreover, there is sometimes a confusion between evidence and certainty that can affect policymaking; evidence that scientists perceive to be most convincing is often the most complex and not easily digested by policymakers. There is also a potential for bias in the choice of evidence to legitimize a specific policy ex post, with possible political manipulation of the research (Soussana et al. 2021). Hence, it is important to appraise the evidence, including its limitations, using guidelines and procedures to assess quality in terms of credibility and legitimacy (for example, in the health domain, WHO guidelines).

Many analyses show the extent to which scientific evidence is framed by social and political debates. For example, the reform of Europe's Common Agricultural Policy in the 1990s was fueled by "economic" models from INRA.[9] These "scientific models" were attractive because they also converged with other stakeholders' interests (Fouilleux 2000, Fouilleux 2004).

As mentioned above, policymakers and scientists are not the only players. Many other stakeholders play an explicit or implicit, visible or invisible role in science–policy interfaces (OECD 2021a). Sometimes the concept of governance, when it involves other stakeholders (such as public–private partnerships or voluntary guidelines), becomes so broad that its legitimacy can be questioned in view of the potential for a strong imbalance in the actors' powers, privatization of public goods, and betrayal of the common good. Strengthening civil society involvement in food system governance is presented by some as part of the solution (IPES-Food 2021), and its absence as a step backwards (Canfield et al. 2021). However, the ambiguity of these relations can frustrate both scientists and policymakers and highlights the need to build capacities on both sides.

Asymmetries within and among countries in terms of scientific capacity

Applied scientific research is context-specific, and some developing countries are lacking the scientific capacity to tackle their most burning challenges (for example, climate or SDG roadmaps, UNFSS dialogues) (Beintema and Stads 2017). These countries often rely on knowledge generated elsewhere, generally in wealthier countries. Sharing such knowledge is certainly advantageous when is done through respectful, inclusive, and balanced partnerships, but there are obvious risks to relying heavily on international research to build national policies (Soussana et al. 2021). Scientific capacity is an essential driver of development (US NSTC 1999, CIRAD 2017); dependence on science produced elsewhere decreases a country's sovereignty over its own transformation and can affect the framing of national challenges, the design of development and transformation pathways and, ultimately, the relevance of solutions and citizen adherence to policies.

[8] With regard to health, Lomas et al. (2005) define evidence as "findings from research and other knowledge that may serve as a useful basis for decision-making in public health and health care." This definition was adopted by The Health Evidence Network (EVIDENT).

[9] Institut national de la recherche agronomique (French public research institute)

In food systems, there will be a range of science-providers driven by different interests and funding mechanisms; this could be a source of strong asymmetries due to power relationships. A critical challenge for governments is to coordinate and guide this diverse innovation system toward the country's agreed-upon strategies and plans. Building such strategies and plans is just the first step; maintaining coherence over the years may be a challenge, as changes of political leadership bring different visions.

3. Recommendations to go beyond conventional roles

These recommendations draw heavily from the synthesis of the February 2021 high-level science-policy event (Hainzelin et al. 2021). Enhancing the powerful leverage of science–policy interfaces requires engagement from both sides and a balance of power in their interactions.

Science should move beyond sounding alarms and supplying knowledge

Science is and will be of foremost importance in supporting the sustainable transformation of food systems. Scientific institutions have the mandate to produce certified knowledge, using rigorous methods backed by solid theories. Yet the role of science is far greater than simply providing evidence or transferring knowledge that will help in designing solutions, as scientist are well placed to convene and collaborate with key food system actors, especially managers, political actors, and policymakers, to jointly build plausible change scenarios based on their different bodies of knowledge. Scientists cannot pose as an external arbiter to decide what should or should not be done, but they should reinforce their role of knowledge brokers.[10]

When considering a specific food system in a specific territory, scientific institutions should address solution-oriented research questions in collaboration with other actors based on a common vision of the needed changes. This engagement should build the capacity to mainstream knowledge and solutions into a wider territorial development picture, with links to different relevant sectors, such as health, education, and infrastructure (Caron et al. 2017). The diversity and the complexity of interconnected pathways and dynamics of change in food systems also imply an epistemic rupture in the way most research is doing its business; rather than prescribing and transferring turnkey packages, researchers should be designing, constantly learning, contributing expertise, promoting collective intelligence, and brokering coalitions of change.

Science is expected to help in exploring and designing plausible futures, including desirable and undesired disruptions, using foresight tools such as modelling and scenario building. To anticipate and facilitate responses to shocks, monitoring and early warning systems should be put in place that quickly assess vulnerabilities across several food system dimensions and proactively dialogue with decision-makers. When change pathways are integrated at higher

[10] Knowledge brokers are organizations or individuals who serve to facilitate interactions between researchers and policymakers, supporting both groups to better understand the goals and professional culture of the other, creating better links and partnerships, and ultimately leading to improved evidence for informed policymaking" (Knight and Lyall 2013). Knowledge brokers also support researchers by translating and adapting findings to the local context (Norton et al. 2016).

scales—national, continental, or global—common constraints or challenges appear to be in the way of desirable transformation. Science must also be instrumental at these scales and contribute to transformation by facilitating agreement on a shared vision of desired changes and formulation of explicit pathways to achieve them. This means understanding the change processes (Béné et al. 2020), their patterns, power dynamics, consequences, and obstacles, and their impacts on management of shock responses and risk and uncertainty. This includes offering science-based insights into trade-offs across stakeholders, sectors, spatial levels, and timeframes, and identifying lock-ins that create path dependencies, including the issue of why scientific evidence is not being used. Science should also be able to provide a spatiotemporal perspective of these tradeoffs that integrates views from across the natural, technical, and social sciences.

Policy should make effective use of knowledge for decision-making

As most food system innovation is context-specific and takes place in complex environments, action-oriented knowledge transfer is not a straightforward linear process. Innovation must be specifically tailored to local contexts for effective brokerage and collaboration among multiple stakeholders. Consequently, it is essential that scientists participate in multisectoral transformation arrangements, for example, commissions involving key actors—policymakers, civil society, and private sector—and recommend policy actions through transparent, solution-based deliberative dialogue processes.

Given overlapping challenges and sometimes contradictory expectations, political actors and policymakers should not expect single solutions that meet all their criteria. They should strive to benefit from scientists' contributions by collaborating with the science community to ensure relevant and timely research. Novel incentives and institutional mechanisms should be explored to stimulate and strengthen dialogue and action toward positive outcomes in complex contexts. These mechanisms should be conducive to coordinated engagement of science and policy actors, while remaining open to a range of stakeholders throughout the process.

Policymakers should support the decision-making process by putting forward explicit demands to the science community to identify obstacles to food system transformation, to develop technological, institutional, and policy innovations that will promote the desired transformation, and to design progress metrics that account for the complexity of this transformation, along with the trade-offs and impacts. This will help build the dialogue process across scientific disciplines as well as between scientists and policymakers, and identify different possible, plausible, and tailored transformative pathways in a long timeframe that buffers possible shifts arising from any change of political leadership.

This mutual engagement also implies capacity building for policymakers to gain further insight into complex science-based solutions, the trade-offs, the extent of uncertainty, and the nature of scientific evidence. Scientists must also acknowledge the political dimension of scientific research and have a clearer understanding of the policymaking process, the constraints of political timeframes, divergent interests, and power asymmetries.

Enhanced science-policy interfaces founded on these principles could better ensure that knowledge—as a public good—is a keystone of food system transformation that contributes to sustainable development.

Business "as un-usual" to boost food system transformation

There is not one science–policy interface but many, at different scales, for different functions, addressing different challenges. These interfaces need to be strengthened, connected, and streamlined to ensure the consistency of food system transformation. Working with existing interfaces, rather than creating new ones, is likely the best way forward.

To meet the challenges, scientists and policymakers will have to interact in new ways: designing together rather than transferring and applying knowledge, and fostering dialogues, co-learning, and convergence rather than confrontation and polarization. This "business as ***un***-usual" would rely specifically on four pillars:

- Generating actionable knowledge, data, and metrics together to move beyond obstacles and to address trade-offs and barriers to change, including power asymmetries, path dependency, conflicts of interest, and risk and uncertainty.
- Articulating models, knowledge, and place-based innovation to design, implement, and assess specific transformative pathways: this requires specific arrangements, dialogues, and approaches, including scientific approaches.
- Connecting expertise mechanisms to address multisectoral and multiscale processes toward sustainable development; at the international level, the joint mobilization of IPCC, IPBES, and HLPE/CFS is necessary to address the interconnected challenges of climate, environment, and food systems.
- Strengthening scientific cooperation through major challenge-oriented alliances and programs, spanning public and private researchers that address priorities for food system transformation.

Without effective science–policy interfaces, transformation is hampered at a time when urgent action is crucial to design and implement healthy, equitable, and sustainable food systems. The COVID-19 pandemic has shown that a tailorable science–policy interface can be beneficial. The key challenge today is to develop effective mechanisms to actively connect scientific knowledge with policy actions through deliberative dialogue. Examples of effective interfaces are reason for optimism. But new thinking and flexible funding models, at national and global levels, are also required to enable science to respond to short-term policy needs without diverting funds from longer-term research. Strengthening scientific capacity is a critical longer-term objective requiring commitment from national governments as well as more strategic and coordinated approaches from the global scientific community, especially in view of cross-country imbalances in scientific capacity.

Now is the time to learn from and make effective use of these interfaces, while connecting them, boosting their impact, and innovating to build a desirable future. Science–policy interfaces can play a decisive role if they are able to dovetail divergent views and overcome polarized debates and sectoral fragmentation. They must also help us to look ahead and to bridge local and global processes and actions.

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