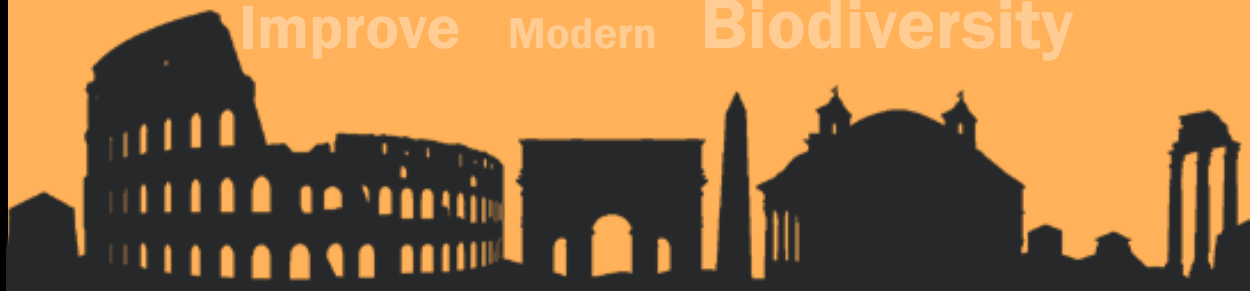
Institute on Science for Global Policy (ISGP)

Science and Governance:
The Future of Modern Agriculture

A program and conference organized, facilitated, and moderated by the ISGP with support from the Office of Agricultural Policy, U.S. Department of State

(Hybrid Format: In-person [Rome, Italy] and Internet)

September 22, 2020



Rome

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An ongoing series of dialogues, critical debates
and ongoing caucuses examining the role of science and technology
in advancing effective domestic and international policy decisions

Institute on Science for Global Policy (ISGP)

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Introduction

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and
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and
former Science and Technology Adviser to U.S. Secretaries of State
Colin Powell and Condoleezza Rice

Current Realities

At the outset of the 21st century, most societies face difficult challenges concerning how to appropriately use, or reject, the dramatic new opportunities offered by modern scientific and technological advances. Since scientific research, and the commercially viable technologies that emerge from it, are now developed globally, such societal decisions require candid domestic and international debates among leaders from governmental, private sector, and public advocacy communities. The daunting challenge of simultaneously recognizing technological opportunities and potential risks requires an understanding of how scientific achievements foreshadow transformational changes that can impact human health, global stability, and sustainable environmental and economic prosperity. These complex responsibilities are directly shaped by a multitude of societal pressures exerted by policy makers holding diverse, and often conflicting, views, priorities, and goals. Successful decisions balance real-world practicality with a recognition of the cultural sensitivities and public understanding needed to ensure that science and technology are successfully integrated into effective societal actions that merit public acceptance.

ISGP programs and conferences are designed to provide the egalitarian environments in which governmental, private sector, and public advocacy leadership can engage in intense, respectful, and resourceful exchanges of views and priorities through critical debates and caucuses aimed at identifying Evidence-Based Options (EBOs) and Actionable Next Steps (ANSs) for real-world scientifically credible decisions.

Introduction

The content of this book was taken from material presented at a conference on the Future of Modern Agriculture (FMA) organized, facilitated, and moderated by the Institute on Science for Global Policy (ISGP). The ISGP-FMA program and conference received support from The Office of Agricultural Policy, U.S. Department of State, and logistical coordination with the USUN Mission to the United Nations Agencies in Rome, Italy (including the U.N. Food and Agricultural Organization – FAO).

The ISGP-FMA conference focused on the complex and critical decisions needed to resolve how to effectively blend the principles, methodologies, and goals of agrotechnology and agroecology into modern food production and agriculture – issues that are rapidly and profoundly reshaping both. Given the increasing global demand for nutritious food, successfully identifying pathways by which to practically integrate the respective advantages of agrotechnology and agroecology *writ large,* while minimizing any potential negative scientific and cultural impacts, is a major issue on which future food production and agricultural sustainability depend. The resultant decisions are anticipated to alter human health, environmental sustainability, economic prosperity, and societal stability worldwide.

The ISGP-FMA conference assembled a distinguished group of subject-matter experts and major stakeholders to debate these issues by candidly exchanging views and priorities to be applied towards identifying the EBOs and ANSs needed to advance real-world societal decisions. ISGP-FMA conference participants, representing governmental, private sector, public advocacy, scientific, technological, and economic communities, focused on how to integrate and/or blend agrotechnological and agroecological methodologies and priorities to support effective societal decisions while fully recognizing the diverse cultural, ethical, and economic interests that often define 21st century societies.

ISGP invitation-only conferences conducted under the Chatham House Rule (not-for-attribution) provide environments in which distinguished subject-matter experts and stakeholders holding diverse, often contradictory, views and priorities can directly and respectfully debate societally significant issues of both domestic and international importance. The individuals invited by the ISGP to participate in these conferences routinely make and/or significantly influence major governmental, private sector, and community decisions affecting the public *writ large*.

ISGP-FMA Conference Format

The organization of the ISGP-FMA conference began with extensive interviews by ISGP staff (exceeding 100 for FMA) to identify highly credentialed, internationally

recognized subject-matter experts, two of whom were each invited to prepare a concise (three-page) position paper describing current realities, scientifically credible opportunities and potential risks, and policies and decisions needed to understand how agrotechnology and agroecology are shaping the FMA.

To accommodate the health and travel constraints imposed by the global COVID-19 pandemic, the structure and format of this one-day, invitation-only ISGP-FMA conference was a modification of the typical ISGP debate/caucus model. While the basic format and principles underlying the debate/caucus format pioneered by the ISGP for more than a decade were maintained, adjustments were made to convene the entire conference in one day using a blended in-person/internet format. This modified ISGP format accommodated the USUN Mission's interest to provide an in-person experience for those able to assemble in Rome while incorporating (via the internet) those not able/willing to travel to Rome. Participants from nine time zones ranging from the West Coast of the United States to South Africa were engaged.

Structurally, this modified ISGP debate/caucus format was arranged to have the two subject-matter experts who prepared the position papers be debated for one hour each (5-minute summary statement by the author followed by a 55-minute debate). The debates, moderated by ISGP staff, engaged 36 participants (about one-third of the debaters were in-person in Rome and two-thirds of the debaters were connected via the internet). Two separate subject-matter experts were invited to prepare commentaries, each of which focused on one of the position papers. Each commentary was critiqued by all 36 in-person and internet participants (as well as the position paper authors) for 15 minutes.

The final event in the ISGP-FMA conference was a plenary caucus involving all 38 in-person and internet participants that was facilitated by ISGP staff for two hours. The plenary caucus focused on identifying EBOs and ANSs.

The entire ISGP-FMA conference was conducted under the Chatham House Rule (not-for-attribution).

Through these modifications, the ISGP sought to capture as much of the spontaneity, intensity, and effectiveness of its widely endorsed in-person debate/caucus conference format while recognizing the limitations imposed by the COVID-19 pandemic and the blended in-person/internet format.

The ISGP staff used recordings of all debates, discussions, and the plenary caucus to prepare not-for-attribution summaries. These recordings were held in the custody of the ISGP before being destroyed. The position papers, commentaries, and the not-for-attribution summaries are included in this book. The EBOs and ANSs emerging from the plenary caucus are also presented early in the book.

Concluding Remarks

The ISGP-FMA conference was designed to provide an environment that facilitated candid, critical debates and discussions leading the practical, real-world EBOs and ANSs on how to integrate and/or blend agrotechnological and agroecological approaches to benefit modern agriculture. As one of the most significant societal challenges in the 21st century, finding effective outcomes is anticipated to impact essentially all societies worldwide. The ISGP remains committed to facilitating the identification of such productive outcomes while remaining neutral. All aspects of the ISGP-FMA conference conformed to the ISGP commitment to express no independent opinions nor lobby on any issue except rational thinking.

Plenary Caucus Outcomes

Preface

The two-hour plenary caucus followed the two position paper debates and the two commentary presentations and discussions. The plenary caucus engaged all participants in focusing on developing Evidence-Based Options (EBOs), and Actionable Next Steps (ANSs).

EBOs defined overarching, aspirational goals that reflected the central themes identified in the position papers, debates, commentary presentations, and discussions. Six distinct EBOs, identified during the plenary caucus, are presented below.

ANSs articulated specific tools, policy instruments, and actions that were considered to be effective pathways toward achieving specific EBOs. A total of 58 ANSs were identified and associated with specific EBOs

Themes

Several recurring and overarching themes concerning the future of modern agriculture emerged during the conference and were highlighted in the plenary caucus. These themes represent general ideas and viewpoints that are collectively found, to varying degrees, among all EBOs:

- broadening the range of, and methods by which, stakeholders engage in policy decisions;
- appropriately recognizing the impact of climate change on modern agriculture;
- enhancing nutritional benefits delivered throughout food and agricultural systems;
- significantly expanding and improving consumer education on the critical role of agriculture in societal stability and progress;
- expanding options for farmers in their selection of crops and agricultural methodologies;
- increasing market access for farmers in local, national, regional, and international arenas.

While these themes were useful in structuring the conversation, additional themes emerged during the plenary caucus itself. The plenary caucus discussion underpinning each EBO and its respective ANSs, is characterized by an annotation inserted after each EBO/ANS section.

Evidence-Based Options (EBOs) and Actionable Next Steps (ANSs)

EB01:

Increase investments supporting sustainable agriculture that equally recognize the critical importance of environmental, economic, and societal viewpoints and priorities.

- **ANS1.1:** Expand investments in agricultural producers and small and medium-sized enterprises (SMEs), including smallholder farms and family producers, while recognizing each as an independent business often having diverse commercial interests and priorities.
- **ANS1.2:** Improve policies that strengthen the institutional environments in which small farmers operate, especially with regard to financial support, governmental regulation, and consumer confidence.
- **ANS1.3:** Structure private sector environments to prioritize investments in smallholder farms and female-led enterprises engaged in sustainable agriculture.
- **ANS1.4:** Expand commercial connectivity among smallholder farmers to improve access to local, regional, national, and international markets.
- **ANS1.5:** Increase direct investment in the human resources required by farmers to engage the skilled personnel needed for sustainable agriculture.
- **ANS1.6:** Invest in local research and development addressing climate change and enhancing nutritional benefits in food products as opposed to focusing on agricultural yields.
- **ANS1.7:** Incorporate the principles of true cost accounting and cost/benefit analysis to guide practical farming decisions and investments in food systems.
- **ANS1.8:** Prioritize risk mitigation in the formulation of agricultural insurance linked to financing and investments.

EB01 Plenary Caucus Annotation

Participants highlighted that increasing both public and private sector investments is a fundamental issue for sustainable agriculture. While smaller than investments in pharmaceuticals and biomedical research, existing investments in food and agriculture arenas have provided significant returns that merit larger financial

commitments. In addition to increasing total investments in the food and agriculture arena, more targeted financial support is needed to strengthen the general ecosystems that are fundamental to sustainable agriculture. The definition of successful sustainability with regard to investment needs to reflect inclusivity (e.g., respect for cultural norms, consumer diversity, and small farmer priorities). Attention to environmental sustainability and societal stability issues remain critical elements in defining successful sustainability.

EB02:

Expand and strengthen efforts to promote opportunities based on credible scientific and technological understanding to support sustainable agriculture.

- **ANS2.1:** Invest in inclusive agricultural production methods that incorporate science-based approaches and leverage modern innovations, including biotechnology, to produce-water-and-nutrient-use efficiency, climatic resilience, as well as pest and disease-resistance to increase productivity while using less resources.
- **ANS2.2:** Increase the use and availability of e-commerce platforms and enable their use for extension services, which include demonstration gardens, to allow farmers to compare management, scientific, and technological options.
- **ANS2.3:** Provide financial and capacity building support for countries to develop national e-agriculture plans.
- **ANS2.4:** Increase research on approaches that support the harmonization of intellectual property systems and amend the Nagoya Protocol to benefit a broader community of farmers.
- **ANS2.5:** Expand the development of real-world pathways improving how scientific advances based on credible research are incorporated into the commercialization of practical technology and marketable products.
- **ANS2.6:** Lower demand-side barriers that influence the adoption of biotechnologies with regard to social norms and consumer acceptance.
- **ANS2.7:** Ensure the affordability and adaptability of scientific and technological advancements with respect to local food and agricultural priorities for effective dissemination.
- **ANS2.8:** Support multistakeholder dialogues focused on the priorities of farmers concerning investments in science and technology that support both immediate and long term agricultural sustainability.
- **ANS2.9:** Develop global protocols that address the negative impact of mycotoxins using technological advances to increase yield without further resource use.
- **ANS2.10:** Enhance educational programs for the development of personnel with agricultural skills based on credible scientific understanding, especially in developing countries.
- **ANS2.11:** Develop uniform regulation for technological adoption concerning data, data access, and transparency throughout the food supply chain.

- **ANS2.12:** Harmonize frameworks, metrics, indicators, and data concerning novel food-tech developments for holistic evaluation throughout food and agricultural systems.
- **ANS2.13:** Increase global crop and livestock diversity by strengthening the capacity of small and medium-sized enterprises (SMEs) to develop novel food products (requires revisiting Annex I of the International Treaty on Plant Genetic Resources for food and agriculture).

EBO2 Plenary Caucus Annotation

The need to expand investment in food and agricultural sustainability was uniformly endorsed, with special emphasis on the role of promoting the application of scientific and technological advances required. This emphasis was reflected in the large number of ANS recommendations focused on the importance of science and technology in advancing modern agriculture as well as supporting environmental sustainability (i.e., addressing climate change). The importance of leveraging modern innovations and productivity was also noted as a major factor in cost-benefit analyses and the harmonized metrics associated with food system evaluation.

Leveraging modern innovations is critical to optimize private sector productivity while minimizing resources. It was also noted that the failure to recognize opportunity costs of not employing technological innovations negatively affects the mitigation of climate change impacts, across both public and private sectors. True cost benefit analyses and harmonized holistic metrics are fundamental to accurately assessing the impacts of science and technology in food and agricultural arenas. A greater focus on digital transformations (i.e., e-commerce platforms) helps focus agrisystem supply chains on environmental sustainability, access to finance, extension services, and market access related to smallholder farmers.

EB03:

Transform agricultural and food systems worldwide to more effectively deliver healthy diets, nutritional value, and food security while maintaining a safe and accessible source of food for a rapidly increasing global population.

- **ANS3.1:** Strengthen evidence-based national dietary guidance, and effectively coordinate the degree of their coherence and harmonization among governments, private sector, consumers, and stakeholders.
- **ANS3.2:** Remove policy instruments which de-couple agricultural supply and demand to increase food safety, security, and nutritional value.
- **ANS3.3:** Explore infrequently utilized and under-valued crops that are potentially able to support healthy diets, safe products, and local food security: (i) develop agricultural crops with higher nutritional value, (ii) increase the use of on-farm agrobiodiversity, and (iii) focus ecological breeding and cultivar development to increase nutritional density and quality.
- **ANS3.4:** Minimize agricultural and food loss/waste throughout the value-chain with special emphasis on smallholder farmers, by expanding products from food processing normally considered of no use and clarifying communication throughout the supply chain concerning losses and waste.

EB03 Plenary Caucus Annotation

A focus on linking supply and demand issues was suggested as being an important aspect of sustainable food systems since it is intended to optimize the availability of healthy and nutritious products with consumer priorities, while avoiding food insecurity. It was noted that agricultural investment benefits from an understanding of how consumer patterns evolve especially in highly urbanized areas. In addition, consumption patterns were viewed as a valuable indicator of a healthy and nutritious agricultural system reflecting consumer priorities. Attention to the impact of decreasing food waste/loss was discussed numerous times as a factor in linking supply and demand issues.

The need to increase diversity in crops and livestock used globally supports the entry of smallholder farmers into wider markets and mitigates the risk of existing food insecurity as well as potential insecurities associated with climate change. Since the global food system currently relies on about 200 of the approximately 6,000 food varieties available, and only about nine of these are widely grown, it was emphasized that the future of food, agricultural, and nutritional security remains at high risk until more diversity is introduced.

EB04:

Expand existing, and initiate new, efforts to develop programs that support improved soil health (e.g., carbon farming), effective ecosystem services, and their respective impacts on existing and emerging markets.

- **ANS4.1:** Adopt new targets to reduce nonpoint source pollution from agriculture through the expansion of regenerative methods, best management practices, and technological innovations.
- **ANS4.2:** Incentivize farmers to implement ecosystem services by developing financially supported carbon markets that may provide direct payments to farmers.
- **ANS4.3:** Strengthen sustainability metrics and health assessments for soil that define practical goals for soil carbon content in the Nationally Determined Contributions laid out by the Paris Agreement.
- **ANS4.4:** Support sustainable forest management by incentivizing the introduction of trees into cropping systems based on the credible interpretation of agroforestry principles.

EB04 Plenary Caucus Annotation

The importance of ensuring soil health, expanding carbon farming, and providing ecosystem services in emerging markets was noted. The need for public policies that facilitate markets supporting effective carbon farming through a stable payment system was suggested, especially for smallholder farmers in emerging African markets. A focus on the details of how such public policies would be formulated, including specific incentives is critical.

EBO5:

Establish communication networks that effectively share and debate the often diverse views and priorities found among subject-matter experts (e.g., scientists, technologists, sociologists), stakeholders, consumers, and farmers required to collectively advance sustainable agriculture.

- **ANS5.1:** Increase efforts to connect private sector stakeholders with consumers via social media platforms to integrate consumer preferences in product development.
- **ANS5.2:** Emphasize the development of dialogues focused on real-world issues requiring technological solutions (e.g., crop disease, malnutrition morbidity, widespread hunger) rather than debating specific technologies themselves.
- **ANS5.3:** Increase awareness on the practical complementarity of agroecology and biotechnology.
- **ANS5.4:** Improve the effectiveness of communication regarding innovative technology applications in food and agricultural arenas to encourage the engagement of youth in agriculture as a career of choice.
- **ANS5.5:** Ensure inclusion and multistakeholder engagement of farmers, women, and youth in the formulation and implementation of governmental, private sector, and public advocacy discussions and decisions concerning sustainable agriculture and societal stability.

EBO5 Plenary Caucus Annotation

A fundamental principle needed to be incorporated into any effective communication network requires that all relevant voices are engaged and that their priorities are accurately reflected in outcomes. Formats initiated with requests for viewpoints and priorities encompassing governmental, private sector, and public advocacy positions and priorities, followed by critical debates, convened in environments that optimize candid exchanges of ideas, both in agreement and disagreement, are essential for effective outcomes. It was noted that the success of modern agriculture depends directly on communication networks that give attention to the full range of public and private sector stakeholders, including smallholder farmers.

EB06:

Ensure equality of economic access among all components of the food-supply chain and agricultural system, especially with respect to reducing systematic biases against smallholder farmers.

- **ANS6.1:** Develop transparent, rule-based international trade priorities, including the minimization of trade wars and non-tariff trade barriers, to increase market access and decrease potentially restrictive transaction costs for smallholder farmers.
- **ANS6.2:** Increase public investment and infrastructure (e.g., roads, ports, e-commerce, communication technologies, and access to information and credit).
- **ANS6.3:** Evaluate the extent to which trade policies interfere with the choices of farmers (e.g., organic regulations).
- **ANS6.4:** Establish a pluralistic system that prioritizes flexibility for farmers to choose the agricultural approaches that are appropriate to their local conditions.
- **ANS6.5:** Promote local knowledge and technology to further integrate sustainable agricultural approaches for farmers**.**
- **ANS6.6:** Facilitate the exchange of best practices by increasing access to global research results via mechanisms such as extension services and other multi-lateral platforms.
- **ANS6.7:** Strengthen youth and women-led agricultural activities and food entrepreneurship that increase productivity by developing agricultural ecosystems focused on improving the efficiency of time devoted to farming with special emphases on removing existing time constraints on youth and women engaged in agriculture.

EB06 Plenary Caucus Annotation

Stakeholders generally agreed that it was critical to invest in public infrastructure such as roads and ports that reduce market barriers and raise farm profitability for those in more isolated area. Participants elaborated that market access could be expanded by information and communication technologies for both ecommerce or access to credit. Stakeholders acknowledged that there is no one-size-fits-all solution, reminding participants of the importance of promoting local knowledge and technologies. Participants generally agreed on the need to establish systems that enable farmers to choose the right approach for themselves according to their capacities, context, and unique realities.

Concerns were raised that due to COVID-19, simple infrastructure solutions typically developed by the public sector could be overlooked. In fact, while much of the discussions focused on immediate challenges, participants were reminded of the need for an emphasis on the *future* of modern agriculture.

The Future of Modern Agriculture (FMA) Conference Agenda

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13:15 - 13:45 CET [1] (07:15 - 07:45 EST[2])	**In-Person Registration / Online Technical Start** Roma Eventi - Fontana di Trevi Piazza della Pilotta, 4 - 00187 Rome, Italy
13:45 - 13:55 CET (07:45 - 07:55 EST)	**Technical Instructions** Daniela Baeza Breinbauer, ISGP Senior Investigator; Ciarán Fitzpatrick, ISGP Fellow
13:55 - 14:00 CET (07:55 - 08:00 EST)	**Introductory Remarks** Dr. George Atkinson, ISGP Founder and Executive Director
14:00 - 15:00 CET (08:00 - 09:00 EST)	**Debate One** (**Position Paper One**) "*The Future of Modern Agriculture: Combining Sustainable Practices with New Technologies*" **Dr. Pedro Rocha**, International Specialist in Biotechnology and Biosafety, Inter-American Institute for Cooperation on Agriculture, San Jose, Costa Rica Moderator: Daniela Baeza Breinbauer, ISGP Senior Investigator
15:00 - 16:00 CET (09:00 - 10:00 EST)	**Debate Two** (**Position Paper Two**) "*The Future of Modern Agriculture: An African Perspective on Capacity Building and Financial Viability for Smallholder Farms*" **Mr. Mandla Nkomo**, Managing Director, Solidaridad Network - Southern Africa, Regional Expertise Centre, Johannesburg, South Africa Moderator: Daniela Baeza Breinbauer, ISGP Senior Investigator

16:00 - 16:15 CET (10:00 - 10:15 EST)	Break
16:15 - 16:30 CET (10:15 - 10:30 EST)	**Commentary One and Discussion (on Position Paper One)** **Dr. Jeremy Brice,** Visiting Fellow, Department of Sociology, London School of Economics, London, United Kingdom Moderator: Daniela Baeza Breinbauer, ISGP Senior Investigator
16:30 - 16:45 CET (10:30 - 10:45 EST)	**Commentary Two and Discussion (on Position Paper Two)** **Dr. Thouraya Triki,** Director, Sustainable Production, Markets and Institutions Division, International Fund for Agricultural Development, Rome, Italy Moderator: Daniela Baeza Breinbauer, ISGP Senior Investigator
16:45 - 16:50 CET (10:45 - 10:50 EST)	**Review of Plenary Caucus Format** Dr. George Atkinson, ISGP Founder and Executive Director
16:50 - 18:50 CET (10:50 - 12:50 EST)	**Plenary Caucus (Evidence-Based Options and Actionable Next Steps)** Moderator: Daniela Baeza Breinbauer, ISGP Senior Investigator Scribe: Kat Wheeler, ISGP Program Director
18:50 - 19:00 CET (12:50 - 01:00 EST)	**Closing Remarks** U.S. Ambassador Kip Tom Dr. George Atkinson, Founder and Executive Director, ISGP Daniela Baeza Breinbauer, ISGP Senior Investigator
19:00 CET (01:00 EST)	**Adjournment**

[1] Central European Time Zone (Rome, Italy)
[2] United States Eastern Time

Position Paper One
The Future of Modern Agriculture: Combining Sustainable Practices with New Technologies**

Pedro J. Rocha, Ph.D.
International Specialist in Biotechnology and Biosafety, Inter-American Institute for Cooperation on Agriculture (IICA), San Jose, Costa Rica

Summary
Agriculture is a vital activity for humanity that has positive and negative impacts. To improve its performance (e.g., sustainability, efficiency, profitability, competitiveness, climate adaptivity, biodiversity, food security), agriculture requires the integration of various production approaches, novel and existing technologies, distribution and marketing models, and the efficient operation of reasonable policies and regulatory frameworks. These collective efforts need to focus on achieving environmental sustainability and economic improvement within the framework of the United Nations (UN) Sustainable Development Goals (SDGs) via three strategic pathways: (i) science and technology (S&T), (ii) institutionality[1], and (iii) social norms.

Current realities
Agriculture develops in a context characterized by (i) a growing population with increasing demands and diverse consumption habits, (ii) extreme climatic variability (droughts, floods, and frosts), (iii) the emergence of new weeds, pests and diseases (WP&D), (iv) intense and frequent political, economic, and social changes, and (v) significant uncertainty due to the current disease pandemic. Furthermore, geographical heterogeneity and vulnerability in each of these areas mark or govern the global agricultural sector. In the face of such challenges, farmers in many countries have not been able to use available technological tools, due to factors including science unfamiliarity/incomprehension, high technology costs, over-regulation or lack of regulatory clarity, and a global debate associated with methods of production (e.g., organic, conventional, biotechnological).

These realities hinder sustainability and reduce young people's motivation to continue with farming activities. However, as S&T advancements are applied to

[1] Understood as the institutions (at local, national, regional, and multinational levels) and their instruments (policies, rules, norms, protocols, standards, statements).

sustainable agriculture, outstanding innovations also inspire the next generation to develop their lives on farms. Computer sciences (e.g., hardware, software, and internet) have generated a revolution for farming management that contributes to the implementation of sustainable agricultural practices. Digital tools (e.g., satellite/aerial images, artificial intelligence), enable improved soil and water management, precise planting, optimal use of fertilizers, and crop health vigilance in a rapid and cost-effective way. Additionally, the use of smartphones is improving farm education, crop administration, negotiation, and profitability. Although various national programs for computer literacy and improved connectivity have been partially implemented, major efforts are required to remedy many countries' weak computer and information management skills.

Biotechnology is also providing remarkable opportunities for sustainable agriculture. Some important advancements include: (i) various types of bio-inputs (e.g., biofertilizers, plant growth regulators, biological N-fixers), (ii) bioinformatics, (iii) marker assisted selection, (iv) genome sequencing, (v) precision bio-techniques (e.g., gene editing), (vi) novel food products, (vii) crop health diagnostics and management, and (viii) *in vitro* cell and tissue culture techniques for different purposes (e.g. cloning, cryo-conservation, embryo rescue, disinfection of planting material). Such advances have been accompanied by significant regulatory changes in several countries (e.g., Argentina, Australia, Brazil, Canada, Chile, Colombia, Japan, Honduras, Paraguay, United States) to address bio-inputs expansion, safe use of modern biotechnology, gene editing progress, and sustainable use of biodiversity. Thus, through biotechnological innovation, food and nutritional security are strengthened to improve food safety and quality within a framework of sustainability.

All forms of agriculture try to optimize their processes to improve productivity and reduce environmental impact through management practices aimed at reducing greenhouse gas emissions, protecting biodiversity, using residues (circularization), and rationally managing resources (from water, soil, seed and fertilizer to time, labor and money). To incorporate sustainability practices, various instruments (environmental policies, standards, and protocols) have been generated and are being implemented at both the national and sectoral levels. Despite these common goals, there is a well-known, ideological debate regarding organic agriculture and the use of genetically modified (GM) crops. The debate on this topic has negatively affected the performance of sustainable practices and biotechnology development. It has also confused both producers and consumers and often resulted in over-regulation, trade disruptions, and increased costs. Given current and anticipated global agricultural sustainability challenges, and considering the demonstrated

safety of biotechnologies, farmers need to be offered available technological options and given the opportunity to choose the most appropriate methods based on their particular situation.

Scientifically credible approaches and challenges

Although the heterogeneity of the agricultural sector is a constant, modern agriculture follows a pathway of environmental, economic, and social sustainability focused on "producing more and better" that offers the possibility of incorporating and allowing the coexistence of multiple technologies, from the empirical (traditional) to the scientific (advanced). Likewise, surrounding institutionality and societal norms become fundamental for the advancement or stagnation of the agricultural sector.

Optimal crop management in diverse ecosystems requires the progressive use of computer- and biology-based practices, regardless of the scale of production, to reach agricultural sustainability. Information and communication technologies (ICT) assist the digitalization of national extension systems, serve to implement early warning systems (WP&D, for prices and weather forecast, etc.), and reduce intermediation by improving interaction among stakeholders. Biotechnology provides technologies, processes, and products that improve energy efficiency, optimize the use of natural resources, and accelerate the production of agricultural inputs (e.g., seeds, varieties, and bio products). Regulations need to respond efficiently with the implementation of reasonable policies and standards as well as feasible, and easily understood, approval processes.

Sustainable farming practices and modern biotechnology products can be integrated while remaining complementary. For example, mitigating the impact of water scarcity in small cropping areas and under moderate-to-severe drought conditions can be achieved by increasing organic matter through minimum tillage (which is made more efficient by the rational use of herbicides); using cover crops (mainly legumes); and incorporating bio-inputs (e.g., compost, K- and P biosolubilizers, N-biofixers). However, under extreme/exceptional drought conditions, or in vast farming areas, it is necessary to adjust agri-management and use drought-tolerant seeds. Different techniques generate both conventional and GM drought-tolerant crops. In general, such specialized varieties have similar yields, but use less water (30% less for conventional and up to 70% less for GM-crops).

Regarding WP&D, there are no functional strategies for generalized application, since the various technologies for control (from biological to chemical) are dependent on multiple biotic, abiotic, and regulatory factors. In this scenario, science-based sustainable practices need to work in conjunction with ICTs and

traditional-, modern-, and precision-biotechnologies to either generate or validate temporary and long-term practical options.

Modern agriculture requires research- and extension-institutes, sectoral and social organizations, and efficient legal frameworks to respond to the current and anticipated challenges. Thus, technical- and institutional-innovation is necessary, and countries need to urgently mobilize financial and human resources, even under the current crisis. Communication and social influence have also demonstrated a powerful influence, with positive and negative effects, on agricultural development. For example, current social networks have demonstrated the ability to open markets, improve trade, and support consumers, but also to attack specific technologies (e.g., GM) without scientific evidence. Agricultural problems cause economic and emotional impacts on producers that are similar to those impacts caused by the COVID-19 pandemic. Unfortunately, societies do not readily mobilize in a timely or effective manner to address essential agricultural issues, including how social perceptions impair farmers' capabilities. Although some governments assist, in most cases, farmers are alone.

Evidence based options and actionable next steps

It would be ambitious and likely unattainable to propose a single formula for solving the complex problems of agriculture. However, the development of modern agriculture needs to forge a path of resilience, characterized by the integration of S&T, institutionality, and social norms. Specifically,

- The public and private sectors need to invest in continued research to develop and improve technologies/products that contribute to achieving the 2030 SDGs. These programs need to prioritize technologies that: (i) facilitate the rational use of natural resources (e.g., water, soil, biodiversity), (ii) improve energy efficiency, (iii) remove contaminants from crop areas, and (iv) accelerate the availability of seeds, varieties, and agricultural inputs.
- Extension institutes need to use on-site and virtual-renovated systems to expand the reach of digital agriculture solutions that make validated technologies locally and rapidly accessible to farmers.
- Regulatory systems need to recognize the importance of science-based policies to ensure the safety and innocuousness of agricultural activity and its products.
- Science-based rules and regulations need to be clear, transparent, and predictable to strengthen stakeholder confidence (regulators, developers, markets, consumers).

- Governments – with a strategic view and a financial effort – need to create or strengthen scholarly opportunities that motivate young people to consider agriculture as an important life option that allows them to improve both personal and collective standards of living, to use diverse technologies, to produce food and non-food products, and to make a responsible use of the environment.
- Governments and private sector entities need to pioneer programs for computer and scientific literacy to promote the understanding and use of technological alternatives.
- Based on a better understanding of S&T, different stakeholders need to address ideological debates (particularly on biotechnology and sustainability) in a more objective and comprehensive way, by leaving aside conceptual fragmentation, showing the challenges and the opportunities, and proposing practical actions.
- Public demonstration plots need to be established that apply organic agriculture practices and modern biotechnology products jointly.
- Transparent and efficient communication forums engaging governments, private sector, academia, and the public need to be convened to discuss the interaction of S&T, institutionality, and society in response to agricultural problems and in pursuit of improved agriculture performance.

***** A position paper prepared for presentation at the ISGP conference convened on September 22, 2020, concerning The Future of Modern Agriculture (FMA) organized, facilitated, and moderated by the ISGP with support from the Office of Agricultural Policy, U.S. Department of State.***

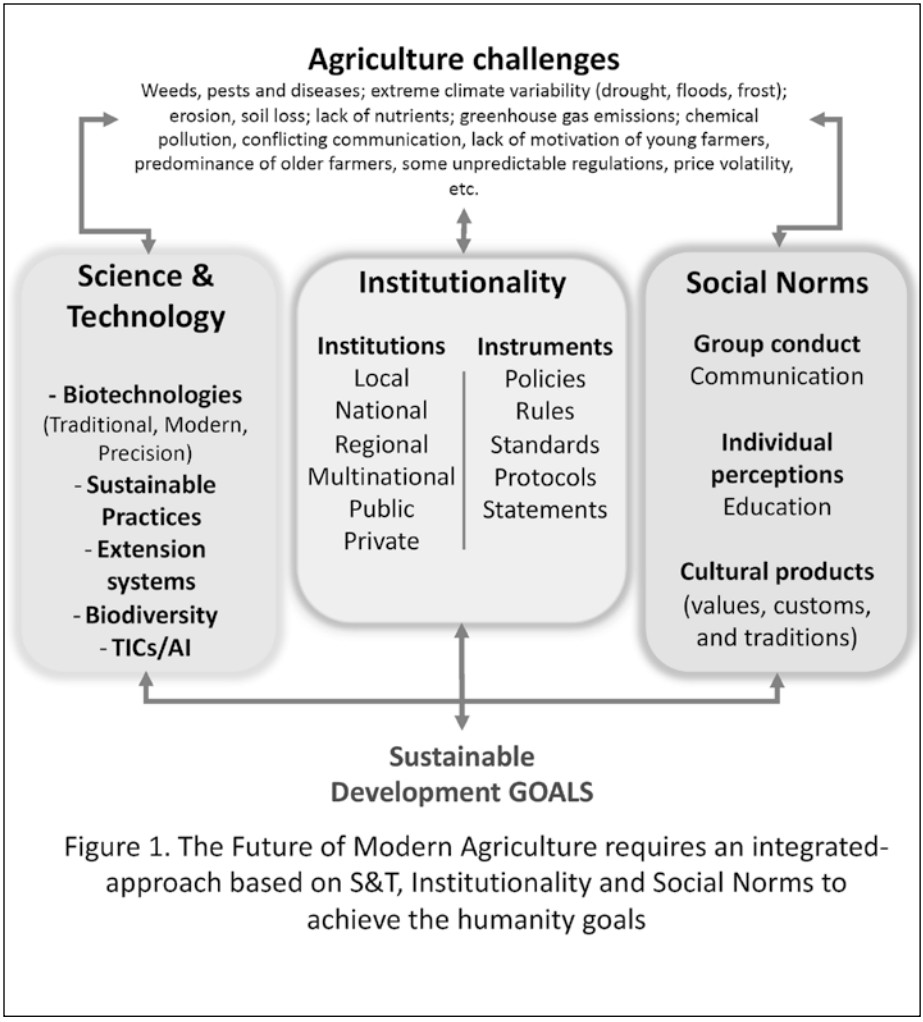

Figure 1. The Future of Modern Agriculture requires an integrated-approach based on S&T, Institutionality and Social Norms to achieve the humanity goals

Debate One Summary

This not-for-attribution Debate Summary was prepared by the ISGP staff from an audio recording, and its transcription, of the debate of the position paper prepared by Dr. Pedro Rocha (see paper above and author biographical information in the Appendix). Dr. Rocha initiated the debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 60-minute period. This Debate Summary represents the best effort of the ISGP to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Rocha and other participants. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Rocha, as evidenced by his position paper. Rather, it is, and should be read as, an overview of the discussion and exchange of views and priorities, both in support and opposition, to points expressed by all those participating in the debate.

Current Realities

It was generally recognized that several interrelated arenas need to be considered if modern agricultural challenges are to be successfully addressed, including an accurate understanding of credible scientific and technological advances, respect for diverse public (consumer) priorities based on varying societal and cultural norms, and real-world options associated with differing institutional systems (i.e., institutionality). Many elements within each of these arenas were separately analyzed, critiqued, and reconfigured to create a framework for actionable decisions based on common goals. The interconnectivity of the central issues within these arenas was the focus of much of the discussion.

Several challenges to enabling the use of innovative technologies and sustainable agricultural management practices were identified. Many of these challenges pertained to the complex nature of economic systems. Concern regarding the presence of market externalities affecting the development and implementation of specific approaches for improved agricultural systems was repeatedly expressed. In addition to concern regarding the absorption of externalities and other potential non-agricultural burdens, the responsibility for, and prioritization of, funding resources for sustainable agriculture initiatives was considered a critical barrier. Intellectual property issues were raised as an important element in any practical analysis, based on the recognition that they directly affect the priority given by the private sector to the development and application of any new technology.

Multiple stakeholders noted the importance of understanding pluralistic agricultural systems and the necessity of establishing multilateral cooperation among stakeholders, especially governments, as a practical approach to success within these complex systems. However, the perception that all stakeholders have the capacity to effectively collaborate in multilateral discussions was questioned. It was strongly suggested that some adjustments and/or revisions to the development of multilateral discussion are needed. Several stakeholders noted that farmers are consistently and incorrectly excluded from the planning of multilateral initiatives. It was strongly posited that the presence of farmers in decision-making processes was of the utmost importance.

With respect to the importance of technological choices available to farmers, some stakeholders observed that the impact of modern agricultural technologies has attracted the interest of young farmers more than those in previous generations. Despite this interest, young farmers generally do not have access to many modern technologies, often due to the cost of technologies and/or regulations restricting access. While it was acknowledged that not all technologies can be used to obtain effective outcomes on farms without significant improvements, making technological options more available to young farmers may facilitate the learning and practice that leads to the increased familiarity with which improvements are needed to underpin better agricultural outcomes.

Regarding available choices in their business practices, market access for farmers was noted as an impediment to their choices. Relatedly, noting that many countries are experiencing growing urban areas and middle-class populations, it was asserted that the balance between consumer demands for cheap food and their demand for sustainable practices may largely dictate the conflicting options available to farmers in selecting the crops they grow. It was suggested that cost considerations, which may apportion most of the financial burdens of sustainability to farmers in some regions, may shift towards consumers, given changing societal priorities concerning environmental responsibility. These societal priorities are likely to change significantly based on COVID 19 pandemic and post-pandemic realities.

Given the potential opportunities for technologies that improve agricultural sustainability, several concerns were raised regarding the application of the various existing technologies. Though multiple stakeholders acknowledged the potential benefits of biotechnologies, such as gene-editing techniques, the practical, historical application of biotechnology was questioned. While it was stated that plant characteristics beyond yield (e.g., nutritional content, nutritional diversity) are essential to sustainable food systems, it was also stated that biotechnology has not been used to address these areas. Further concern was raised that past

biotechnological approaches may have been misapplied, regarding their effects on biodiversity. It was claimed that, in practice, biotechnology has consistently reduced the biodiversity of the crops that farmers grow, both within the new species/varieties (e.g., genetic diversity) and for farm systems overall (e.g., focusing on fewer crops). Conversely, areas in which biotechnologies have reportedly improved agricultural and food system sustainability were posited. These included the affordability of farming for producers, reduced use of pesticides, reduced carbon footprints, and preserving cultivars/varieties that face extinction.

The need for a cohesive regulatory framework for assessing and approving applications of gene editing was professed by multiple stakeholders. Concern regarding the possibility of bioterrorism via genetic technological advancements was also raised. It was acknowledged that bioterrorism is an exceedingly difficult factor to account for when developing technologies and that there are many virtuous opportunities for the same technologies.

Scientifically Credible Approaches and Challenges

Uncertainty was expressed regarding which stakeholders are responsible for addressing externalities associated with specific approaches and policies for agricultural practices designed to improve environmental, societal, institutional, and health impacts. It was suggested that these decisions need to be determined situationally, through analyses at the local, regional, national, and international level. The view that resultant societal, cultural, economic, and health factors are critical elements in crafting policy decisions on sustainable agriculture was widely confirmed. In support of these conclusions, a framework for effectively encompassing the diverse challenges found in different localities was postulated. Market realities and incentives need to be viewed as separate "motivators" for implementing change, while technologies are viewed as "facilitators" supporting these changes. In combination, the interaction of these two factors can provide farmers with an expansion of suitable market opportunities.

Considering market supply and consumer demand, it was questioned whether attention on the "demand side" needed to be considered as a more important element than the primary emphasis on "supply side" previously discussed. Both are critical within any food system. The importance of considering modern consumer demands and the capacitation of quality jobs throughout the food supply chain was asserted.

The need to ensure that farming is a feasible and profitable profession for producers was frequently posited since many proposed approaches to agricultural sustainability affect farmers directly. Multiple stakeholders supported the assertion that farmers need to have flexibility in shaping their farming practices, especially

with respect to access to modern technology, management models, and market diversity. With flexibility, their priorities can be tailored to their specific situation. However, it was noted that farmers often do not have choices and it is questionable whether they will have such choices in the foreseeable future. Multiple stakeholders viewed the specific elements defining "access" as an impediment to farmer choice.

It was recognized that there is not always a "wrong" or "right" approach to facilitating and improving farming practices. Most depend on difficult choices facing the farmer (e.g., balancing agroecology, biotechnology, and organic approaches). The persistent broadcasting of both factual and incorrect narratives that dichotomize options available to farmers serve to confuse them when they are determining the best techniques, practices, and technologies for their farming experience.

Regarding farmer choices, it was posited that programs supporting diverse financial options, broad consumer communication, and market information-sharing may have a larger impact on effective decisions for farming practices than the provision of seeds. Specifically, it was suggested that giving farmers reliable market information allows them to determine which markets have demand and price incentives for specific products/commodities. Such accurate information derives from digital information, communication, and financial technologies that coordinate large amounts of data and present the results in forms that give farmers clarity in their choices. However, it was also stated that relevant decision makers and financial experts need to be involved in such processes to provide predictive risk analysis related to potential unintended results (e.g., market flooding).

It was widely acknowledged that the application of modern technologies (e.g., gene-editing, genetic modification, digital finance, digital communication) have the potential to improve both economic and environmental sustainability, but only if proper consideration is given to situational, scientific, cultural, and local/regional priorities. However, it was also acknowledged that no technology is perfect, and that mistakes have been made when approaches do not take into account the diversity of factors surrounding local, regional, national, multinational realities. It was emphasized that the specific application of a technology needs to be scrutinized rather than scrutinizing only the technology itself. It was asserted that specific challenges for sustainability (e.g., maintaining biodiversity, improving nutritional benefits) can be effectively addressed with biotechnological approaches, if relevant societal, economic, and environmental priorities are considered. Multiple approaches are often needed to support effective sustainability decisions. Biotechnologies are not necessarily the exclusive approaches needed to support sustainable farm management practices, but rather need to be considered in combination with agroecological approaches. In all these considerations for improving farmer information, it was generally

acknowledged that regulation can play an overarching and often dominant role. It was suggested that Argentina could be taken as a positive example for regulatory clarity regarding intellectual property rights, as the country reportedly experiences high levels of innovative developments among small and medium-sized companies.

Evidence-Based Options and Actionable Next Steps

Educating consumers about the realities of farming was cited as a possible way to improve value capture for producers, especially when introducing new practices and approaches to consumers that benefit the whole food system. Education that specifically corrects societal norms that romanticize the public perception of agriculture (i.e., impeding the understanding of the importance of farming) was suggested. Food production needs to be rewarded and increasing its recognition among consumers was suggested as a method of improving value capture for producers. Furthermore, targeting specific groups (i.e., legislators, regulators, and media communicators) with educational programs was suggested to improve the efficacy of these initiatives. It was asserted that transparency in the form of both positive and negative points concerning ideological disagreements related to biotechnology is a requirement. To ensure sustainability, educational programs also need to address issues that are related to sustainability after production. Food loss and food waste were stressed as especially important issues to address. Investments in, and development of, expanded farm extension services was widely cited as an important method of providing farmers with education on sustainable management practices, new technologies, and market access.

Regarding the absorption of market externalities, it was posited that the private sector could not be expected to drive all investment in technological developments. It was asserted that the recent COVID-19 pandemic has diverted societal investment in and attention to private/public initiatives for technological approaches in agriculture. It was suggested that approaches that do not require large amounts of funding need to be prioritized and that funding at both the local and national level would likely be the most important sources of financing for sustainability initiatives such as those discussed here.

The difficulty of informing farmers about their available options was identified as a major impediment to expanding the choices available to farmers. It was asserted that expanded extension systems would be necessary to demonstrate to farmers the opportunities to which they have access. Limited technology access is often traced to its affordability, particularly for farmers in developing countries. The formation of strong South-South partnerships/initiatives was proposed as an effective approach collectively addressing these issues and providing important constructive

opportunities, including information sharing using digital technology/platforms.

It was suggested that the evolution of gene editing technologies would be important for developing and increasing the benefits of sustainable management practices for farmers. Specifically, it was noted that gene editing technologies can be more easily developed by small and medium-sized companies, which improves the economic balance within the agricultural private sector. Depending on the specific application, gene editing can also effectively address issues that are relevant to a broad cross-section of stakeholders (e.g., small and large producers, companies throughout the supply chain, and consumers).

In general, the establishment of many pathways for multilateral discussions and collaborations was viewed as essential for overcoming challenges to agricultural sustainability. It was repeatedly noted that all relevant stakeholders (e.g., scientific/research, governmental, private sector, public advocacy) need to be engaged in decision-making processes, with a particular emphasis on the inclusion of farmers and farmer representatives. Farmer perspectives are critical for developing research and development planning, policy initiatives, and sustainable management practices. In addition, farmer viewpoints and priorities are critical in the promotion of specific crops/cultivars, effective consumer communication, and the development of a plethora of potential programs to address targeted sustainability challenges. It was strongly noted that the perception that contentious disagreements exist about the proper approaches to agricultural sustainability are incorrect. Such contention can become a significant barrier to discussions and initiatives. It was posited that multilateral decisions and actions engaging multistakeholders have the most impact on national and international policies. Therefore, it was asserted that multilateral cooperation is essential in the current era that has been characterized by failures in intergovernmental, intersectoral, and interpersonal relations.

Commentary One (On Position Paper One) Multiple Futures for Agriculture: Combining Technologies, Rethinking Practices, Developing Institutions**

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At the core of this paper is a powerful promise that sustainable food futures can be forged through reconciling ingrained oppositions between science and social norms, and between traditional practices and modern technologies. Moving beyond assumptions that economic development depends upon replacing traditional agricultural practices and environmental knowledges with modern technologies, it holds that: "Sustainable farming practices and modern biotechnology products can be integrated while remaining complementary" (Rocha 2020: 2).

The prospect of overcoming these divides is alluring, and there is much to like in the policy options which follow from the paper's call for greater integration between differing production practices and technologies. The paper's proposals for renewed public and private investment in agricultural research and extension programs, transparent and scientifically credible regulation, and inclusive public discussion of the challenges and opportunities presented by agricultural innovation are welcome. Meanwhile, the paper's emphasis on the importance of forging a sustainable agricultural future not only of science and technology, but of their interaction with (inter-) governmental institutions and with context-specific social norms is refreshing. Perhaps especially so for a sociologist accustomed to arguing that the practical applicability, economic effects, and political legitimacy of technological innovations are contingent upon how they fit into, relate to, and reconfigure the social institutions, practices and infrastructural arrangements which prevail in specific sites of application. As such, the paper's suggestions that "farmers need to be (…) given the opportunity to choose the most appropriate methods based on their particular situation," including "the possibility of incorporating and allowing the coexistence of multiple technologies, from the empirical (traditional) to the scientific (advanced)" hold considerable appeal (Rocha 2020: 2).

While such tolerance for technological multiplicity is attractive, it does pose its own challenges. As the paper rightly notes (Rocha 2020: 3), if the effects and

implications of technologies depend upon the situation in which they are put to work, then it is "likely unattainable to propose a single formula for solving the complex problems of agriculture." This implies that it will be necessary to determine anew in each local context: (i) whether each invention needs to be applied, (ii) which interests, policy objectives, and social values are likely to be advanced (or jeopardized) by its introduction, (iii) and in what ways it needs to (or not) be combined with existing practices.

This task requires a pluralist global food system capable of tolerating diversity in technologies and production models, and it sets high expectations for governance systems. Notably, it is likely to demand approval processes and regulatory institutions capable of both weighing scientific evidence about the safety and environmental impacts of new agricultural technologies and facilitating open exploration and evaluation of their social and economic consequences. The numerous techniques of anticipatory governance and public engagement used in recent decades to regulate technological innovation – from foresight exercises to public dialogues and citizens' assemblies – provide indications of how such arrangements might operate. However, they remain disproportionately the preserve of well-resourced state agencies in the Global North, and achieving the paper's vision is likely to require development of both institutions and governance instruments suited to a wider range of both national and subnational contexts. The paper's call for regulatory transparency and active public engagement in debate provide solid foundations upon which to build such institutions. Yet it could go further in explaining how such decision-making institutions might accommodate differing visions of the goals of agricultural reform and mediate between stakeholders whose interests are bound up with different trajectories of technological development.

In the presence of contradictory goals, interests, and beliefs, forging legitimate and consensual responses to controversial technological developments is likely to require democratic accountability in and control over regulation – and perhaps upstream public participation in the development of research agendas – in addition to transparency and debate.

***** A commentary prepared for presentation at the ISGP conference convened on September 22, 2020, concerning The Future of Modern Agriculture (FMA) organized, facilitated, and moderated by the ISGP with support from the Office of Agricultural Policy, U.S. Department of State.***

Commentary One Discussion Summary

This not-for-attribution Summary of the discussion was prepared by the ISGP staff from an audio recording, and its transcription of the discussion of the commentary prepared by Dr. Jeremy Brice (see commentary above and biographical information of the author in the Appendix). Dr. Brice initiated the discussion with a two-minute statement on the position paper prepared by Dr. Pedro Rocha and then actively engaged the conference participants, including the position paper authors, throughout the remainder of the 15-minute period. This Discussion Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Brice and other participants. Given the not-for-attribution format of the event, the views comprising this summary do not necessarily represent the views of Dr. Brice, as evidenced by his commentary. Rather, it is, and should be read as, an overview of the areas of discussion that emerged from all those participating in the discussion.

Overall, the discussions focused on (i) stakeholder inclusion, (ii) farmer choice, (iii) the power of consumer preferences, and (iv) the current state of science-policy interfaces. The position paper debates were acknowledged to have moved beyond assumptions that economic development depends on replacing traditional agricultural practices with modern technologies, and rather to emphasize the importance of including authentic local voices in the framing of questions and setting of priorities for agricultural research and development. While the limitations of early stage technological benchmarks (e.g., genomic modifications) were noted, it was also recognized that assuming the presentation of credible results to different people would lead to common conclusions and broadly supported, practical societal decisions.

There was general support for the goals and policy options in Position Paper One, and specifically of the suggestion that farmers choose a specific agricultural method to pursue based on their individual situation. It was underlined that local ecological and societal conditions *writ large* need to determine which new agricultural methods are integrated with existing practices. Effectively integrating diverse policies with existing cultural norms was acknowledged as a difficult, but important task. Ensuring the primacy of democratic, accountable decisions as an integral part of existing local priorities was viewed as critical to promoting a harmonized, standardized global food system. The paradoxical barriers of

encouraging government institutions to support global diversity in technology and production against the contravening pressure for farmers to harmonize agricultural practices with international standards and consumer preferences were recognized.

Immediate and opportunity costs associated with every agricultural, farming decision, especially for farmers facing severe physical and financial constraints, places a premium on how choices are prioritized. In addition, the emerging constraints represented by changing environmental conditions and shifting consumer demands for traceability in food and agriculture further complicate the prioritization process. Providing farmers with accurate, timely information remains the critical element needed to support effective decisions within the context of local conditions. The asymmetry of such information among developed and developing countries (where institutional constraints limit the capacity to analyze and/or use the information) was important.

The minimal information on how, and by whom, options offered to farmers would be defined was considered as a problem, since controversies regarding biotechnology application (and technology in general) often focus on what specific techniques need to be developed and made available for particular localities and agricultural challenges. These controversies are often inhibited by a confusion over who needs to significantly influence and control these decisions. Improvements need to be made in the procedure defining technological choices and shaping the final decisions. Models for how to engage the relevant stakeholders at local, state, and national levels can be found in numerous countries that regularly include authentic voices from agricultural and farming communities.

The questions on how consumer preferences can be validated and leveraged to create a framework of best practices revolved around the recognition that consumer preferences studies on technologic innovation are often flawed because individuals do not necessarily understand the technology itself, or how to use it. Consumers may express concerns about the safety of genetically modified food, but neither credible scientific data nor purchasing behavior results validate or confirm these opinions. Consumer preferences can greatly influence the value chain throughout a food system as purchases among retailers, processors, and farmers are made. Since consumer choices are often not determined by preferences, but rather by the availability and practical marketplace options, actual consumption measured by surveying consumer behavior routinely differs from stated preferences.

Questions were raised concerning what programs exist and what changes or additions are needed to improve the impact of credible scientific information on real-world policy decisions. Expanding the involvement of non-scientists from throughout the affected communities (e.g., existing regulatory panels) and the

inclusion of farmers, private sector representatives, and agricultural researchers in citizen assemblies, establishing agricultural extension services, and policy discussions is needed. These activities conform to the view that an umbrella of "stakeholder engagement approaches" is essential to improve how institutions mediate among stakeholders with diverse interests and values concerning technological innovation. Support was expressed for a consensual model in discussions of congregational technologies based on emphasizing the transparent, open debate needed to ensure democratic accountability in the formulation and execution of regulation.

The research and development of biotechnological products is expensive and time consuming and requires input from many different end users in the allocation of resources, the efficiency of which depends on support from all relevant stakeholders (e.g., investments are ineffectively channeled into developing a genetically modified crop that are not well adapted to specific conditions for an end user). The detailed involvement of farmers in the allocation of resources was generally considered to be especially important since diversity in goals directly impact the effectiveness of efforts to standardize food systems. Standardization needs to support regional, subcontinental, and continental priorities. These decisions need to include citizen assemblies to successfully support technological developments and overcome misunderstandings from those with values and beliefs that do not match available scientific evidence. These individuals need not necessarily represent vested interests but must to represent a diversity of perspectives held among consumers. The use of credible evidence, rather than knowledge-deficit, authoritative viewpoints to engage these individuals can encourage clarifying debate amongst themselves.

It was noted that fragmentation throughout the food and agricultural systems occurs when scientists, farmers, and policymakers retreat to their respective areas. A more structured, ongoing science-farmer-policy interface is required to resolve disagreements and diverse perspectives to obtain meaningful, practical decisions. Since few such platforms exist, it was generally agreed that efforts are needed to form bridging programs (perhaps emulating ISGP programs) among developed and developing countries that function continuously outside of the formal ministerial frameworks. While, historically, farmer cooperatives effectively drove agricultural research in the global North, reduced financial resources have diminished their impact. Revitalizing their role could provide an ideal platform to expand multi-stakeholder engagement.

Position Paper Two
The Future of Modern Agriculture: An African Perspective on Capacity Building and Financial Viability for Smallholder Farms**

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Summary

There are three distinct eras of African agriculture: The Precolonial, Colonial, and Post-Independence Periods. Each period has had distinct characteristics in terms of organization, productivity, use of technology, and focus of attention. Now, African agriculture is poised for a new epoch, which will be driven by new continental realities and demands as well as global imperatives. To achieve a future of modern agriculture in Africa that is ecologically sound, climate-sensitive, and socially empowering, five areas must be priorities for the future: (i) natural resource use efficiency, (ii) integrated livestock systems, (iii) leveraging technology, (iv) human resources, and (v) glocality[1].

Current Realities

At a continental level, Africa is experiencing rapid population expansion, urbanization (to reach 50% within a decade), and accelerated economic growth that will increase the population of middle-class consumers, who will inspire dietary changes. Within these contexts, Africa's agricultural sector still provides livelihoods for most of the population but has yet to demonstrate a model that raises people out of poverty. This crisis is compounded by an equally pressing challenge of climate change, which finds most of African agriculture ill-prepared. Consequently, efforts to define the future of modern agriculture must address endemic poverty, in both the countryside and in urban centers, in a climate responsive manner.

The COVID-19 global pandemic has pointed to a now irrevocable fact that the world is interconnected. Therefore, when reimagining the future of modern agriculture in Africa, global realities must come into play. It is a reality that Africa

[1] "Glocality" refers to finding a balance between what is good for the global and local agricultural sectors.

must feed the world in addition to feeding itself, so global food security will have a significant impact on how African agriculture progresses into modernity. The imperative for feeding the global population of 9 billion in 2050 must be balanced with Africa's local needs and the needs of her farmers.

Africa's agricultural "scorecard" over the last decade makes it clear that transitioning to modernity will be a demanding task. Under-productivity in essential grain crops, inadequate adoption of technology (e.g., irrigation), insufficient use of improved inputs (e.g., soil nutrition correction tools, productive seed varieties, crop adjuncts), and low mechanization levels (e.g., tractors/km^2) all present urgent challenges. Governmental investments in agriculture, based on the Maputo and Malabo declarations, remain suboptimal. Financial flows into agriculture in the forms of infrastructure, equipment, and inputs finance are far from adequate.

Furthermore, Africa's "food-energy-water nexus" is out of balance. Energy needs are driving high rates of deforestation, which in turn impacts land degradation, and ultimately results in reduced flow rates in African rivers and waterways. A vicious cycle is playing itself out.

Scientifically credible approaches and challenges

Despite these bleak realities, there remains an opportunity to reimagine the future of modern agriculture on the African continent that is ecologically sound, climate-sensitive, and socially empowering. Five areas can be highlighted as priorities for the future:

1. Natural resource use efficiency: All of agriculture's future depends on the optimal use of natural resources (e.g., water, soil, biodiversity, renewable energy). Although Africa has significant under-utilized water resources and fertile land, land degradation and limited use of water-saving techniques suggest that Africa might not be able to deliver on the promise it holds for the rest of the world. While most farmers use rainfall for their row crops, expanding productivity in Africa will require the use of efficient irrigation technology (e.g., micro-irrigation). Scientific studies have mapped and classified Africa's agricultural soils, creating a basis for improved soil health management. For sustainable growth, more tools must be available to farmers, including smallholders, to monitor and manage soil health.

The UN Food and Agricultural Organization (FAO) indicates that dietary choices are limited to no more than 200 out of 6,000 cultivated food crops globally (2019). Out of these 200, only nine are responsible for 66% of total crop production. Maize, for instance, uses 500-800mm of water in a typical growing season, while less commonly grown crops like sorghum/millet use 450- 650mm. Promoting such alternative grain crops may give the world a chance to meet its nutritional

requirements. Over 100 orphan crops with the potential to support diets and incomes for African farmers have been identified.

A shift from fossil-based energy holds promise for African agriculture. The industrialized agri-food production model driven by external inputs is not the future. This system unduly pressures small farmers and ecosystems. Ecologically sensitive approaches, focused on soil regeneration and utilization of agricultural waste for energy, are needed for improved sustainability.

2. Livestock integrated systems: Much of the focus on agricultural development is directed at crop production systems. However, to achieve balanced ecological outcomes, sustainable crop- livestock mixed systems that work in tandem need to be implemented. In Africa, cattle and small stock help counteract rangeland degradation and invasive plants. OXFAM (2014) indicates that, in addition to crop/ livestock diversification and crop rotation, animal manure application contributes to integrated soil management, a key concept within agroecology.

3. Leveraging technology: The last century has brought incredible technological advances in biological, digital, and physical sciences. Genetic modification, mobile telephony, nanotechnology, and other advances have created opportunities to foster genetic advancement, quicker exchange of information, and precision delivery of nutrients. In the finance and infrastructure spheres, a balance must be struck to create alternative technology pathways. Secure and traceable fintech advances have revolutionized credit profiling for smallholder farmers, access to funds via digital platforms, and efficient distribution of insurance services. Business models like Uber demonstrate that access trumps ownership of high value assets (e.g., homes, cars). Through this approach, infrastructure (e.g., silos, processing facilities, production facilities like high-tech greenhouses) can be accessed on a pay-as-you-use basis, creating an investment case for capital-holders to build new business models. As margin pressure across agricultural supply chains increases, efficiency improvements become crucial. Technologies like blockchain are needed to improve transparency in supply chain connections by bettering traceability and impacting cost structures across the supply chain.

4. Human Resources: Without a human pipeline of talent, agri-food systems will be in trouble. Barriers impeding the adoption of new agricultural approaches across Africa include ageing farmer demographics, poverty, and gender, racial, and ethnic discrimination. For example, women generally participate in providing labor, but not in income sharing. Therefore, the future of African agriculture must allow and encourage women to participate in the sector fully as creators and sharers of value. Active discrimination in countries like South Africa and Zimbabwe shows that

great odds must be overcome to deliver inclusive and equitable agricultural systems.
5. Glocality: For its multi-annual strategic plan (MASP III), Solidaridad has noted an existential threat to the principle of sustainability. For all the talk of sustainability by CSOs, corporates and governments, nothing fundamental seems to be changing locally. Globally, the agricultural sector must address inequalities by improving profitability for producers through better access to global markets and forward integrations. Locally, it must promote healthy food production, effective rural services, and policies that strengthen rural-urban food systems. Furthermore, the pursuit of sustainable, field-grown food systems will be impelled by competition from novel and alternative food sources. A radical new path that recognizes global imperatives while ensuring local sustainability must be charted. Understanding glocality will help to find a balance between what is good for both global and local agricultural sectors. Agriculture will only be saved if it strikes a sustainable path towards this balance. The time for action is now!

Evidence-based options and actionable next steps

It is key to note the intensely challenging influence of cross-cutting issues among these five key areas, including persistent poverty and underlying discrimination. Sadly, there is still pervasive poverty associated with agriculture, especially in Africa, where as many as 75% of food producers live in poverty. The only way to change this is focusing on living income, not the narrow measures of yield or price. This will require deliberate action, going beyond rhetoric and tokenism towards real action. Agriculture cannot afford to leave behind more than half of its population if it is to succeed: Focus needs to be placed on raising the floor, as opposed to raising the bar.

- Development experts need to introduce technologies that enable (i) efficient irrigation without requiring expensive infrastructure like centrifugal pumps and filters (e.g., N-Drip), and (ii) large scale use of subsurface drip installations in crops like maize and sugarcane to replace flood irrigation to reduce water and energy use while increasing productivity.
- Agricultural technologists must introduce remote sensing systems (e.g., satellite technology) to measure soil moisture and provide efficient advisory services that will support water conservation (e.g., Vandersat). Soil scientists need to facilitate quick (24 hours), affordable ($10), accurate, and accessible digital soil testing for farmers to improve soil health management.
- Seed companies, government extension services, and farmers need to establish collaborative programs that promote and enable the use of the 100+ orphan crops with potential to improve diets and incomes and end the "single-crop narrative."

- Government services and the private sector need to develop circular economies by leveraging agroecological practices including: aquaculture; biochar; composting; holistic planned grazing; no-till; pasture cropping; perennial cultivation; and silvopasture, to support regenerative systems that improve waste/pollution elimination, product/materials utility, and soil organic matter biodiversity/content to improve carbon sequestration and water cycles.
- Livestock needs to be recognized as an important part of rural livelihood assets in Africa and integrated into modern, ecologically sound agricultural systems.
- The energy sector needs to pursue innovative and alternative energy sources to power mechanization, irrigation, and rural household energy use (e.g., harvesting agricultural waste for energy purposes), which will reduce the carbon footprint of intensive farming.
- Service providers need to exploit mobile device capabilities to expand availability and access to various tools (e.g., financial services, training, market services, certification services).
- Governments and companies need to invest in traceability technologies (e.g., blockchain) to make supply chains transparent and distribute more value back to producers.
- Financiers need to facilitate access to farm equipment via a shared use model (e.g., Mobility for Africa).
- Knowledge institutes need to urgently invest in a pipeline of young talent in food production.

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***** A position paper prepared for presentation at the ISGP conference convened on September 22, 2020, concerning The Future of Modern Agriculture (FMA) organized, facilitated, and moderated by the ISGP with support from the Office of Agricultural Policy, U.S. Department of State.***

Debate Two Summary

This not-for-attribution Debate Summary was prepared by the ISGP staff from an audio recording, and its transcription, of the debate of the position paper prepared by Mr. Mandla Nkomo (see paper above and author biographical information in the Appendix). Mr. Nkomo initiated the debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 60-minute period. This Debate Summary represents the best effort of the ISGP to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Mr. Nkomo and other participants. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Mr. Nkomo, as evidenced by his position paper. Rather, it is, and should be read as, an overview of the discussion and exchange of views and priorities, both in support and opposition, to points expressed by all those participating in the debate.

Current Realities

Many of the concerns voiced regarding agricultural development globally, and especially in Africa, were market related. Given the large proportion of smallholder farmers in Africa, market access was frequently identified as a key regional issue. It was posited that aside from their production of expensive commodity crops (e.g., palm, cotton, coffee, tea, cocoa), African farmers largely do not receive the true value of their products. It was observed that growers of expensive commodity crops are not producing nutritional food crops, and consequently are not addressing the food insecurity plaguing many areas. Therefore, it was posited that governments create a burden for themselves in the form of public food insecurity, often related to the prioritization of non-food crops, routinely remains a burden borne by governments. These differences between investments in expensive commodity crops and those directly addressing food security cause market disruptions. Overall, in both cases, African farmers are not being fairly compensated for their labor.

A contribution to these compensatory inequities is the presence of many middlemen in the food and agricultural supply chain who do not add value. These middlemen are a significant source of value-loss in global markets. A potential lack of infrastructure was suggested as a barrier to market access and value-sharing issues. As African crops are entering global markets, African farmers are still not being

included in fair value distribution. The relative impact of numerous middlemen and substandard infrastructure as operative impediments to value capture for African farmers remain unresolved, but both were considered important.

Several stakeholders expressed concern that public Farm Input Subsidy Programs (FISPs) often incentivize farmers to produce a single, or very few, crops (e.g., maize). Consequently, it was asserted that farmers lose many opportunities for growing a variety of crops that provide access to multiple markets, more diverse value chains, and holistic personal nutritional options.

Numerous stakeholders contended that modernizing the farming process for smallholder farmers requires a more effective approach than the "industrialization models" adopted by many developed countries. While making useful technologies available to smallholder farmers was frequently mentioned as a priority, the agroecological contexts surrounding sustainable agriculture were also emphasized. Recommended changes from industrialization models were motivated by the perceived shortcomings in the agricultural systems of developed countries (e.g., focus on developing and improving only a few crop species, monoculture, degraded soil health). Maintenance of biodiversity, soil-health management, regenerative agricultural practices, and agroforestry techniques were all noted as important contributions based on agroecological understanding. Reduced biodiversity in farming was attributed to many factors that promote monoculture agriculture, including government policies, non-diversified private sector investment, and limited research and development (R&D) priorities. Multiple stakeholders agreed that industrial animal production is an example that is a detriment to environmental health.

Concern was expressed regarding the call for crop/livestock integrated systems described in the Position Paper, based on the difficulties associated with balancing increased production and ecosystem services. Soil health management, which is considered integral to productive agroecological systems, was widely supported as important for maintaining sustainable agricultural practices. However, some stakeholders questioned the need for, and/or efficacy of, requesting smallholder farmers to prioritize soil testing and soil health management. As soil health does not necessarily provide an immediate, tangible payoff, incentivizing the adoption of soil management practices was viewed as potentially difficult, with respect to gaining farmer interest. It was noted that, even though the preservation of soil health does not provide an immediate return-on-investment, it is a matter of urgency, since much farming land may no longer be arable in 5 to 10 years if current practices persist.

Although the Position Paper largely focused on capacity-building for smallholder farmers, it was suggested that integrated approaches involving all key

stakeholders throughout the entire food systems would be equally important. It was noted that, since food systems cannot function without effective, profitable, ecologically sustainable agriculture used at primary agricultural sites, approaches that focus upon farmer capacity building still merit high priority.

There was also some discussion regarding the long-term efficacy of maintaining an agricultural system that is primarily composed of smallholder farmers. Given the consistent "migration" of citizens from rural to urban areas, there may be a natural trend toward larger landholdings as rural populations decrease over time. However, it was asserted that this trend would not negate the continued need to provide high-quality services to the many remaining smallholders with micro-landholdings. Furthermore, specific concerns regarding the methods of facilitating a significant transition to larger-scale landholdings were raised. It was argued that attempts to promote larger landholdings through "landgrab" policies (i.e., purportedly in Mozambique) have subsequently left smallholders without land *or* livelihoods. Rural/urban nexuses, which significantly impact local and regional food systems, were described as largely influenced by the migration from rural to urban lifestyles in many African mega-cities. The difficulty of encouraging smallholder farmers to continue producing food in support of increasing urban populations was identified as a significant, interrelated challenge arising from the reality of rural/urban migration.

Policy landscapes that directly affect individuals were identified as important factors in fostering sustainable livelihoods for smallholder farmers. Concern was expressed that policymakers often do not understand the needs and priorities of farmers facing local and regional economic and agricultural challenges that limit their options. The need to repair the disconnect between implemented policies and smallholders' experiences was strongly expressed.

It was noted that the adoption of the Malabo and Maputo declaration, designed to support policies that benefit smallholders, have not been fully implemented. In addition to limiting research and development priorities, expanding market pressures, and narrowing development strategies, it was asserted that the resultant policies also have a role in reducing the diversity of crops that farmers cultivate. For example, Food Income Subsidy Programs have purportedly helped produce caloric surpluses in some countries by prioritizing monoculture production (e.g., maize). Conversely, it was contended that such programs have failed to address, and even exacerbated, food and nutritional insecurity by reducing diversity in consumer diets. It was stated that prioritizing the cultivation of only a few crops for formal markets/supermarkets has created significant problems related to consumer health (e.g., obesity, malnutrition).

Serious concerns regarding the ageing demographics of farmers in most countries were discussed extensively. The challenges of ensuring that a new generation of farmers will continue to produce food in the future were identified as important aspects of most of the other topics discussed. Significant concern was widely voiced about how to incentivize young people to pursue farming careers, either as continuation of their family commitments or as new, productive, and exciting business pursuits. The challenges were seen to require broad approaches keeping young farmers engaged and motivating increased food production as well as creating youth-centered business models within different parts of agricultural systems. The "optics" of agriculture were cited as a major challenge to youth engagement. Many young people see their parents consistently struggling to succeed as farmers and therefore, decline to follow the same path. Subsistence agriculture was specifically noted to perpetuate cycles of poverty by failing to provide new economic opportunities.

It was widely agreed that, to address these current realities, it is necessary to facilitate diverse multistakeholder discussions and initiatives such as those underway within this ISGP-FMA program and conference.

Scientifically Credible Approaches and Challenges

The potential benefits of traceability technologies (e.g., blockchain) to optimize value-capture for farmers emerge from opportunities to transparently trace ingredient and product pathways throughout the supply chain were and are critical parts of an effective food and agriculture system. Enhanced public education and accessible market information was recognized as fundamental to promote greater transparency in trade regimes that support the ability of farmers to add/retain value in their transactions. It was proposed that opportunities for market access, value capture, and overall economic prosperity depend on expanding and improving farmer access to diversified crops that increase market value.

The outcomes of the Green Revolution in India were used to support the hypothesis that failures to promote diversity in cultivation practices (e.g., primarily growing a single commodity for the market while having to purchase their sustenance) may result in farmers becoming widely malnourished, despite producing food as an occupation. Such a business model was denounced for making farmers dependent upon external market forces for their nutrition. If Africa is to experience its own Green Revolution, it was widely expressed that Africa needs to incorporate the principles of agroecology (I.e., crop diversity, ecological resilience, soil health, agroforestry). Furthermore, it was asserted that the political economy

of agriculture cannot be ignored when determining which crops are developed and promoted to smallholder farmers.

To address biodiversity, the use of underutilized, underdeveloped, and "orphan crops" in modern plant breeding and cultivar development was viewed as a high priority. There was concern regarding the decade-long timeframes required to develop non-domesticated crops suitable for markets. However, it was also noted that many of these alternative crops have always been cultivated and consumed, and that their exclusion from scientific research and development does not reflect a lack of potential or a need for research and development initiatives directed to domesticate these crops. With the application of modern scientific methods for crop improvement, there are a plethora of "orphan" and underdeveloped crops having great potential to grow faster and become productive agricultural products. Biodiversity was also identified as having a major impact on agricultural resilience, especially in African areas facing extreme impacts of climate change (e.g., decreased rainfall, more frequent drought, increasing number of extreme weather events).

While it was recognized that industrial animal production is problematic in the development of African agricultural systems, it was noted that alternative methods of raising livestock need to be considered with caution in the design of regenerative African systems. Mismanagement of animal production can cause significant, negative environmental impacts (e.g., land degradation).

Issues related to soil health management elicited questions from some stakeholders about the need for and efficacy of requesting smallholder farmers to prioritize soil testing in the management of soil health. While engaging farmers directly through demonstration plots and extension services was cited as an important and effective method for promoting soil health, establishing immediate business incentives for soil management was considered more complicated and challenging. It was proposed that connecting soil health and carbon sequestration to certify carbon neutrality for use in carbon markets could potentially provide farmers with a significant tangible payoff connected directly to supporting environmental sustainability.

Recognizing that stakeholders have different prioritizations for approaches to achieving agricultural sustainability, it was generally acknowledged that it is important to consider the broad realities within complicated food systems. Multiple debaters pursued the connection between market issues for farmers and overarching food systems. It was suggested that connecting smallholder farmers more closely with the needs of consumers can improve and expand marketplace participation. As diets change, demand for diversified nutrition choices, diverse food product

options, and support for environmental responsibility, were all noted as important issues in gauging consumer priorities.

Nonetheless, since developed countries often promote larger, commercial landholdings, it was postulated that providing mature financial systems, technical assistance, and emerging technology to these larger landholdings may be more cost-effective than the comparable efforts focused on millions of geographically dispersed smallholder farms with diverse interests. Furthermore, the employment of displaced smallholders within the new food-systems generated by commercial agricultural development was viewed as potentially more stable, since workers would rely on wages rather than uncertain crop yields. The analysis and facilitation of pathways promoting the transition from rural livelihoods in farming to waged or urban livelihoods would need to be targeted and meticulously addressed to avoid serious negative impacts, foreseen and unanticipated (e.g., displacing subsistence farmers without providing alternative options for a living income). The dichotomy between dwindling rural populations and expanding urban populations significantly influences how different food systems are developed (e.g., food sovereignty, balanced exports/imports, and the utilization of natural resources) depend upon farmers' capacities. Therefore, effective policies remain dependent on the real-world experiences of farmers themselves and their capacities for change.

When analyzing agriculture from a systems level, it is often difficult to identify indicators for "successful" national or local agriculture systems. It was acknowledged that such indicators would vary situationally (e.g., by region, commodity, market), but some potential examples of situational "successes" in agriculture were provided: food security (i.e., caloric production), diverse crop production (e.g., different crops, genetic diversity within species, diverse nutrients), mass participation (e.g., engaging many people with different social roles), and the ability to improve upon or overcome serious dilemmas (e.g., famine).

It was proposed that, to address the negative optics associated with agricultural lifestyles in developing countries, it is necessary to help smallholders develop successful agricultural enterprises that also benefit the whole community. It was also postulated that establishing a "pipeline of skills" related to farming as well as broader agricultural systems (e.g., agricultural processing skills, expanded educational opportunities, real-world scientific and technological training) are needed to successfully engage the next generation and foster diverse agricultural choices in different localities. A new generation with the necessary skills could create important paradigm shifts surrounding the major issues that smallholders face (e.g., problematic and unfair production systems for African commodity crops). It was asserted that stakeholders cannot simply tell young people that they need to take

part in farming and agriculture, but rather, agricultural careers need to provide demonstrable opportunities that attract the commitment of the younger generation. For example, improving value-capture for farmers can be successfully implemented if the next generation of farmers understands the realistic economic advantages emerging from technologically empowered agriculture. These opportunities were viewed as dependent on creating an evidence-based perspective that can support paradigm shifts in current production systems.

Finally, concerns that farmers are largely overlooked during the planning and convening of multi-stakeholder programs and discussions were raised. Significantly, as reiterated by many stakeholders, the practical knowledge, perspective, experience, and understanding available from farmers is essential to the development of sustainable agricultural systems. Inclusion in such programs/discussions also provides farmers with learning opportunities.

Evidence-Based Options and Actionable Next Steps

While specific crops that expand choices for farmers vary, the example of legume (e.g., soybeans) cultivation in Mozambique was proposed as a potentially beneficial case to consider, with respect to diverse demands for soy-derived products on local markets. To ascertain such local priorities, direct input from local farmers concerning how to increase financial return for their labor was viewed as fundamental. One stakeholder asserted that changing incentivization systems/programs to promote the production of several diverse crops for multiple markets was necessary.

The use of modern technologies (e.g., tissue culture, CRISPR) to improve less-studied, but culturally relevant, crops was cited as an avenue for reducing research and development time frames, especially if seed producers, public sector initiatives, and/or functioning public-private partnerships are willing to invest in such crops.

It was hypothesized that improved range management, improved animal husbandry, and expanded livestock marketing/financial services are key factors for achieving this balance. Consequently, establishing/expanding extension services was suggested as a necessary step to teach farmers about field/rangeland management (e.g., which animals are suited to different types of land), herd structures, and marketing systems for livestock.

It was posited that farmers respond well to evidence-based data. Comparisons involving results from plot cultivation with/without recommended soil management practices can clearly identify benefits to smallholders. Furthermore, by bundling services such as soil testing, farm mapping, and access to cultivation inputs under different conditions can demonstrate even greater benefits. These efforts convert predictions into tangible outcomes that can promote adoption by farmers. Practical

ways to increase the capacity for smallholder farmers to manage the health of their soil include providing affordable soil tests with prompt results, access to soil health information, and advisory services (e.g., what actions to take based on soil measurements, how to integrate livestock and crop farming, how to effectively add manure, how to improve soil organic carbon through mulching).

It was posited that targeted initiatives that directly address specific issues seem to be the most effective at improving agricultural outcomes. Supporting communally beneficial crop production and developing pipelines to access the skills and knowledge are essential to effectively invest in practices for agricultural development and/or rural infrastructure. Initiatives that mobilize and allocate investment to agricultural development (e.g., the Kirchner Food Fellowship) were suggested as targeted approaches to financing issues. The need for governments to provide significant investment in agriculture (e.g., investment amounts recommended by authorities in the field of development) was also expressed.

In general, the use of new technological developments (e.g., digital technologies, communication technologies, biotechnologies) were viewed as inspirational for young people to continue taking part in agricultural systems. Enlisting young people in developing solutions to agricultural dilemmas was offered as another way of engaging the next generation, while also improving the optics of agriculture for the other young people that they engage. It was noted that the COVID-19 pandemic has provided an example of how young people could help to organize digital technologies to solve broad agricultural issues. Creating youth-centered business models by employing the new generation to provide services and solutions to smallholder farmers was noted as an effective method of fostering youth engagement.

Facilitating the meaningful incorporation and articulation of the interests, views, and challenges given high priority by farmers through advocacy and organization was proposed as essential for the inclusion of farmers into multistakeholder discussions. It was noted that such multistakeholder discussions are often facilitated by civil society organizations. It was added that stakeholders from different parts of food and agricultural systems (e.g., researchers, private industry, policymakers, and government regulatory agencies) need to be actively engaging one another, with an emphasis on engaging working farmers. Lack of communication was cited as a significant impediment to implementing effective approaches to sustainable agriculture.

Commentary Two (on Position Paper Two) The Future of Modern Agriculture: An African Perspective on Capacity Building and Financial Viability for Smallholder Farms**

Thouraya Triki, Ph.D.
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International Fund for Agricultural Development, Rome, Italy

Overall, the paper is well written and provides some interesting suggestions to improve productivity and sustainability of agriculture in Africa. Nevertheless, it could benefit from a strengthening of the link between what is being discussed and recommended and the title (which I assume is the scope of this document: *An African Perspective on Capacity Building and Financial Viability for Smallholder Farms)*. For instance, it would be useful to clarify how the discussion and recommendations contribute to improved financial viability of smallholders in Africa? I was surprised to see that access to finance is only lightly covered within the capacity building discussion, but only briefly. It is important to highlight the specificities of smallholders within the agriculture space. Their small size, for example, makes it cost-ineffective for buyers and financial intermediaries to deal with them. This is due to the fact that buyers have to deal with a large number of suppliers, thus preventing economies of scale, while financial intermediaries will struggle to cover the processing and management cost of very small loans to them. This is not the case for larger players. Smallholders are also hard to reach, have limited access to the internet and other communication solutions, and have lower literacy rates. It is equally important to convey the message that smallholders have diverse needs: women and youth should be covered explicitly in the discussion.

Consensus is still to be built on whether Africa must feed the world in addition to feeding itself. Africa certainly needs to increase production (area planted) and productivity (yield/area), but, as the continent has a huge food import imbalance, the focus and priority should be on strengthening local markets and regional/ continental markets.

Natural resources – efficient management of natural resources is key, but there are specific challenges of doing so on public and private land, including land tenure challenges. Farmers really do not need tools to manage and monitor soil health –

they need to be able to make investments that generate a profit for their farm, and not be forced to make short term trade-offs that they know undermine their long term production and future.

Technology – technology could have a transformational effect. I suggest the author include a brief description of the general state of the art/practice of digital technologies applied in agriculture in Africa. There are compelling examples from the region worth being referenced, even in a simple broad SWOT-like analysis, if the aim of the paper is to remain general. The author should consider adding Information and Communications Technologies for Development (ICT4D) and digital extension as focus areas in addition to pay-as-you-use high tech greenhouses. Uber is mentioned, but not Hello Tractor, which is a better example to illustrate his argument.

Human resources – gender issues and women empowerment must be given more attention. Specifically, challenges of low literacy and capacity to adopt modern techniques, limited land tenure, and access to finance are more acute for women because of social, cultural, and economic reasons. A gender-sensitive approach is needed to achieve inclusive agriculture development.

Livestock – the recommendation to enhance livestock/crop integration systems follows a "business as usual" approach, though it is still relevant. The author could consider adding complementary action areas such as (i) climate-smart intensification of livestock production systems; (ii) risk management in the livestock sector; (iii) enhanced availability and accessibility to services (vet services, breeding services, inputs, financial and marketing services); (iv) development of financial packages adapted to "non bankable" smallholder farmers"; (v) access to land and water resources and their sustainable management; (vi) ICT4D applied to livestock production and precision agriculture, and (vii) innovation and livestock products processing.

Next steps – Include recommendations for national investment, affordability, and accessibility for rural poor farming households and link them to the paper's title.

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Commentary Two Discussion Summary

This not-for-attribution Summary of the discussion was prepared by the ISGP staff from an audio recording, and its transcription of the discussion of the commentary prepared by Dr. Thouraya Triki ((see commentary above and biographical information of the author in the Appendix). Dr. Triki initiated the discussion session with a two-minute statement on the position paper prepared by Mr. Mandla Nkomo and then actively engaged the conference participants, including the position paper authors, throughout the remainder of the 15-minute period. This Discussion Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Brice and other participants. Given the not-for-attribution format of the event, the views comprising this summary do not necessarily represent the views of Dr. Triki, as evidenced by her Commentary. Rather, it is, and should be read as, an overview of the areas of discussion that emerged from all those participating in the discussion.

The discussion noted, with appreciation, the many interesting ideas about the African perspective and farmer capacity concerning improving natural resource management and enhancing the integration of livestock and crops systems with technology and human resources. However, there was strong interest in differentiating between the "capacity to produce better and more " versus the "capacity for finance." This distinction is especially important with respect to separating investments in farmers, as professionals, prioritizing soil microbiome management, supporting the viability of smallholder farms, improving market access, and collectively defining an ideal approach for the future of African agriculture.

It was emphasized that investment is key to sustain and expand farmer capacity to absorb a wide range of improvements (e.g., equipment updates) that continuously underpin modern agriculture. It was further noted that increased farmer capacity for soil testing is a key target for agricultural investment, especially in developing agricultural economies. Specifically, the health of the soil microbiome is a key characteristic of soil management that supports both productivity and conservation. The biodiversity reflected in soil health is also important with regard to sustainable agricultural and food systems. Access to finance was considered by some as the most important instrument for the future success of smallholder farmers. It was suggested that there is a need for a transition from grants to loans for smallholder farmers, thereby shifting responsibility to the farmers to encourage them to adopt a longer-term view of their production activities. A need to work with farmers to provide

different solutions that help them transition from a subsidy approach to a more commercial approach was viewed as an essential step toward long-term viability.

The view that enhancing farmer capacity and responsibilities does not detract from the importance of government intervention was strongly expressed. Grant work and capacity building were considered as vital to strengthening smallholder farms. Simultaneously, it was viewed as necessary to ensure that the resources invested are creating an environment that encourages the private sector to continue sustainable funding when grant support expires.

Proposals to significantly increase financial access for smallholder farms was challenged by citing the difficulties in allocating limited financial resources to a growing number of farms. It was noted that a higher number of farms creates greater competition and inevitably, smaller financial resource pools per farm. It was suggested that effective incentive models would allow those who are efficient to maintain a sustainable business model and absorb some of the farmers who would otherwise be struggling financially.

Questions regarding the future of smallholder farms became a central theme. The discussion on smallholders emerged from a comment on the inability of smallholder farms to test soils because of land ownership challenges (e.g., the need to own land is a prerequisite before concerns of soil testing can be addressed). Indeed, the common lack of contextual understanding by policy makers was noted as a barrier to developing policy solutions relevant to the practical situation on the ground. Beyond land-ownership challenges for smallholders across Africa, a second issue was highlighted regarding time constraints. It was noted that smallholder farms are typically managed by women, who commonly have simultaneous responsibilities for child-care and household maintenance. These real-world, multiresponsibilities underline the challenges that can be addressed only by allocating more time to agricultural demands. By shifting the emphasis to deploying technologies to help provide additional time (i.e., agricultural efficiency) to smallholder farmers, rather than prioritizing higher agricultural yields). Such attention on the role and appropriateness of specific technology applications is of special importance for farming systems relying heavily on management by women. Caution was expressed concerning the one-size-fits-all approach for smallholder farms that have inherently different needs than larger farms. It is essential to recall that effective solutions usually emerge from directly and repeatedly engaging smallholder farmers who can directly articulate their unique challenges and priorities.

The increasingly critical role of women throughout decisions shaping the entire ecosystem defining modern agricultural systems was again emphasized. Policies and technological interventions need to consider their potential impacts

on the time constraints women face given all their societal responsibilities. The proper distribution of workload both in agricultural management and societal duties is critical.

Points were made concerning the future of agriculture linking the opportunities and challenges of international versus continental trade, especially with respect to the future of international commodity exports. It was noted that Africa continues to struggle with market access at a continental level. Priority needs to be given to more effectively connecting African economies with themselves (i.e., country to country) in an effort to reduce agri-food imports from other continents. On this note, it was suggested that, prior to discussions on African agriculture, it is critical to develop a clear, widely-supported vision and approach to redistributing agricultural trade within Africa. To achieve such objectives, an outline for pragmatic goals and actionable interventions is needed.

Acknowledgment

Numerous individuals and organizations have made important contributions to the Institute on Science for Global Policy (ISGP) as it organized, facilitated, and moderated the Future of Modern Agriculture (FMA) conference with support from the Office of Agricultural Policy, U.S. Department of State, and the USUN Mission to the UN Agencies in Rome, Italy, including the UN Food and Agriculture Organization (FAO). Special attention was given to the presentation of views and priorities concerning the future of modern agriculture as it relates to the use of agrotechnology and agroecology throughout global and domestic agricultural systems. In recognition of the health and travel constraints imposed by the global COVID-19 pandemic, the ISGP-FMA conference was convened on September 22, 2020, using a blended in-person (Rome, Italy)/internet format. The entire ISGP-FMA conference was conducted under the Chatham House Rule (not-for-attribution).

As detailed in the agenda provided here, the blended format involved written material including two, three-page position papers prepared by invited subject-matter experts, and two separate commentaries (one on each position paper) contributed by invited subject-matter experts. Debates and commentaries focused on the position papers were conducted with facilitation from ISGP staff, as was a plenary caucus focused on identifying Evidence-Based Options (EBOs) and Actionable Next Steps (ANSs).

The ISGP greatly appreciates the willingness of all those in the scientific, governmental, public advocacy, and private sector communities who agreed to be interviewed by the ISGP staff in their efforts to organize the content of this ISGP-FMA conference. Of special significance were the contributions of those invited subject-matter experts who agreed to prepare position papers and commentaries. The willingness of all participants to engage their scientific, governmental, private sector, and public advocacy colleagues in vigorous debates and their efforts to seek common ground, as well as forward-leaning activities, underlies the success of all ISGP conferences. It is noted and greatly appreciated.

The success of every ISGP conference critically depends on the active engagement of all invited participants in the often-intense debates and probing caucuses. The exchange of strongly held views, innovative proposals, and critiques generated from comments and questions throughout the debates, commentaries, and

caucus foster an unusual, and perhaps unique, environment focused on clarifying understanding for both the specialist and non-specialist. The debate, commentary, and plenary caucus format in this conference addresses specific questions related to formulating and implementing effective public and private sector policies that span regulatory, public messaging, and a wide range of business decisions. The ISGP is greatly indebted to all those who participated in the not-for-attribution (Chatham House Rule) debates, commentaries, and plenary caucus.

The members of the ISGP Board of Directors also deserve recognition for their time and efforts in helping to create a viable, increasingly relevant, not-for-profit organization focused on addressing many of the most important scientific, technological, and societal questions of our time.

The energetic, highly professional interview, organization, facilitation, moderating, and writing skills of the ISGP staff were essential to creatively organize and structure the blended in-person/internet format required for this conference. These same skills and commitments were evident in accurately capturing the often-diverse views and perspectives expressed in the critical debates, commentary discussions, and plenary caucus during the conference as well as in the written material presented here. The biographies of position paper authors and commentators, ISGP staff, and ISGP Board of Directors are all provided in the Appendix of this book.

Finally, to facilitate the complicated execution of the blended in-person/internet format, the ISGP assembled several geographically separated, COVID-19 bubbles in which ISGP staff members worked throughout the ISGP-FMA conference. Eckerd College, located in St. Petersburg, Florida, generously provided access to their campus facilities to house one of these ISGP COVID-19 bubbles (ISGP staff conformed to all Eckerd College COVID-19 restrictions). The ISGP is very appreciative of Eckerd College, and especially of Prof. Liza Conrad, for their assistance. The use of these COVID-19 bubbles in Arizona and Florida contributed significantly to the successful execution of the blended in-person/internet ISGP-FMA conference.

Dr. George H. Atkinson
Founder and Executive Director
Institute on Science for Global Policy

Appendix

Biographical Information of Presenters and Commentators

PRESENTER: Pedro J. Rocha, Ph.D., International Specialist in Biotechnology and Biosafety, Inter-American Institute for Cooperation on Agriculture (IICA), San Jose, Costa Rica

Pedro Rocha is a biologist from National University of Colombia. He earned a Ph.D. in plant biotechnology and molecular biology from University of East Anglia and John Innes Centre (Norwich, UK). His professional experience includes: Postdoctoral Research Scientist at The Sainsbury Laboratory in UK; and in in Colombia, researcher at the International Centre for Physics (CIF), researcher at the Program for Agricultural Biotechnology Corpoica (now Agrosavia), research assistant at the International Center for Tropical Agriculture (CIAT), researcher and director of the Division of Biotechnology at the National Oil Palm Research Center (Cenipalma), consultant to the National Planning Department (DNP) in biodiversity and biotechnology, and specialist in technology and innovation (IICA). Currently, he works as International Specialist and Coordinator in Biotechnology and Biosafety at IICA, based in Costa Rica. He has been director of 12 undergraduate and graduate works, author of over 160 technical articles, book chapters, technical reports and press releases, and more than 290 international presentations, and organizer of 30 international events on biotech and biosafety.

The Inter-American Institute for Cooperation on Agriculture

The Inter-American Institute for Cooperation on Agriculture is the specialized agency for agriculture of the Inter-American System that supports the efforts of Member States to achieve agricultural development and rural well-being.

PRESENTER: Mandla Nkomo, B.Sc., Managing Director, Solidaridad Network - Southern Africa Regional Expertise Centre, Johannesburg, South Africa

Mandla Nkomo has worked in agribusiness consulting and conducted industry studies in South Africa, Mozambique, Uganda, Ghana, Zambia, and Zimbabwe as well as for the Mpumalanga Provincial Government. Mandla Nkomo also has experience developing irrigation systems for over 300,000 hectares of land between the Zambezi valley and Bulawayo city in a project to provide water for Bulawayo city.

In addition, Mandla Nkomo has seven years of experience at Technoserve, where he has managed business development for agribusiness and food security as well as interim county director for South Africa and Zambia, with the aim of developing market linkage between commercial agriculture and small-scale farmers.

Solidaridad Network

Solidaridad is an international network organization with partners all over the world. There is one agenda and one strategy: together we learn and progress, together we achieve results and together we decide on future steps. The premise of the structure is that it promotes capacity building: strengthening Solidaridad teams in the region, enabling them to take control of supervisory tasks and to manage programming themselves. The regional Solidaridad teams cooperate with their own partners on the planning, implementation, communication, and evaluation of programs, and on reporting their results.

COMMENTATOR: Dr. Jeremy Brice, Visiting Fellow in Economic Sociology, London School of Economics (LSE) - Department of Sociology

Dr. Jeremy Brice is a Visiting Fellow in LSE's Department of Sociology with a research background in the social science of risk regulation and of food system governance. His doctoral research at the University of Oxford investigated how inter-firm relationships shape the classification and governance of food quality within global production networks, examining how Australian wine producers' changing relationships with overseas distributors and retailers had driven the adoption of conventions of wine quality centered upon geographical provenance. More recent research projects have focused on the anticipation of crisis and the governance of risk within transnational food supply networks and on the role of digital marketplace platforms in reconfiguring urban economies and cultures of food consumption in the UK.

London School of Economics - Department of Sociology

The Department of Sociology embraces a fundamentally international sociology critically interrogating theoretical claims about the relationships between economic, political, social, spatial and cultural change. Energies are focused through concerns with escalating inequalities and injustices across the globe, informed by sustained fieldwork and empirical inquiry in numerous nations.

COMMENTATOR: Dr. Thouraya Triki, Ph.D., Director of Sustainable Production, Markets, and Institutions Division, International Fund for Agricultural Development (IFAD)

Dr. Thouraya Triki is the Director of IFAD's Sustainable Production, Markets and

Institutions Division (PMI) which provides technical support to regional divisions throughout the design and implementation of IFAD's investment projects and Grants. She also actively contributes to shaping IFAD's private sector agenda. Prior to joining IFAD, Dr. Triki held various positions at the African Development Bank working on public sector and private sector projects, in the private sector and academia.

International Fund for Agricultural Development

The mission of the International Fund for Agriculture Development is to eradicate poverty and hunger in rural areas and developing countries, transforming rural economies and food systems by making them more inclusive, productive, resilient, and sustainable.

Biographical Information of ISGP Board of Directors

Dr. George Atkinson, Chairman

Dr. Atkinson founded the Institute on Science for Global Policy (ISGP) and is an Emeritus Professor of Chemistry, Biochemistry, and Optical Science at the University of Arizona. He is former head of the Department of Chemistry at the University of Arizona, the founder of a laser sensor company serving the semiconductor industry, and Science and Technology Adviser (STAS) to U.S. Secretaries of State Colin Powell and Condoleezza Rice. He launched the ISGP in 2008 as a new type of international forum in which credible experts provide governmental and societal leaders with understanding of the science and technology that can be reasonably anticipated to help shape the increasingly global societies of the 21st century. Dr. Atkinson has received National Science Foundation and National Institutes of Health graduate fellowships, a National Academy of Sciences Post Doctoral Fellowship, a Senior Fulbright Award, the SERC Award (U.K.), the Senior Alexander von Humboldt Award (Germany), a Lady Davis Professorship (Israel), the first American Institute of Physics' Scientist Diplomat Award, a Titular Director of the International Union of Pure and Applied Chemistry, the Distinguished Service Award (Indiana University), an Honorary Doctorate (Eckerd College), the Distinguished Achievement Award (University of California, Irvine), and was selected by students as the Outstanding Teacher at the University of Arizona. He received his B.S. (high honors, Phi Beta Kappa) from Eckerd College and his Ph.D. in physical chemistry from Indiana University. He was recently the President of Sigma Xi, The Scientific Research Society. His educational scientific research and diplomatic achievements have been recognized with distinguished appointments and awards in 16 countries.

Dr. Janet Bingham, Member

Dr. Bingham is former President of the George Mason University (GMU) Foundation and Vice President of Advancement and Alumni Relations. GMU is the largest research university in Virginia. Previously, she was President and CEO of the Huntsman Cancer Foundation (HCF) in Salt Lake City, Utah. The foundation is a charitable organization that provides financial support to the Huntsman Cancer Institute, the only cancer specialty research center and hospital in the Intermountain West. Dr. Bingham also managed Huntsman Cancer Biotechnology Inc. In addition, she served as Executive Vice President and Chief Operating Officer with the Huntsman Foundation, the private charitable foundation established by Jon M. Huntsman Sr. to support education, cancer interests, programs for abused

women and children, and programs for the homeless. Before joining the Huntsman philanthropic organizations, Dr. Bingham was the Vice President for External Relations and Advancement at the University of Arizona. Prior to her seven years in that capacity, she served as Assistant Vice President for Health Sciences at the University of Arizona Health Sciences Center. Dr. Bingham was recognized as one of the Ten Most Powerful Women in Arizona.

Dr. Mike Buch, Member

Dr. Buch holds B.A., M.S., and Ph.D. degrees in Analytical Chemistry and Biotechnology. He has nearly 3 decades of experience in the consumer healthcare industry in various roles of increasing responsibility with some of the world's leading companies. He has broad-based knowledge of consumer healthcare and currently serves as Chief Science Officer and Board Member at Young Living Essential Oils, a rapidly growing multibillion-dollar international wellness company and the largest provider of essential oils in the world. He is directly responsible for leading Research, Development, Product Management, and Quality Assurance across Young Living. Dr. Buch has expertise in leading global strategic development programs, open innovation programs, licensing programs, consumer healthcare R&D, advanced technologies labs, advanced optical analysis labs, and biosensor design and research. His work has directly led to the development of consumer healthcare products with annual sales exceeding $3 billion and his products have been marketed in more than 100 countries. His success has resulted in more than a dozen patents in the healthcare field, several books, and numerous articles published in peer-reviewed journals. He is also a member of several prestigious associations, including the American Chemical Society, The New York Academy of Science, and the American Association for the Advancement of Science.

Mr. Fred Downey, Member

Mr. Downey is a former U.S. Army strategist and longtime defense and international affairs expert on Capitol Hill and was vice president of national security at Aerospace Industries Association (AIA). Downey joined AIA from the office of Connecticut Senator Joe Lieberman where he served as Senior Counselor and Legislative Aide for Defense and Foreign Affairs. He had been the senator's key staff person on these issues for 12 years. As Lieberman's representative to the Senate Armed Services Committee, Downey staffed the senator in his role as chairman of the Airland Subcommittee, overseeing Army and Air Force policy and budget issues and the annual defense authorization bill. Before joining Lieberman, Downey worked on defense analytical services for TASC. That came after a 24-year career in the U.S. Army, including Pentagon postings as Assistant to the Director of Net Assessments

at OSD and Strategy Team Chief for the Strategic Plans and Policy Directorate on the Department of the Army Staff.

Dr. Linda Duffy, Member

Dr. Duffy recently retired as a US Federal Government Senior Scientist Administrator in the Department of Health Human Services, National Institutes of Health, at the National Center for Complementary and Integrative Health, where she currently serves as a post-retirement Special Volunteer to the Director. Among her many service achievements at the NIH, she launched and chaired the Trans-NIH Probiotics/ Prebiotics and Microbiome Inter-agency Work Group and served for many years as an Inter-agency Subject Matter Expert in Ad hoc advisory capacities as committee member and Chair. Dr. Duffy received a DHHS Innovation Award in 2016 and was appointed to serve in the dual role of Senior Scientific Advisor in the DHHS Office of the Secretary, within the Office of the National Coordinator, Division of Science Technology. Prior to her distinguished federal government career, she was a former Peace Corps Volunteer in Cote d'Ivoire, West Africa and subsequently served in a dual capacity as Scientific Director of the Women and Children's Health Research Foundation and as a Distinguished Professor Emeritus with former joint appointments in the Departments of Pediatrics, Epidemiology, and Microbial Pathogenesis at the University of Buffalo. She received her Master's degree from Dartmouth College and completed her doctoral and postdoctoral studies under NIH National Cancer Institute Research Fellowships at the University of Buffalo

Dr. Tom Fingar, Member

Dr. Fingar is a Shorenstein APARC Fellow in the Freeman Spogli Institute for International Studies at Stanford University. He was the inaugural Oksenberg-Rohlen Distinguished Fellow in 2010-2015 and the Payne Distinguished Lecturer at Stanford in 2009. From 2005 through 2008, he served as the first Deputy Director of National Intelligence for Analysis and, concurrently, as Chairman of the National Intelligence Council. Dr. Fingar served previously as Assistant Secretary of the State Department's Bureau of Intelligence and Research (2000-2001 and 2004-2005), Principal Deputy Assistant Secretary (2001-2003), Deputy Assistant Secretary for Analysis (1994-2000), Director of the Office of Analysis for East Asia and the Pacific (1989-1994), and Chief of the China Division (1986-1989). Between 1975 and 1986 he held a number of positions at Stanford University, including Senior Research Associate in the Center for International Security and Arms Control. Dr. Fingar is a graduate of Cornell University (A.B. in Government and History, 1968), and Stanford University (M.A., 1969 and Ph.D., 1977 both in Political Science). His most recent books are *Reducing Uncertainty: Intelligence Analysis and National Security*

(Stanford, 2011), *The New Great Game: China and South and Central Asia in the Era of Reform*, editor (Stanford, 2016), *Uneasy Partnerships: China and Japan, the Koreas, and Russia in the Era of Reform,* editor (Stanford, 2017), and *Fateful Decisions: Choices that Will Shape China's Future*, edited with Jean C. Oi (Stanford, 2020).

Mr. Jim Kolbe, Member

For 22 years, Mr. Kolbe served in the United States House of Representatives, elected in Arizona for 11 consecutive terms, from 1985 to 2007. Mr. Kolbe is currently serving as a Senior Transatlantic Fellow at the German Marshall Fund of the United States, and as a Senior Adviser to McLarty Associates, a strategic consulting firm. He advises on trade matters as well as issues of effectiveness of U.S. assistance to foreign countries, on U.S.-European Union relationships, and on migration and its relationship to development. He is also Co-Chair of the Transatlantic Taskforce on Development with Gunilla Carlsson, the Swedish Minister for International Development Cooperation. He also is an adjunct Professor in the College of Business at the University of Arizona. While in Congress, he served for 20 years on the Appropriations Committee of the House of Representatives, was chairman of the Treasury, Post Office and Related Agencies subcommittee for four years, and for his final six years in Congress, he chaired the Foreign Operations, Export Financing and Related Agencies subcommittee. He graduated from Northwestern University with a B.A. degree in Political Science and then from Stanford University with an M.B.A. and a concentration in economics.

Dr. David Moran, Member

Dr. Moran is President of Technology International Partnerships, LLC, and Past-Publisher of Sigma Xi, The Scientific Research Society, "American Scientist" and the "Chronicle of the New Researcher." He has served as President of the National Technology Transfer Center; Director of Industrial Advanced Development & Industrial Outreach, Advanced Technology, Office of Naval Research; Program Element Administrator for Nuclear Propulsion, R&D, Naval Material Command; Director, David Taylor Institute; Assistant Technical Director, Director of Research, and Technology Director, Naval Ship R&D Center. His professional experience in research and teaching at universities includes the U.S. Naval Academy, Full Professor, Navy Chair; West Virginia University; George Washington University; Research Naval Architect, US Navy. He earned a Ph.D. in Hydrodynamics & Mathematics, IIHR; Sc.M., M.I.T, Ocean Engineering, Hydrodynamics; Sc.B., M.I.T.; Harvard University; University Iowa; and Graduate, Federal Executive Institute. He served at Harvard University's JFK School as Senior Official for National Security. He is a member of the Boards of: Tucker Community Foundation; Community Trust

Foundation; Preston Community Fund; and Past-Treasurer, Board of Directors, Maryland Garrett College. His publications include 102 Scientific Papers, 12 Patents in Hydrodynamics and Aerodynamics, and two published Books.

Mr. Joseph Nimmich, Member

Mr. Nimmich is a Partner at Potomac Ridge Consulting. He formerly was Senior Executive Advisor at Booz Allen Hamilton's Civil and Commercial Group. Prior to Booz Allen Hamilton, he served as the Deputy Administrator of the Federal Emergency Management Agency (FEMA) from September of 2014 until January 2017. During his tenure, his primary focus was on strengthening and institutionalizing FEMA's business architecture over the long term to achieve the Agency's mission. He joined FEMA in 2013, as the Associate Administrator for the Office of Response and Recovery. He was responsible for directing the Response, Recovery, and Logistics Directorates, as well as the Office of Federal Disaster Coordination. Prior to joining FEMA, he was the Director of Maritime Surveillance and Security at Raytheon Corp., where he directed maritime surveillance and security operations, as well as their emergency response capabilities. He served in the U.S. Coast Guard for more than 33 years, retiring as a Rear Admiral. His Coast Guard assignments included the First Coast Guard District based in Boston, Massachusetts, where he was responsible for all Coast Guard operations across eight states in the northeast and 2,000 miles of coastline from the U.S.-Canadian border to northern New Jersey. He earned his M.B.A. from the Stern School of Business at New York University.

Dr. Charles Parmenter, Member

Dr. Parmenter is a Distinguished Professor Emeritus of Chemistry at Indiana University. He also served as Professor and Assistant and Associate Professor at Indiana University in a career there that spanned nearly half a century (1964-2010). He earned his bachelor's degree from the University of Pennsylvania and served as a Lieutenant in the U.S. Air Force from 1955-57. He worked at DuPont after serving in the military and received his Ph.D. from the University of Rochester and was a Postdoctoral Fellow at Harvard University. He has been elected a Member of the National Academy of Sciences and the American Academy of Arts and Sciences, and a Fellow of the American Physical Society and the American Association for the Advancement of Science. He was a Guggenheim Fellow, a Fulbright Senior Scholar, and received the Senior Alexander von Humboldt Award in 1984. He has received the Earle K. Plyler Prize, was a Spiers Medalist and Lecturer at the Faraday Society, and served as Chair of the Division of Physical Chemistry of the American Chemical Society, Co-Chair of the First Gordon Conference on Molecular Energy Transfer, Co-organizer of the Telluride Workshop on Large Amplitude Motion and

Molecular Dynamics, and Councilor of Division of Chemical Physics, American Physical Society.

Mr. Thomas Pickering, Member

Mr. Pickering is Vice Chairman of Hills & Co, international consultants. He co-chaired a State-Department- sponsored panel investigating the September 2012 attack on the U.S. diplomatic mission in Benghazi. He served as U.S. ambassador to the United Nations in New York, the Russian Federation, India, Israel, El Salvador, Nigeria, and the Hashemite Kingdom of Jordan. Mr. Pickering also served on assignments in Zanzibar and Dar es Salaam, Tanzania. He was U.S. Under Secretary of State for Political Affairs, president of the Eurasia Foundation, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, and Boeing Senior Vice President for International Relations. He also co-chaired an international task force on Afghanistan, organized by the Century Foundation. He received the Distinguished Presidential Award in 1983 and again in 1986 and was awarded the Department of State's highest award, the Distinguished Service Award in 1996. He holds the personal rank of Career Ambassador, the highest in the U.S. Foreign Service. He graduated from Bowdoin College and received a master's degree from the Fletcher School of Law and Diplomacy at Tufts University a second master's degree from the University of Melbourne in Australia.

Dr. Eugene Sander, Member

Dr. Sander served as the 20th president of the University of Arizona (UA), stepping down in 2012. He formerly was vice provost and dean of the UA's College of Agriculture and Life Sciences, overseeing 11 academic departments and two schools, with research stations and offices throughout Arizona. He also served as UA Executive Vice President and Provost, Vice President for University Outreach and Director of the Agricultural Experiment Station and Acting Director of Cooperative Extension Service. Prior to his move to Arizona, Dr. Sander served as the Deputy Chancellor for biotechnology development, Director of the Institute of Biosciences and Technology, and head of the Department of Biochemistry and Biophysics for the Texas A&M University system. He was Chairman of the Department of Biochemistry at West Virginia University Medical Center and Associate Chairman of the Department of Biochemistry and Molecular Biology at the College of Medicine, University of Florida. As an officer in the United States Air Force, he was the assistant chief of the biospecialties section at the Aerospace Medical Research Laboratory. He graduated with a bachelor's degree from the University of Minnesota, received his master's degree and Ph.D. from Cornell University and completed postdoctoral

study at Brandeis University. As a biochemist, Dr. Sander worked in the field of mechanisms by which enzymes catalyze reactions.

Dr. Ben Tuchi, Member and Secretary/Treasurer

Dr. Tuchi serves on the boards of two additional non-profit corporations; he is Treasurer of the Campus Research Corporation and President of the Arizona Research Park Authority. He received his B.S. and M.S. degrees in Business Administration from the Pennsylvania State University and his Ph.D. in Finance from St Louis University. His full time teaching career began in 1961 at St. Francis College and continued until 1976 at West Virginia University. From 1976 through 1996 he served in cabinet levels at West Virginia University, The University of Arizona, The University of North Carolina at Chapel Hill, and finally as Senior Vice Chancellor for Business and Finance of the University of Pittsburgh. During those assignments he was simultaneously a tenured professor of finance. He retired from the last executive post in 1996 and returned to a full- time teaching position as Professor of Finance at the University of Pittsburgh, until his retirement in 1999. For the two years prior to his retirement he was the Director of Graduate Programs in Business in Central Europe, at Comenius University, making his home in Bratislava, The Slovak Republic.

Mr. Richard Armitage, Special Adviser

Mr. Armitage is the President at Armitage International, where he assists companies in developing strategic business opportunities. He served as Deputy Secretary of State from March 2001 to February 2005. Mr. Armitage, with the personal rank of Ambassador, directed U.S. assistance to the new independent states (NIS) of the former Soviet Union. He filled key diplomatic positions as Presidential Special Negotiator for the Philippines Military Bases Agreement and Special Mediator for Water in the Middle East. President Bush sent him as a Special Emissary to Jordan's King Hussein during the 1991 Gulf War. Mr. Armitage also was Deputy Assistant Secretary of Defense for East Asia and Pacific Affairs in the Office of the Secretary of Defense. He graduated from the U.S. Naval Academy. He has received numerous U.S. military decorations as well as decorations from the governments of Thailand, Republic of Korea, Bahrain, and Pakistan. Most recently, he was appointed an Honorary Companion of The New Zealand Order of Merit. He serves on the Board of Directors of ConocoPhillips, ManTech International Corporation, and Transcu Ltd., is a member of The American Academy of Diplomacy as well as a member of the Board of Trustees of the Center for Strategic and International Studies.

Jennifer Boice, Special Assistant to the Board

Ms. Boice worked for 25 years in the newspaper industry, primarily at the Tucson Citizen and briefly at USA Today. She was the Editor of the Tucson Citizen when it was closed in 2009. Additional appointments at the Tucson Citizen included Business News Editor, Editor of the Online Department, and Senior Editor. She also was a business columnist. She received her M.B.A. from the University of Arizona and graduated from Pomona College in California with a degree in economics. She has worked at the Institute on Science for Global Policy in a variety of positions since 2010.

Biographical Information of ISGP Leadership and Staff (Senior Fellows, Fellows, and Adjunct Fellows)

Dr. George H. Atkinson, Founder and Executive Director

The professional career of Dr. Atkinson spans several diverse arenas including academic responsibilities for teaching, scientific research, grant preparation, and administration within university communities, duties as the Founder and Chief Executive Officer of Innovative Laser Corp. that designed high sensitivity laser sensors for the semiconductor industry, and public service as a science and technology adviser within the U.S. government. His U.S. government activities crossed different agencies and departments and included service as the Science and Technology Adviser to the Secretaries of State Colin Powell and Condoleezza Rice. His recent efforts, facilitating the use of credible scientific understanding in the formulation and implementation of governmental, private sector, and societal policies worldwide, are reflected in his launching of the Institute on Science for Global Policy (ISGP). Dr. Atkinson is an Emeritus Professor of Chemistry, Biochemistry, and Optical Sciences at the University of Arizona. He has been recognized for his teaching (Outstanding Teacher at the University of Arizona; Distinguished Alumni Award, Indiana University; Honorary Doctorate and MacArthur Award, Eckerd College) and research (Senior Alexander Humboldt Award and Senior Fulbright Fellow, Germany; Senior SERC Awards at the Royal Institution of Great Britain and Oxford University, U.K; Lady Davis Professorships at Hebrew University and the Technion, Israel; Distinguished Visiting Professor, University of Tokyo, Japan; Distinguished Professor Award, University of California, Irvine). He was elected in 2014 President of the Sigma XI, The Scientific Research Society.

Ms. Kat Wheeler, Program Director

In her position as Program Director for the ISGP, Ms. Wheeler plays an integral leadership role in the conceptualization, design, organization, and implementation of ISGP programs. Ms. Wheeler initiated her work at the ISGP in 2019 as Associate Program Director for the FDA sponsored ISGP Innovative Foods and Ingredients Conference (2019) which engaged more than 70 senior leaders from the private sector, public advocacy, governmental, and scientific and technological communities. Subsequently, Ms. Wheeler has engaged in topics spanning food traceability, climate impacts on agriculture, plant breeding, agricultural sustainability, communication and food labeling, medical supply chain security, and veterinary medical countermeasures, etc. Prior to her time at the ISGP, Ms. Wheeler carried out work

in support of farm to school in Michigan, conducted research on coffee farmers' views on third party certifications in Costa Rica, and volunteered for farmworker rights in Florida. She received a B.A. in Environmental Studies with a minor in Biology from Eckerd College, in St. Petersburg, FL.

Ms. NiCole Bice, Program Coordinator

Ms. Bice has a diverse background in both education and business experience. Before joining the ISGP, she was an Academic Coordinator at a Professional Sports Academy and has served as an Administrator, Lab Facilitator, Teacher, and Curriculum Supervisor at a variety of schools and organizations. She attended the University of Arizona in Tucson and graduated with a B.A. degree. She has a lifelong interest in education, business, and current science-related topics. She recently received certifications in both global education perspectives and business management.

Ms. Jennifer Boice, Financial Director

Ms. Boice worked for 25 years in the newspaper industry, primarily at the Tucson Citizen and briefly at USA Today. She was the Editor of the Tucson Citizen when it was closed in 2009. Additional appointments at the Tucson Citizen included Business News Editor, Editor of the Online Department, and Senior Editor. She also was a business columnist. She received her M.B.A. from the University of Arizona and graduated from Pomona College in California with a degree in economics. She has worked with the Institute on Science for Global Policy since 2010 in a variety of positions.

Ms. Daniela Baeza Breinbauer, Senior Investigator

Ms. Baeza Breinbauer is a Project Officer and Researcher at LSE Consulting where she oversees all projects in the fields of Environment; Development Economics; Health; and Behavioural Science. By training she is a Development and Environmental Economist with a background in Human Rights and Science Policy. She has previously consulted for a variety of government and non-government institutions including the United Nations, European Commission, EU Committee of the Regions, U.S. Government, and the Government of India. She holds an M.Sc. in International Development Management (Applied Development Economics Specialism) from the London School of Economics, and a double B.A. in Global Affairs/International Relations and Political Science, with a focus on Human Rights Law, from Eckerd College. She is a current post-graduate candidate on the Environmental Economics and Climate Change (EECC) program at the LSE.

Mr. Ciaran Fitzpatrick, Fellow

Mr. Fitzpatrick graduated with Honors from Eckerd College, where he received a B.S. in Biology, as well as a second major in International Relations & Global Affairs. As an ISGP Fellow, he has played a key supportive role in the development and organization of current and prospective ISGP programs. Notably, he played an integral role in the planning and execution of the Future of Modern Agriculture Conference, which was convened with support from the DOS and engaged approximately 36 senior stakeholders, including diplomats, UN representatives, private sector leaders, civil society groups, and scientific/academic experts. At Eckerd, Mr. Fitzpatrick was a Ford Apprentice Scholar as well as a cell biology research assistant. He hopes to become a biological researcher, using scientific communication to bridge the gap between research and policy. He takes special interest in the fields of food security and sustainability, global health, climate change, ecology, biodiversity, and genomics.

Ms. Margaret Patkus, Fellow

Ms. Patkus majored in Environmental Studies and Race & Ethnic Studies at St. Olaf College (Northfield, MN). Her passions for food justice, community health, and sustainability were ignited during her internship as an educator with the Poughkeepsie Farm Project (Poughkeepsie, NY) during the summer of 2016. This led her to pursue several community engagement roles with non-profit organizations as well as a semester in Italy studying the economics and culture of sustainable food systems. Since joining the ISGP as a Fellow in September of 2019, Ms. Patkus has played a key supportive role in the development and organization of current and prospective ISGP programs, contributing to internal research efforts, stakeholder identification and engagement, and other critical planning and analysis. This work has spanned topics such as global bioeconomy development, agricultural biotechnology, agroecology/soil health, climate change impacts on the nutritional quality of food, food traceability, and plant breeding.

Mr. Brian Akpan, Adjunct Fellow

Mr. Akpan is a graduate of the University of Arizona in the field of Materials Science and Engineering. During his time in college, he was heavily influenced by an interest in sustainable and environmentally sound materials. He is deeply motivated to help the world operate efficiently by including a firm foundation of science, materials, and a pro-environmental, sustainable approach to creating new products. Mr. Akpan seeks to add value to the ISGP by bringing a strong reporting capability on research papers from the scientific to the public sphere.

Ms. Roxanne Hoorn, Adjunct Fellow

Ms. Hoorn's background is in science communication, research, ethics, and food systems. She is a graduate of Eckerd College, receiving two bachelor's degrees in Biology and Philosophy, respectively. She also served as Science Outreach Club President and Varsity Ethics Bowl Team Co-Captain while at Eckerd. Ms. Hoorn has worked as a lab teaching assistant in biology and genetics, STEM educator for Florida non-profits, farm hand and manager around North America, Food Systems Associate in Northern Michigan, and currently works on an urban hydroponics farm in St. Petersburg, Florida. She seeks to communicate science to diverse audiences and find tangible, science-based solutions to environmental and humanitarian issues within our local and global food system.

Ms. Allison Rose, Adjunct Fellow

Ms. Rose is a current undergraduate at the University of California, Davis majoring in International Agriculture Development and minoring in Community Nutrition. Ms. Rose's interest in agriculture and nutrition spans her personal and professional life - alongside her studies, she interns at her school's student farm in the ecological garden, she is an avid cook and baker, and she loves to connect with others over food. Ms. Rose hopes to work in food and agriculture policy in the future, helping to spread sustainable and factual knowledge across the globe.

Mr. Christopher Samuel, Special Advisor

Chris Samuel has more than 20 years of global communications and public affairs experience in the food-agriculture (Bayer, Monsanto), consumer goods (P&G, J&J), industrial (Siemens) and non-profit sectors in highly regulated and multicultural environments. As Director of Corporate Preparedness and Engagement at Bayer, he led external affairs strategy on corporate reputation, biotechnology and data science technologies on sustainability, transparency, safety, human rights, and trade issues. He has also led more than 15 sustainability partnerships with Governments and NGOs including Conservation International, UNICEF, Habitat for Humanity, Room to Read and others. Chris served as the Chair - CropLife's Communications Committee, Co-Chair - U.S.-ASEAN Business Council Food & Agriculture Committee, and represented Bayer at BIO, Consumer Brands Association, CRISPRcon, World Economic Forum, and World Business Council for Sustainable Development. He was a Professor of Corporate Affairs at the Singapore Management University, and Xavier Institute of Communications. Chris is Board Member at STAGES St. Louis, and Thespo youth theatre festival.

ISGP Conferences and Programs

Recent ISGP Conferences

- *Science and Governance: The Future of Modern Agriculture* conference, convened September 22, 2020, in a hybrid in-person (Rome, Italy) / internet format, with support from The Office of Agricultural Policy, U.S. Department of State.
- *Sustainable Agriculture: The Role of Plant Breeding Innovation* conference, convened November 17-19, 2020, in an internet format, with support from the American Seed Trade Association and Euroseeds.

Previous ISGP Conferences

All books from ISGP conferences are freely available to the public and can be downloaded from the ISGP site:

www.scienceforglobalpolicy.org.

Hardcopies of these books are available by contacting
nbice@scienceforglobalpolicy.org.

ISGP conferences and books on Emerging and Persistent Infectious Diseases (EPID):

- *EPID: Focus on Antimicrobial Resistance,* convened March 19–22, 2013, in Houston, Texas, U.S., in partnership with the Baylor College of Medicine.
- *21st Century Borders/Synthetic Biology: Focus on Responsibility and Governance*, convened December 4–7, 2012, in Tucson, Arizona, U.S., in partnership with the University of Arizona.
- *EPID: Focus on Societal and Economic Context*, convened July 8–11, 2012, in Fairfax, Virginia, U.S., in partnership with George Mason University.
- *EPID: Focus on Mitigation*, convened October 23–26, 2011, in Edinburgh, Scotland, U.K., in partnership with the University of Edinburgh.
- *EPID: Focus on Prevention*, convened June 5–8, 2011, in San Diego, California, U.S.
- *EPID: Focus on Surveillance*, convened October 17–20, 2010, in Warrenton, Virginia, U.S.
- *EPID: Global Perspectives*, convened December 6–9, 2009, in Tucson, Arizona, U.S., in partnership with the University of Arizona.

ISGP conferences and books on Food Safety, Security, and Defense (FSSD):

- *FSSD: Equitable, Sustainable, and Healthy Food Environments*, convened May 1–4, 2016 in Vancouver, British Columbia, Canada, in partnership with Simon Fraser University.
- *FSSD: Food Security and Diet-linked Public Health Challenges*, convened September 20–23, 2015 in Fargo, North Dakota, in partnership with North Dakota State University.
- *FSSD: Focus on Food and the Environment*, convened October 5–8, 2014, in Ithaca, New York, in partnership with Cornell University.
- *FSSD: Focus on Food and Water,* convened October 14–18, 2013, in Lincoln, Nebraska, U.S., in partnership with the University of Nebraska–Lincoln.
- *FSSD: Focus on Innovations and Technologies,* convened April 14–17, 2013, in Verona, Italy.
- *FSSD: Global Perspectives,* convened October 24, 2012, in Arlington, Virginia, U.S., in partnership with George Mason University.

ISGP conferences and books on Food Innovations (FI):

- *FI: Innovative Foods and Ingredients*, convened June 23–26 in Minneapolis, Minnesota, United States, with sponsorship from the U.S. Food and Drug Administration.

ISGP Academic Partnership (IAP) conferences and books:

- *Socioeconomic Contexts of Sustainable Agriculture,* convened October 14–15, 2016, in Danbury, Connecticut, in partnership with Western Connecticut State University.
- *Water and Fire: Impacts of Climate Change*, convened April 10–11, 2016, in Sacramento, California, in partnership with California State University.
- *Communicating Science for Policy*, convened August 10–11, 2015, in Durham, North Carolina, in partnership with Sigma Xi, The Scientific Research Society.
- *FSSD: Food Security: Production and Sustainability*, convened April 24–25, 2015, in St. Petersburg, Florida, in partnership with Sigma Xi, The Scientific Research Society, and Eckerd College.
- *FSSD: Safeguarding the American Food* Supply, convened April 10–11, 2015, in Collegeville, Pennsylvania, in partnership with Sigma Xi, The Scientific Research Society, and Ursinus College.

- *EPID: Focus on Pandemic Preparedness,* convened April 11–12, 2014, in Collegeville, Pennsylvania, U.S., in partnership with Ursinus College.

ISGP conferences and books on Science and Governance (SG):

- *Climate Impact on National Security (CINS–1, CINS–2A, CINS–2B),* convened November 28–December 1, 2016, April 3–4, 2017, and May 17–19, 2017 in partnership with the U.S. Army War College in Carlisle, Pennsylvania.
- *The Genomic Revolution,* convened September 6, 2014, in cooperation with the Parliamentary Office on Science and Technology of the British Parliament within the House of Lords. London, United Kingdom.

ISGP conferences and books on Global Challenges (GC):

- *ISGP Climate Change Program (ICCP): The Shore's Future: Living with Storms & Sea Level Rise*, convened November 20–21, 2015, in Toms River, New Jersey, in cooperation with the Toms River Working Group, Barnegat Bay Partnership, Barnegat Bay Foundation, and the Jay and Linda Grunin Foundation.
- *ICCP: Sea Level Rise: What's Our Next Move?*, convened October 2–3, 2015, in St. Petersburg, Florida, in cooperation with the St. Petersburg Working Group.
- *ISGP Climate Change Arctic Program (ICCAP): Sustainability Challenges: Coping with Less Water and Energy,* convened June 5, 2015, in Whittier, California, in cooperation with the Whittier Working Group.
- *ICCAP: Living with Less Water*, convened February 20–21, 2015, in Tucson Arizona, in cooperation with the Tucson Working Group.