Production Security Farming Cultures

Institute on Science for Global Policy (ISGP)

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Food Safety, Security, and Defense: *Focus on Technologies and Innovations*

Conference convened by the ISGP April 14–17, 2013
at the Villa Quaranta Park Hotel, Verona, Italy

Technology Sub-Saharan India Consumers

Social Development Infrastructure

Agriculture Challenges Food Public

Perceptions Farmers Responsible Meat

Standards Communication Local

Research Technology Labels Europe

Distribution Policies Industrialization

Africa Industry Products Postharvest

Institute on Science for Global Policy (ISGP)

Food Safety, Security and Defense: *Focus on Technologies and Innovations*

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Villa Quaranta Park Hotel near

Verona, Italy

April 14–17, 2013

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

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Table of contents

Introduction

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Preface

The contents of this book were taken from material presented at an international conference convened by the Institute on Science for Global Policy (ISGP) on April 14–17, 2013, convened near Verona, Italy. This ISGP conference, the second in the ISGP program on Food Safety, Security, and Defense (FSSD), focused on Technologies and Innovations.

The process underlying all ISGP conferences begins with the recognition that there are significant scientific advances underlying FSSD, a topic that has emerged on the international stage as a critical issue affecting the human condition across cultural, ethical, and economic aspects of essentially all societies. Decisions within societies concerning how to appropriately incorporate such transformational science into public and private sector policies rely on candid debates that highlight the credible options developed by scientific communities throughout the world. Since FSSD can potentially have significant impact worldwide, it deserves attention from both domestic and international policy makers from a wide range of disciplines. ISGP conferences offer those rare environments where such critical debates can occur among credible scientists, influential policy makers, and societal stakeholders.

Based on extensive interviews conducted by the ISGP staff with an international group of subject-matter experts, the ISGP invited seven highly distinguished individuals with expertise in FSSD to prepare the three-page policy position papers to be debated at the Verona conference. These seven policy position papers, together with the not-for-attribution summaries of the debates of each paper, are presented in this book. The areas of consensus and actionable next steps that were developed by all participants in the caucuses that followed the debates are also presented. The debate summaries and caucus results were written by the ISGP staff and are based on contributions from the conference participants.

Current realities

While the material presented here is comprehensive and stands by itself, its policy significance is best appreciated if viewed within the context of how domestic and international science policies have been, and often currently are being, formulated and implemented.

As the second decade of the 21st century opens, most societies are facing difficult decisions concerning how to appropriately use, or reject, the dramatic new opportunities offered by modern scientific advances and the technologies that emanate from them. Advanced scientific research programs, as well as commercially viable technologies, are now developed globally. As a consequence, many societal issues related to science and technology (S&T) necessarily involve both domestic and international policy decisions, both in the public and private sectors. The daunting challenges to simultaneously recognize immediate technological opportunities, while identifying those emerging and "at-the-horizon" S&T achievements that foreshadow transformational advantages and risks within specific societies, are now fundamental governmental responsibilities. These responsibilities are especially complex since policy makers must consider the demands of different segments of society, which often have conflicting goals. For example, decisions must balance critical commercial interests that promote economic prosperity with the cultural sensitivities that often determine if, and how, S&T can be successfully integrated into any society.

Many of our most significant geopolitical policy and security issues are directly connected with the remarkably rapid and profound S&T accomplishments of our time. Consequently, it is increasingly important that the S&T and policy communities (public and private) communicate effectively. With a seemingly unlimited number of urgent S&T challenges, both affluent and less-affluent societies need their most accomplished members to focus on effective, real-world solutions relevant to their specific circumstances. Some of the most prominent challenges involve (i) infectious diseases and pandemics, (ii) environmentally compatible energy sources, (iii) the consequences of climate change, (iv) food safety, security, and defense (v) the cultural impact of stem cell applications, (vi) nanotechnology and human health, (vii) cyber security for advanced telecommunication, (viii) the security implications of quantum computing, and (ix) the cultural radicalization of societies.

Recent history suggests that most societies would benefit from improving the effectiveness of how scientifically credible information is used to formulate and implement governmental policies, both domestic and international. Specifically, there is a critical need to have the relevant S&T information concisely presented to policy communities in an environment that promotes candid questions and debates led by those nonexperts directly engaged in decisions. Such discussions, sequestered from publicity, can help to clarify the advantages and potential risks of realistic S&T options directly relevant to the challenges being faced. Eventually, this same degree of understanding, confidence, and acknowledgment of risk must be communicated to the public to obtain the broad societal support needed to effectively implement any decision.

The ISGP mission

The ISGP has pioneered the development of a new type of international forum based on a series of invitation-only conferences. These ISGP conferences are designed to provide articulate, distinguished scientists and technologists opportunities to concisely present their views of the credible S&T options available for addressing major geopolitical and security issues. Over a two-year-plus period, these ISGP conferences are convened on different aspects (e.g., innovations and technologies) of a broad, overarching topic (e.g., FSSD). The format used emphasizes written and oral, policy-oriented S&T presentations and extensive debates led by an international cross section of the policy and scientific community. ISGP conferences reflect global perspectives and seek to provide governmental and community leaders with the clear, accurate understanding of the real-world challenges and potential solutions critical to determining sound public policies.

ISGP programs rely on the validity of two overarching principles:

1. Scientifically credible understanding must be closely linked to the realistic policy decisions made by governmental, private sector, and societal leaders in addressing both the urgent and long-term challenges facing 21st century societies. Effective decisions rely on strong domestic and global public endorsements that motivate active support throughout societies.

2. Communication between scientific and policy communities requires significant improvement, especially concerning decisions on whether to use or reject the often transformational S&T opportunities continually emerging from the global research communities. Effective decisions are facilitated in venues where the advantages and risks of credible S&T options are candidly presented and critically debated among internationally distinguished subject-matter experts, policy makers, and private sector and community stakeholders.

Historical perspective

The dramatic and rapid expansion of academic and private sector scientific research transformed many societies of the 20th century and is a major factor in the emergence of the more affluent countries that currently dominate the global economic and security landscape. The positive influence of these S&T achievements has been extremely impressive and in many ways the hallmark of the 20th century. However, there have also been numerous negative consequences, some immediately apparent and others appearing only recently. From both perspectives, it would be difficult to argue that S&T has not been the prime factor defining the societies we know today. Indeed, the 20th century can be viewed through the prism of how societies decided to use the available scientific understanding and technological expertise to structure themselves. Such decisions helped shape the respective economic models, cultural priorities, and security commitments in these societies.

It remains to be seen how the prosperity and security of 21st century societies will be shaped by the decisions made by our current leaders, especially with respect to how these decisions reflect sound S&T understanding.

Given the critical importance of properly incorporating scientifically credible information into major societal decisions, it is surprising that the process by which this is achieved by the public and its political leadership has been uneven and, occasionally, haphazard. In the worst cases, decisions have been based on unrecognized misunderstanding, overhyped optimism, and/or limited respect for potentially negative consequences. Retrospectively, while some of these outcomes may be attributed to politically motivated priorities, the inability of S&T experts to accurately communicate the advantages and potential risks of a given option must also be acknowledged as equally important.

The new format pioneered by the ISGP in its programs seeks to facilitate candid communication between scientific and policy communities in ways that complement and support the efforts of others.

It is important to recognize that policy makers routinely seek a degree of certainty in evaluating S&T-based options that is inconsistent with reality, while S&T experts often overvalue the potentially positive aspects of their proposals. Finite uncertainty is always part of advanced scientific thinking and all possible positive outcomes in S&T proposals are rarely realized. Both points need to be reflected in policy decisions. Eventually, the public needs to be given a frank, accurate assessment of the potential advantages and foreseeable disadvantages associated with these decisions. Such disclosures are essential to obtain the broad public support required to effectively implement any major decision.

ISGP conference structure

At each ISGP conference, internationally recognized, subject-matter experts are invited to prepare concise (three pages) policy position papers. For the April 14–17, 2013 ISGP conference near Verona, Italy, these papers described the authors' views on current realities, scientifically credible opportunities and associated risks, and policy issues concerning innovations and technologies. The seven authors were chosen to represent a broad cross section of viewpoints and international perspectives. Several weeks before the conference convened, these policy position papers were distributed to representatives from governments, societal organizations, and international organizations engaged with the ISGP (the United States, Sweden, Italy, Switzerland, Spain, the United Kingdom, South Africa, Russia, Canada, the United Nations, and Australia). Individuals from several private sector and philanthropic organizations also were invited to participate and, therefore, received the papers. All participants had responsibilities and/or made major contributions to the formulation and implementation of domestic and international policies related to FSSD.

The conference agenda was comprised of seven 90-minute sessions, each of which was devoted to a debate of a given policy position paper. To encourage frank discussions and critical debates, all ISGP conferences are conducted under the Chatham House Rule (i.e., all the information can be used freely, but there can be no attribution of any remark to any participant outside the conference setting). In each session, the author was given 5 minutes to summarize his or her views while the remaining 85 minutes were opened to all participants, including other authors, for questions, comments, and debate. The focus was on obtaining clarity of understanding among the nonspecialists and identifying areas of consensus and actionable policy decisions supported by scientifically credible information. With active participation from North America, Africa, Australia, and Europe these candid debates are designed to reflect international perspectives on real-world problems.

The ISGP staff attended the debates of all seven policy position papers. The not-for-attribution summaries of each debate, prepared from their collective notes, are presented here immediately following each policy position paper. These summaries represent the ISGP's best effort to accurately capture the comments and questions made by the participants, including the other authors, as well as those responses made by the author of the paper. The views expressed in these summaries do not necessarily represent the views of a specific author, as evidenced by his or her respective policy position paper. Rather, the summaries are, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the debates.

Following the seven debates, small groups held caucuses with each caucus representing a cross section of the participants. A separate caucus for the scientific presenters also was held. These caucuses focused on identifying areas of consensus and actionable next steps for consideration within governments and civil societies in general. Subsequently, a plenary caucus was convened for all participants. While the debates focused on specific issues and recommendations raised in each policy position paper, the caucuses focused on overarching views and conclusions that could have policy relevance both domestically and internationally.

A summary of the overall areas of consensus and actionable next steps emerging from these caucuses is presented here immediately following this introduction under the title of **Conference conclusions.**

Concluding remarks

ISGP conferences are designed to provide new and unusual (perhaps unique) environments that facilitate and encourage candid debate of the credible S&T options vital to successfully address many of the most significant challenges facing 21st century societies. ISGP debates test the views of subject-matter experts through critical questions and comments from an international group of decision makers committed to finding effective, real-world solutions. Obviously, ISGP conferences build on the authoritative reports and expertise expressed by many domestic and international organizations already actively devoted to this task. As a not-for-profit organization, the ISGP has no opinions nor does it lobby for any issue except rational thinking. Members of the ISGP staff do not express any independent views on these topics. Rather, ISGP programs focus on fostering environments that can significantly improve the communication of ideas and recommendations, many of which are in reports developed by other organizations and institutes, to the policy communities responsible for serving their constituents.

ISGP conferences begin with concise descriptions of scientifically credible options provided by those experienced in the S&T subject, but rely heavily on the willingness of nonspecialists in government, academe, foundations, and the private sector to critically debate these S&T concepts and proposals. Overall, ISGP conferences seek to provide a new type of venue in which S&T expertise not only informs the nonspecialists, but also in which the debates and caucuses identify realistic policy options for serious consideration by governments and societal leaders. ISGP programs are designed to help ensure that S&T understanding is integrated into those real-world policy decisions needed to foster safer and more prosperous 21st century societies.

Conference conclusions

Area of Consensus 1:

While the security of the food supply in many regions is expected to significantly decrease because of environmental changes, rising human populations, ineffective governance, ill-considered patterns of food consumption, and inefficient supply and distribution infrastructures, the impact of each of these factors can be effectively mitigated by altering technological, behavioral, economic, and sociocultural policies.

Actionable Next Steps

- Reduce the loss and waste of food throughout the food chain as a top priority for increasing food security, including improving the existing methodologies used to identify and quantify current channels for food loss and waste.
- Optimize the impact of food protein, both by more effectively using existing sources and innovatively developing more diverse sources (e.g., insects).
- Improve the quality of food distribution systems, markets, and infrastructure (e.g., roads, ports, cold storage) available for the food supply chain, especially in less-wealthy regions.
- Harness existing and emerging technologies (e.g., nanotechnology, packaging technology) in the food sector to identify when the safety of products is in question.
- Improve the public messages concerning the appropriate balance between the cosmetic appearance of food products and their inherent nutritional quality.

Area of Consensus 2:

Providing food security for a rapidly growing human population requires the innovative development and application of credible scientific understanding and practical technologies. All such efforts, especially those focused on genetic improvements involving traditional breeding and biotechnology/transgenic methods as well as technical advancements in nanotechnology, packaging, and preservation technologies, must be tailored to different cultural, political, and economic conditions and perspectives.

Actionable Next Steps

- Elevate the importance of public engagement and viewpoints in the development and implementation of technology and in the development and implementation of governmental and private sector policies.
- Enable research and development to be conducted in specific areas of need by coordinating with local stakeholders, existing economic communities, and practical research infrastructures.
- Require safety and nutrition information on labels using regulations based on credible scientific understanding related to products rather than process.
- Design and conduct awareness and education programs to provide science-based information about emerging technologies to decision makers and the public.
- Analyze and evaluate existing and pilot programs designed for sustainable development throughout the farm-to-table continuum, prior to adapting and deploying best practices more widely.

Area of Consensus 3:

Political stability and good governance, including credible, evidence-based regulatory structures (e.g., science-based food safety standards) are essential for sustainable food security.

Actionable Next Steps

- Harmonize food safety standards globally using *Codex Alimentarius* and the World Trade Organization Sanitary and Phytosanitary Standards (WTO SPS),while incorporating knowledge from complimentary scientific sources (e.g., voluntary industry standards, subject matter experts, open source data knowledge, and public-private partnerships).
- Encourage the development of robust local and international supply chains that allow for distribution and movement of food across borders.

- Utilize evidence-based approaches for assessing and managing risks and benefits of food applications.

Area of Consensus 4:
Effective engagement between public/private institutions and consumers concerning food safety is required to improve consumer understanding of risks and benefits, to assist consumers in making informed decisions, and to build trust throughout the society.

Actionable Next Steps

- Design and implement communication training programs for food specialists to communicate their understanding of the relevant science more effectively to the general public through a variety of media.
- Identify and support credible and trusted role models, spokespersons, and media for the communication of scientific information (e.g., the complexity of the food chain and the relationship between food and health).
- Launch a well-designed and compelling public education campaign to raise awareness and inspire a change in public attitudes and actions regarding food waste.

Area of Consensus 5:
Effective efforts to address issues in food safety, security, and defense require integrated contributions from multiple governmental and private sector entities and from diverse academic disciplines to facilitate acceptance of technology policies.

Actionable Next Steps

- Alter the academic merit review system and funding structures to more effectively recognize and reward transdisciplinary research, teaching, and outreach.
- Include social scientists early in the process of assessing the risks associated with food safety, security, and defense so that the solutions developed are more likely to be accepted by the public.
- Strengthen social sciences expertise in less-affluent countries where food security is an issue (e.g., via universities, think tanks).

ISGP conference program

Sunday, April 14

12:00 – 17:00 **Registration: Villa Quaranta Park Hotel**

16:30 – 17:00 **Conference Meeting: Science presenters**

17:00 – 17:30 **Conference Overview: All presenters and participants**

17:30 – 18:45 *Reception (hotel lobby bar)*

18:45 – 19:00 ***Welcoming Remarks***
Dr. George Atkinson, Institute on Science for Global Policy (ISGP) Founder and Executive Director

19:00 – 20:00 *Dinner*

20:00 – 20:40 ***Evening Remarks***
"Food Safety and Epidemic Threats in the Globalized Environment"
Dr. Ilaria Capua, Member, Chamber of Deputies, Italian Parliament, and Head of the Division of Comparative Biomedical Sciences, Istituto Zooprofilattico Sperimentale della Venezie, Legnaro, Italy

Monday, April 15

07:00 – 08:30 *Breakfast*

Presentations and Debates: Session 1

09:00 – 10:30 **Dr. Martina Newell-McGloughlin, International Biotechnology Program, University of California, Davis, United States**
Agricultural Biotechnologies Potential Contribution to Global Food Security and Stewardship of the Earth's Resources

10:30 – 11:00 *Break*

11:00 – 12:30 **Prof. Felix Escher, Institute of Food Science and Nutrition, Swiss Federal Institute of Technology, Zurich, Switzerland**
Food Security and Safety Between Science and Culture

12:30 – 13:30 *Lunch*

Presentations and Debates: Session 2

14:00 – 15:30 **Prof. Linus Opara, Stellenbosch University, South Africa**
Postharvest Technologies for Food Security and Safety: Linking Knowledge, Infrastructure, and Policy

15:30 – 16:00 *Break*

16:00 – 17:30 **Prof. Lynn Frewer, Newcastle University, United Kingdom**
Technology, Society, and Food Security: Developing a Societally Inclusive Research and Policy Agenda

18:30 – 19:30 *Reception*

19:30 – 20:30 *Dinner*

20:30 – 21:00 ***Evening Remarks***
"ISGP 2013–2014 Programs"
Dr. George Atkinson, ISGP Founder and Executive Director

Tuesday, April 16

07:00 – 08:30 *Breakfast*

Presentations and Debates: Session 3

09:00 – 10:30 **Prof. Donald Schaffner, Rutgers University, United States**
Risk-based Decision-making to Improve Food Safety, Security, and Defense

10:30 – 11:00 *Break*

11:00 – 12:30 **Dr. José Gil, Research Centre for Agri-food Economy & Development —Barcelona Technical University, Spain**
Public Perception of Genetically Modified Food and Policy Implications

12:30 – 13:30 *Lunch*

Presentations and Debates: Session 4

14:30 – 16:00 **Prof. Vijaya Raghavan, McGill University, Canada**
Facilitating Technology Adoption

16:00 – 17:00 *Break*

Caucuses

17:00 – 21:00 **Focused group sessions**

Wednesday, April 17

07:00 – 08:30	*Breakfast*
09:00 – 12:20	**Plenary Caucus Session** Dr. Matt Wenham, ISGP Associate Director, *moderator*
12:20 – 12:30	**Closing Remarks** Dr. George Atkinson, ISGP Founder and Executive Director
12:30 – 13:30	*Lunch*
13:30	*Adjournment*

Agricultural Biotechnology's Potential Contribution to Global Food Security and Stewardship of the Earth's Resources**

Martina Newell-McGloughlin, D.Sc.
Adjunct Professor, Plant Pathology, and Director, International Biotechnology Program, University of California, Davis, Davis, California, United States

Summary

Over the coming decades, food and agricultural production systems must be significantly enhanced to respond to a number of transformative changes. These changes include a growing world population, increasing international competition, globalization, increasing meat consumption in developing countries, and rising consumer demands for improved food quality, safety, nutritional content, convenience, and provenance. New and innovative techniques for improving the efficiency of the global agriculture sector will be required to ensure an ample supply of healthy food. From the food deserts of inner cities to the infertile areas of many regions, access to a healthy diet remains elusive for many. Dramatic increases in the occurrence of obesity, cardiovascular disease, diabetes, cancer, and related ailments in more-affluent countries are in sharp contrast to the chronic malnutrition in many lower-income countries. Both sets of problems require a modified food supply, and the tools of biotechnology, while not the sole solution, have a significant role to play. Agricultural biotechnology, including advanced plant breeding and genetic engineering (GM crops), has already helped farmers around the world boost their productivity and grow crops in more ecologically healthy fields, while allowing much more efficient use of resources. This technology allows reduced tillage, which cuts down on greenhouse gas emissions, water runoff, soil erosion, and fuel consumption. This technology also allows improved pest control, increased yields on existing acreage, and reduced pressure to convert forests and wildlands into farmland. However, the technology's potential may remain unfulfilled if such barriers as disproportionate and nonrisk-based regulatory regimes, effective disinformation campaigns, and lack of resources prevail.

Current realities

The ultimate grand challenge of our times is the sustainability of the biosphere and our place in it. Can we learn how to meet our needs today without compromising the ability of future generations to meet theirs? With the 7 billionth member of humanity having joined the planet, achieving global food security sustainably is the single most important issue facing civilization and, by implication, the planet in the next 30 years. To meet the world's needs by 2050, it is estimated that 70% more food must be produced from less land and fewer inputs, (e.g., using less water, energy, fertilizer, and chemical pest controls). The inequities between more- and less- affluent countries must be addressed using technologies that are scalable across these economic imbalances. Of immediate concern is the state of current global food reserves. In 2012, the United Nations issued an unprecedented warning about the state of global food supplies. The U.N. noted that failing harvests in the United States, Ukraine, and other countries eroded global food reserves to their lowest level since 1974, when the world's population was much lower. World grain reserves are so dangerously low that another year of severe weather in food-exporting countries could trigger a major hunger crisis by the end of 2013. Clearly, unprecedented needs require innovative solutions.

Scientific opportunities and challenges

From a basic nutrition perspective, there is a clear dichotomy in demonstrated need between different regions and socioeconomic groups, the starkest being injudicious consumption in more-affluent regions and under-nourishment in less-affluent countries. Both extremes are forms of malnourishment, one resulting from inadequate supply and the other, in many but not all instances, from imprudent choices often influenced by economic considerations. Plant-based products comprise the vast majority of human food intake, either directly or indirectly through animal feeds, irrespective of location or financial status. In some cultures, either by design or default (e.g., as a result of poverty) plant-based nutrition comprises virtually the total diet. Thus, significant nutritional improvement can be achieved via modifications of staple crops. Ingo Potrykus' Golden Rice is a seminal example of this contention. Incorporation of beta-carotene into rice cultivars and widespread distribution of this "packaged technology in the seed" could prevent 1 million to 2 million deaths each year by alleviating vitamin A deficiency. Yet, despite being under consideration for more than a decade and subjected to a barrage of risk assessments, it is still awaiting release from regulatory purgatory. One has to ask what conceivable environmental risks could possibly result from Golden Rice that would offset the benefit of preventing millions of agonizing deaths from malnutrition.

Of the 17 million farmers who grew biotech/GM crops in 2012, more than 15 million (nearly 90%) were in developing countries and, for the first time, developing countries grew more of the global biotech crops than industrial countries (52% versus 48%). Biotechnology can speed conventional breeding programs and may offer solutions where conventional methods fail, which is beneficial for growers, consumers, and the environment. The benefits experienced by larger-scale farmers in both industrialized nations and less-affluent countries are already considerable. Research by Brookes and Barfoot showed that from 1996 to 2011, biotech contributed to increasing crop production valued at $98.2 billion and reduced the environmental pesticide footprint by more than 15% by removing 473 million kilograms (active ingredient) of pesticides from the environment. Insect-resistant maize also has a collateral effect: less insect damage results in much less infection by fungal molds which in turn reduces mycotoxin contamination, a serious health hazard. Likewise, insect-resistant Bt maize has led to cumulative benefits over 14 years of between $3.2 billion to $3.6 billion with $1.9 billion to $2.4 billion of this total accruing to non-Bt maize growers through a "halo" protective effect. In addition, there was a reduction in carbon dioxide emissions in 2011 alone of 23.1 billion kg, which is equivalent to taking 10.2 million cars off the road. A 2005 paper from the Royal Society suggested that intensive high-yield farming on less land is better for wildlife than "wildlife friendly" farming. Through increased yields, biotech is contributing to conserving biodiversity by saving 108.7 million hectares of land from being converted to agricultural production (James, 2013). In addition to the large commodities, the technology has also helped some specialty crops. Virus-resistant papaya developed using biotechnology saved the industry in Hawaii as no natural resistance exists in the cultivated varieties other than via biotechnology; the use of new varieties has also helped organic growers by reducing the reservoir of virus in plants from which insects transmit the disease. A similar scenario may be needed to save the Florida citrus industry and the California wine industry from refractory pathogens for which there are no known effective and sustainable control systems.

Commercialization of biotechnology products should be just another step in a long history of human interaction with nature to meet societal needs and, as such, the same parameters of risk-based assessment should apply. Genetic modification through breeding has a long history of safe utilization for crop improvement, and modern biotechnology simply extends those benefits through more precise methods. Biotechnology offers an efficient and cost-effective means to produce high-quality food, feed, and fiber, as well as a diverse array of novel, value-added products. Unfortunately, disproportionate regulatory burdens placed on crops developed via biotechnology force reliance on older, less effective, and unsustainable crop improvement and production systems that will inevitably have a negative impact on food security. One example is the Fortuna potato that contains two genes from a wild relative that confer robust resistance against late blight disease, a $5 billion problem, obviating the need to spray with fungicides, including the organic-approved copper sulfate. Yet its developer is abandoning the European Union as it sees little hope of winning regulatory approval for Fortuna despite the potential benefits to growers and the environment. While farmers in the E.U. can afford, and continue to utilize, fungicides, low-input farmers with few other alternatives could greatly benefit from crops that are genetically superior and deliver disease resistance traits. Erecting barriers to the development and commercialization of the new technologies and innovative methods to improve crops will instead ensure that less productive and more environmentally damaging practices will expand inexorably to meet food demands.

Policy issues

- **Technical Complexities:** Technical and translational challenges must be overcome to enable introduction of desirable traits. Adequate resources are needed to ensure cutting-edge science can be applied to crop improvement. In addition, mechanisms should be put in place to facilitate translation by anticipating the downstream development, deployment, and commercialization requirements.
- **Globalization & Intellectual Property:** There is a negative impression of ownership of intellectual property in seed technologies and perceived enhancement of corporate power with possible negative impacts on employment or small farms. Innovation cannot occur without recoupment of investment. Mechanisms must be in place to reduce intellectual property barriers, improve commercialization strategies, and facilitate the transfer of advantageous technologies.
- **Liability:** There are unreasonable expectations of prevention of adventitious presence (i.e., unintentional appearance of foreign material in a product) that is nonproportional. Coexistence between different production systems requires reasonable tolerances and thresholds to be proportionate and workable.

- **Regulatory oversight:** Worldwide regulatory regimens are asynchronous and not science-based. Regulatory frameworks must be developed that ensure adequate protection of the consumer and the environment while not stymieing innovations that enable deployment of beneficial technologies.
- **Consumer acceptance:** There has been an effective misinformation campaign around biotechnology and the agenda has been ceded to those with alternate intent. A more effective communication strategy must be developed with scientists setting the agenda using evidence-based science and appropriate context. Trusted sources must be used to deliver the message.

Ultimately, resources are finite and true sustainability can come only from an enlightened philosophy that promotes the development of resource-enhancing technologies.

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***** A policy position paper prepared for presentation at the conference on Food Safety, Security and Defense: Focus on Technologies and Innovations, convened by the Institute on Science for Global Policy (ISGP) April 14–17, 2013, in Verona, Italy.***

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Dr. Martina Newell-McGloughlin (see above). Dr. Newell-McGloughlin initiated the debate with a 5-minute statement of her views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate 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. Newell-McGloughlin. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Newell-McGloughlin, as evidenced by her policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- If the significant benefits provided by genetic modification technologies to agriculture and crop development around the world are to continue, it is critical that the unfavorable perceptions of these technologies held by the public and policy makers be changed by effectively providing unbiased, credible information.
- Extensive data exist regarding improving food production output via genetic modification compared with previous production technologies and this knowledge has contributed to making genetically modified (GM) foods safer and more sustainable. However, regulation of genetic modification technologies is significantly more stringent than regulation of previous technologies, creating a barrier to development and use of genetic modification technology.
- The precautionary principle, which guides approaches to food technologies in Europe, has a negative impact on the use of genetic modification technologies worldwide. Risk-based approaches are better suited to technologies related to genetic modification.

Current realities

Numerous mistakes were made when genetically modified (GM) foods were first developed on a large scale. Errors were identified in (i) the products developed, (ii) the economic decisions made, and (iii) the marketing and communication strategies pursued. One of the first genetically modified products developed, the 'Flavr-Savr' tomato, involved a gene being added to a tomato variant that was lacking in taste. The resulting product was very limited in its success. Additionally, rather than focusing on the existing market for fresh tomatoes, there were attempts to bypass this market, which had a negative effect on sales.

Particular consideration was given to errors made regarding messaging during the development of GM products. Neither scientists in academia nor those in the private sector adequately engaged with other stakeholders who had an interest in genetic modification (e.g., NGOs and special interest groups). It was not imagined that these groups might have concerns different from those foreseen by industry or researchers. Failure to include relevant stakeholders during the GM crop development process led to countless difficulties for the acceptance of GM foods.

Technologies developed prior to biotechnology have either been very minimally regulated or regulations were introduced at a later stage once risk-assessment processes were better understood. Biotechnology, on the other hand, has considerably more stringent regulations than previous technologies. It was suggested that this discrepancy is incongruent with the real issues and that the regulation of biotechnology goes beyond what is necessary.

The extent to which concern for GM products relates to apprehensions about the strength of multinational corporations, rather than the technology itself, was discussed. Often, stakeholders are concerned not simply with the safety level of a specific technology, but with issues such as globalization and ownership of intellectual property.

The general population was viewed as having a limited understanding of the history of hybrid crops and breeding techniques. Although plants have been crossbred for many centuries (and thus essentially genetically modified), it is often assumed by the public that the first time genetic modification has occurred is in the context of modern technologies. It was further noted that in a recent Eurobarometer survey, a large percentage of respondents believed that crops that were not genetically modified did not contain genes. Concern was expressed about the impact of these incorrect assumptions.

Mistrust of genetic modification technologies in sub-Saharan Africa, both on the part of consumers and politicians, was highlighted. It was suggested that this resulted in large part to a history of unsafe products (e.g., peanuts contaminated with toxins) being delivered to Africa from more-affluent regions as part of aid programs designed to improve food security. It was further noted that considerable damage was wrought by “Western” plant varieties being introduced into Africa without correct training and education, and that these mistakes have added to mistrust of new technologies. However, genetic modification technologies have already been applied on a large scale in more-affluent regions with no food safety issues resulting from the consumption of GM foods. For this reason, concerns that Africans are being given an unsafe or lower-quality product are unfounded. It was further suggested that concern about genetically modified organisms (GMOs) in sub-Saharan Africa is the fault of Europeans who have spread fears about the safety of GMOs.

It was suggested that there is a level of hypocrisy in European attitudes toward GMOs. Although there is strong reluctance to use biotechnology in crops or animal production, many enzymes and flavors that are part of foods, or used in the production of foods, are developed using GM recombinant fermentation processes (e.g., French cheeses are made with genetically engineered enzymes). The use of genetic modification in Europe is therefore not unprecedented, and indeed many farmers are interested in utilizing GM crops. However, concern from politicians about a potential public backlash prevents wider utilization of these crops.

One example of a success is the role of genetic modification technologies in saving the papaya industry in Hawaii. Ringspot virus, to which papaya has no natural resistance, was endemic in Hawaii and destroying papaya farming. Using biotechnology approaches, a papaya resistant to ringspot was engineered. Once this was crossbred with papayas in Hawaii, ringspot ceased to be a problem and the industry was revived. The organic papaya industry was helped by association, since levels of ringspot diminished overall.

Hundreds of scientific studies have found that genetic modification technologies may be safer and have lower environmental impacts than other food production methods. It was suggested that this is due to stringent regulations around genetic modification as well as the concentration of scientific expertise in this area. Although a large number of studies have confirmed the safety of genetic modification, this information is rarely widely publicized. While genetic modification can bring many benefits, caution was expressed against viewing this technology as a panacea, since it is simply one of many tools that can be used in efforts to reduce food insecurity.

Of all the farmers that are growing GM crops, approximately 90% are in less-affluent countries. It was suggested that the introduction of this technology in those nations has provided farmers with greater income streams and thus increased economic freedom. India was identified as a country that has had considerable success with the introduction of GMOs. When Bt cotton (a pest-resistant cotton plant containing the gene for Bt toxin) was first introduced, it was not appropriately adapted for an Indian context. However, once bred with indigenous cotton, Bt cotton became widespread in India. India has not unreservedly embraced GM technologies. Recent attempts to allow Bt brinjal to be grown in India were dismissed by the Indian Supreme Court on the grounds that the GM fruit would not be accepted by consumers.

Scientific opportunities and challenges

Biotechnology provides numerous opportunities for food production, in part because considerably more is known about this technology than previous production processes. There is a risk that excessively high barriers to entry will lead to relying on production systems that are both less safe and less sustainable. A challenge, therefore, lies in ensuring that the benefits of biotechnology can be widely realized.

Since individuals are considerably more likely to respond to messages invoking fear than they are to messages that are positive, communication issues present significant challenges for genetic modification technologies. Given that negative campaigning about genetic modification is so fervent, the challenge to communicate positive messages about GMOs is particularly great. An opportunity may lie in using stories and examples (e.g., how genetic modification saved the Hawaiian papaya industry) to explain the positive aspects of genetic modification technology.

The various challenges related to the labeling of GM products were considered. It was noted that if everything involved in the production of a crop was put on a label (e.g., herbicides, pesticides) consumers would become extremely concerned, since surveys suggest that labels are regarded as warnings against something negative. The prohibitive costs associated with labeling were also noted, in part because of the complexities of tracing each ingredient in a product back to the initial source.

While there was general consensus that safety concerns about genetic modification were unfounded, questions about environmental risks (e.g., risks associated with the spread of introduced genes) were raised. In the process of introducing traits into a plant, super weeds might be created via gene flow. It was countered that this issue can be mitigated through effective crop management, and that indeed the same risks exist with older breeding techniques. Given that genes will always flow between different crops, control management systems are critically important.

Over-reliance on biotechnology could lead to a system of monocultures that is not sufficiently resistant to change. While it was acknowledged that genetic modification does lend itself to the development of monocultures, it was suggested that sensible approaches to risk assessment could prevent this.

When adopting GM crops, an important challenge lies in ensuring the variety of crops used by farmers are adapted to local environments to mitigate any safety issues and to ensure that the plants are best able to thrive. The provision of adequate training and resources through extension specialists and the development of production management systems are key to achieving this goal.

The opportunities genetic modification technologies provide in the area of postharvest management were discussed. Traditionally, genetic modification has been focused on changing aspects important during production (e.g., pest resistance, herbicide resistance). There is potential, however, to deploy this technology to make changes to postharvest characteristics (e.g., the length of time a fruit or vegetable stays fresh after harvest). Developing such technologies will provide opportunities to considerably reduce the amount of food that is currently wasted postharvest.

As an example, fungal contamination has traditionally been a considerable postharvest concern. With GM crops (e.g., Bt maize), however, a significant reduction in mycotoxin contamination has been demonstrated, since it is far more difficult for insects (e.g., corn worms) to burrow and create holes that fungal spores can use to enter the corn kernel. A second benefit associated with GM crops is the potential to extend the shelf life of products (e.g., down-regulation of the enzyme polygalacturonase), which would aid in decreasing the amount of fresh produce that is lost between the time it is harvested and the time it appears in markets.

There is a risk in promoting GM crop production, particularly in countries where genetic modification technologies have been less readily accepted. However, a failure to promote and introduce these technologies will result in the continued reliance on older, less safe, less sustainable production systems.

Policy issues

The question of how progress might be made on the use of genetic modification in Europe was raised. There was agreement that the precautionary principle, which defines Europe's approach to new technologies, is undesirable since it forces a reliance on older technologies rather than promoting progress. The policy environment regarding new technologies currently is an obstacle in efforts to improve food safety and security.

Although there was agreement that approaches to food technologies need to be risk-based, the extent to which it is realistic to expect Europe to completely alter its assessment systems was questioned. The structure of European legal systems supports the use of the precautionary principle and it is therefore difficult to expect this approach to food technologies to change rapidly. However, there are many inconsistencies in European Union regulation that contradict this point of view (e.g., GMOs are already used in certain food production processes).

Questions were raised regarding challenges relating to intellectual property for farmers using GM crops in less-affluent countries. There was concern that there might be a level of unrest if farmers did not have a sense of ownership over their crops. It was noted that universities in the U.S. are running programs related to public intellectual property both in the U.S. and in less-affluent countries. Although it was acknowledged that large corporations initially own the intellectual property from GM products because of the high costs of developing those products, it is extremely important that farmers have a stake and are able to work in conjunction with large corporations.

It was suggested that the implementation of genetic modification technologies must be considered from multiple perspectives rather than simply from scientific viewpoints. It was questioned whether the adoption of certain GM products (e.g., GM salmon that matures twice as fast) might have negative effects on smaller industries that rely on non-GM versions of products. Conversely, positive effects, (e.g., the health improvement of those whose incomes increase) also require consideration.

A key factor in gaining consumer trust regarding genetic modification technologies is to increase levels of transparency. Labeling was considered as one method that might contribute to more transparency. It was recommended, however, that all labeling should be based on risk analysis and that labeling a product based on the process by which it is made would be a problematic precedent.

Discussion focused on the best ways to work with policy makers from around the world to alter perceptions toward genetic modification technologies. Because of historic precedents (e.g., being sent food that was contaminated with toxins), many less-affluent countries are reluctant to adopt technologies that are advocated by more-affluent countries and policy makers may campaign against these products to appeal to public opinion. One way to counter this trend might be to talk to policy makers individually and demonstrate that genetic modification technologies are also widespread in more-affluent countries (e.g., the U.S.).

The question of who is able to provide credible information to both the public and policy makers about genetic modification technologies was raised. Large corporations, though often integral to genetic modification technology development, are not best placed to provide such unbiased, credible information given their financial interests in GMOs. It was noted that opinion makers in various regions around the world are the most appropriate conduits for providing information, since they have credibility with the wider population. If these individuals are provided with accurate information about genetic modification, this knowledge is more likely to filter down appropriately. One potential way to communicate positive information about genetic modification is to provide stories where GM crops have created positive change.

Food Security and Safety Between Science and Culture**

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Summary

Food security will continue to be a major problem area for human existence. Food safety needs continued attention as new threats emerge. Science and technology can contribute to solving the many problems in food security and safety provided an interdisciplinary approach is taken and the issue of food acceptability as a cultural and socioeconomic issue is respected. Funding of public agricultural and food research should increase. The dialogue between science and consumers must be intensified to assess and potentially increase the acceptance of disputed technological tools in agriculture and food processing.

Current realities

Food security, as defined by the Food and Agricultural Organization of the United Nations (FAO), "is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." In spite of many relevant achievements in science and technology and efforts by multiple national and international public and private organizations, food security, as expressed in the first of the eight Millennium Development Goals to be reached by 2015, is still far from being a reality. Disparities in progress toward reaching food security in different world regions are increasing. There are also considerable inequalities regarding undernutrition, malnutrition, and overeating. In view of further population growth and uncertain impacts of climate change, the prospect of achieving food security by the target date is unlikely.

Food safety implies availability of food that is safe to eat, and therefore is one of the prerequisites of food security. Food safety continues to be threatened by pathogenic microorganisms and parasites as a major cause of foodborne disease and death, and by any chemical substance in food that leads to acute or chronic intoxication. Food safety outbreaks have increasingly become visible because of improved science-based methodology for detection and intensified national and international surveillance. At the same time, the number of outbreaks has grown by the rapidly expanding worldwide trade of agricultural commodities and food. Due to the biologically inherent variability of microorganisms, new threats are to be expected. Effectiveness of countermeasures such as food legislation and control also varies greatly among different regions of the world.

Public awareness of food safety-related issues presents a critical factor in the debate on how science and technology need to tackle the problems of food security and safety. The perception of risk by the public is frequently in contrast to the rationality put forth by scientists. The broad involvement of consumer groups makes food acceptance a complex topic that goes far beyond the mere technical level of agricultural production and food processing.

In the context of food security and safety, water has become the single most important element of natural resources for finding sustainable solutions.

Scientific opportunities and challenges

Science and technology must continue to contribute to the demanding task of improvement of food security and safety. However, opportunities for lasting success are only given if the scientific approach and the implementation of technology are interdisciplinary and system-oriented. Agricultural and food sciences deal with the whole food chain as a complex system and take availability, stability of supply, access, and utilization as the four pillars of food security into account. Individual advancements of disciplinary science from physics, chemistry, cell biology, microbiology, genomics, plant physiology, and toxicology, to computer science and process engineering, have to be evaluated carefully in the context of the whole food chain.

The interdisciplinary approach must go beyond science and engineering. Psychology, sociology, economics, and other segments of social science point to the socioeconomic and cultural aspects that should be observed if new technologies of agricultural production or food processing and preparation are to be accepted by the consumer. Acceptability of food and economic reality in a particular cultural and economic environment remain decisive factors. In principle, science has to respect the concept of "food sovereignty," which asserts the right of sovereign states to democratically determine their own agricultural and food policies.

Agricultural and food science is based mostly on long-term research. Frequently, the natural life cycles of plants and animals and vegetation periods control the time planning of research activities. In an environment of accelerated output demand, long-term research is more difficult to fund than research on "hype" topics with high public visibility. Interdisciplinary research often has a lower standing for funding agencies than strictly discipline-oriented activities. Public budgets for agricultural research are under pressure or declining.

Policy issues

- The numerous and extensive policies that were developed over the years by national governments and international policy groups and institutions (FAO, World Health Organization [WHO], International Food Policy Research Institute [IFPRI], European Commission Joint Programming Initiative [JPI], etc.) need to be reviewed by the scientific community for overlaps, gaps, and contradictions to define the scientifically relevant inputs that are necessary for food security and safety.
- Publicly funded agricultural research needs to be increased, and focus on areas such as (i) impact of exploitation of agricultural resources on environment (water management, soil depletion, etc.), (ii) impact and necessary adaptation of agricultural production on climate change, (iii) objective comparison of farming systems (conventional, integrated pest management, organic) in view of their potential in different regions of the world and in different economic and social realities, (iv) use of minor crops for food and feed that have received insufficient attention as compared to the major crops of industrialized agriculture, and (v) development of agricultural practice for viable existence of smallholder farmers in developing countries. Research should be carried out locally, but research programs should be coordinated internationally (e.g., via the Consultative Group on International Agricultural Research [CGIAR], FAO).
- Publicly funded food research needs to continue to address nutritional and health aspects of food supply and consumption, among them the serious problem of under-nutrition and malnutrition of children (e.g., deficiencies of iron and other trace minerals, iodine, vitamin A). Implementation of respective nutritional policies should be based on more than one option (e.g., rice: direct delivery of supplements versus fortification of daily meals versus genetic modification of rice) and must observe overall acceptability of food. On the other hand, the problem of obesity needs special attention by the scientific community, again in the context of socioeconomic issues of food supply and consumption.

- Food research in public and private institutions must continue to have activities around food preservation, packaging, and storage. Improvement of traditional technologies or introduction of new concepts should help to cut losses throughout the food chain and increase availability. Priority should be given to storage technologies for areas with critical climate conditions (high temperatures and high relative humidity).
- Investment by public agricultural and food research needs to consider institutional and personal capacity building as one of the most important aims. This is of importance in areas of the world where infrastructure for scientific activities and scientific personnel is lacking. Capacity building presents a typical task for established and experienced scientists in universities and research institutes.
- Public-private partnership in the agricultural and food sector should continue to be developed and strengthened. It is the private sector that is able to convert scientific inputs into efficient technologies and make them available on the market. Partnership should exist on all levels, from personal contacts to local exchange among industry, government, and international organizations.
- The dialogue between scientists and consumers must be intensified. Only through this dialogue will it be possible to break deadlocks in scientific and technical development such as the introduction of genetic engineering to plant crops and animal husbandry, the application of nanotechnology in food and agricultural engineering, or the application of genomics in solving nutritional problems. This task must be taken up by the scientific community as well as by governmental bodies and international organizations.

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*** A policy position paper prepared for presentation at the conference on Food Safety, Security and Defense: Focus on Technologies and Innovations, convened by the Institute on Science for Global Policy (ISGP) April 14–17, 2013, in Verona, Italy.*

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Prof. Felix Escher (see above). Prof. Escher 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 90-minute period. This Debate 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 Prof. Escher. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Prof. Escher, as evidenced by his policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- The successful implementation of technologies designed to improve global food safety, security, and defense requires effective communication with the public, based on an understanding of current realities regarding the potential advantages and rules.
- Supermarkets and large food companies can contribute to increasing food availability by encouraging product diversity and promoting policies that allow smallholder farmers expanded access to markets (e.g., harmonizing food safety standards among private retailers).
- Since efforts to improve food security are unlikely to succeed if the influence of culture on food choices is not recognized, culturally determined food habits and preferences must be considered when designing capacity-building projects and their related research studies within universities, governments, and the private sector.

- The public-private partnerships essential to food security efforts must be carefully managed in terms of mutual expectations, transparency, public trust, and communication.

Current realities

There was agreement that communication about food safety, security, and defense is important yet challenging. Although food issues are discussed with considerable regularity in the media, concern was raised about the quality and accuracy of the information being discussed. Specifically, while the public tends to view scientists, governments, and industry as having ulterior motives, it appears to be unable or unwilling to identify the motivations of often outspoken nongovernmental organizations or individuals. In addition, there has been a cultural revolution in terms of trust and communication channels. The trusted communicators of the past (e.g., elected leaders, scientists) are not the trusted communicators of the present.

The complexities associated with evaluating data and the nature of evolving scientific information make it more difficult for scientists to communicate effectively with the public. Ambiguities and probabilities are integral to communication regarding food safety, yet it was agreed that few individuals, particularly in the sciences, have the skills to communicate effectively on these topics. Numerous examples were provided where scientists have downplayed risks or expressed excessive degrees of certainty. This unwillingness to communicate uncertainties has undermined the credibility of these individuals, as well as the credibility of other scientists in the longer term.

Communication difficulties are compounded by the fact that scientists tend to have little understanding of the media, and vice versa. As such, scientists often do not convey their messages appropriately. One negative incident has the potential to significantly undermine the public's trust both in the science and the communicators (e.g., the handling of *the Bovine spongiform encephalopathy [BSE]* crisis in the United Kingdom).

Since cultures influence food habits and their implications for food safety and security, certain traditional methods for purchasing or preparing foods in less-affluent countries might come into conflict with best practices for food safety (e.g., the consumption of raw date palm sap in Bangladesh, which transmits Nipah virus). Similarly, individuals may reject foods that are unfamiliar or unpalatable (e.g., new crop varieties developed to have a longer shelf life may not be adopted if the taste or texture of the product is not familiar to consumers). Altering food habits and practices can be extremely difficult when these customs are socially and culturally important. The personal relationship that individuals have with the food they consume was highlighted, and there was agreement that emotion plays a role in the food choices of individuals from different backgrounds.

Concern was expressed regarding the fact that the food chain is primarily controlled by a small section of the global population. Large corporations may be exerting an excessive influence on what food is produced, reducing crop diversity, and making it extremely difficult for smaller, local producers to establish themselves in supermarkets. However, the proportion of the food supply that large corporations control is still small compared with the total volume of products being sold. Also of concern was the uneven control of resources: biotechnology research is largely focused on crops that feed those in more-affluent countries, rather than crops that might be beneficial in less-affluent countries.

Private retailers set varying food standards, making it particularly difficult for smaller businesses and those from less-affluent companies to comply. These standards are often based on political and economic priorities rather than on science-based food safety standards. The efforts made by the Global Food Safety Initiative (GFSI) to harmonize standards and assist smaller retailers were recognized. However, some considered that the GFSI's work does not go far enough in assisting small-scale producers.

Scientific opportunities and challenges

There was considerable agreement that the dialogue between scientists and consumers must be intensified, particularly with regard to food production processes and food technologies. While there is a considerable amount of dialogue taking place around food issues, it was generally agreed that the quality of information is lacking. In particular, scientists need to avoid expressing excessive levels of certainty, because this attitude often serves to diminish trust. In addition, the private sector must avoid ignoring scientific evidence that contradicts industry preferences. It was agreed that industry, academia, and government scientists must work together to increase the volume, improve the quality, and direct the tone of scientific dialogue.

Context is one specific component that can be used to improve communication to the public about food system risks. Providing examples in which a risk is being discussed as a comparison with other risks provides a relative context to the public when statistics and percentages are difficult to evaluate independently. Direction for the consumer is another specific tool that can be integrated into food communications. Communicators need to share ideas for what a consumer can do about a potential food risk, rather than simply stating that the risk exists.

Smaller countries, and countries with more tightly controlled communications channels, may find it easier to manage the overall message being delivered for a new food risk or in a crisis.

Large supermarkets have increasingly significant control over what products individuals purchase and where they purchase them. As such, it is essential to consider the position these retailers should play as their influence over the food chain increases.

There exists a challenge for industry to engage with local interests and cultural preferences in research and development. Larger corporations may be more successful in integrating local and cultural preferences because they have greater resources at their disposal. Smaller companies have greater challenges, as they may have fewer scientific or technological staff. The opportunity exists to overcome this, however, through cooperation among research institutes and industry at the local level.

Since it can be difficult to alter or influence behaviors that are culturally or socially relevant, significant challenge exists when traditional food practices contravene current understandings of food safety. This issue was illustrated by the practice of buying live chickens from poultry markets in China rather than from supermarkets. It was suggested, however, that there are opportunities for food-safety education within the bounds of cultural preferences.

There was strong sentiment that greater efforts need to be made to conduct research where it is most relevant, rather than transposing research done in more-affluent countries to less-affluent countries, even though it may be more costly. Large-scale projects, particularly in capacity building, must be conducted in conjunction with local representatives and an understanding of the local food-industry structure. Indeed, it was agreed that linkages among the local public, local governmental agencies, and research institutions are imperative in effective food systems research and development.

There was strong agreement that emphasis must be placed on utilizing an interdisciplinary approach in food safety and security research. By involving individuals from a wide variety of disciplines (e.g., food science, agricultural science, engineering, and social science), efforts to address problems in food safety and security are more likely to succeed. It was recognized, however, that interdisciplinary efforts are particularly challenging (e.g., there is considerable potential for misunderstanding between disciplines), and efforts to incentivize this research must be considered.

Regarding small-scale farmers, particularly in less-affluent countries, , it was noted that competition from larger industry is making it increasingly difficult for smaller farmers to put their products on supermarket shelves. This problem is compounded by the variety of requirements for food safety from retailers. Complying with the various regulations can be costly, which creates barriers especially for small-scale farmers. There was agreement on creating more uniform private food safety standards that are based on science rather than economic priorities.

Within some specific geographic locations, the local crops are of excellent quality and sufficient quantity but the availability of quality protein remains the major limiting factor in improving food security. There was agreement that the urgent need for additional availability of high-quality protein sources needs to be recognized, despite the focus on improving crops. Some of the effort toward crop improvement would be well spent on improving crops that could be used as animal feed in protein-poor regions.

Policy issues

The development of a policy environment in which interdisciplinary research is promoted and well funded was strongly recommended. Interdisciplinary research is often considered less prestigious than single-discipline research, despite its potential to generate improvements in a variety of areas. As such it is necessary to consider how to create incentives for individuals to perform interdisciplinary work. In particular, it is important that social scientists are able to contribute at the early stages of scientific research.

Developing methods for establishing ownership of the outcome of research emanating from public-private partnerships is necessary to encourage such research. Public-private partnerships may be key to addressing issues such as the lack of consumer trust in certain food products. Transparency is essential in developing public-private partnerships that do not experience problems with regard to public perception.

Small, medium, and large enterprises will engage in public partnerships differently. In particular, small to medium enterprises may be good candidates for early-stage discussions aimed at making relevant suggestions for research direction, or for developing new technologies within their business. Working groups for these partnerships can be helpful if they clearly define the scope of the work, who is responsible for the work, and who will be the leader in communicating with the public.

While the importance of conducting research locally was generally agreed upon, there is a complex environment regarding the coordination of funding. The source of funding (e.g., governments, NGOs) for local research, as well as how the research is organized, are important considerations in less-affluent countries.

Policy issues related to the concept of food sovereignty, defined as the right of sovereign nations to democratically determine a country's own agricultural and food policies, were raised. However, the groups that advocate this important concept are often simultaneously sowing fear and disinformation about biotechnology and other new technologies. It was strongly agreed that if science is to respect the sovereign right of states to make their own agricultural and food policy choices, then states also have a responsibility to base their food and agricultural policies on sound science. When these mutual responsibilities are in conflict, it was unclear how to determine which one should prevail. However, it was agreed that good governance is essential to fostering an environment for sound scientific decision-making.

The role of the public sector in supporting the development of "minor" crops (e.g., crops that are important in less-affluent markets) was emphasized. The private sector is often less willing to devote funds to research and development of these crops. Therefore, the responsibility falls to the public sector to ensure that a focus on these crops is maintained and agricultural diversity is not diminished.

In an effort to improve food safety and security globally, policies that aim to harmonize food safety standards among markets should continue to be encouraged. Despite recognized efforts by the GFSI, distributors from emerging markets still are faced with difficulties caused by multiple standards from retailers that are not aligned with Codex Alimentarius standards. To comply with multiple standards, additional staffing and auditing is necessary, which often results in smallholder farms being excluded from potential markets. This was argued by some to be a *de facto* trade barrier in need of urgent attention.

Postharvest Technologies for Food Security and Safety: Linking Knowledge, Infrastructure, and Policy**

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Summary

The availability and access to quality, nutritious, and safe food to meet the demands of a growing global population is one of the grand challenges of our time. With a projected global population increase from more than 7 billion in 2012 to 9 billion in 2050, it is estimated that food production must increase by more than 70% to meet future demand. Recent incidences of rising food prices and supply volatility have highlighted the need for a broad-based approach to the assurance of food and nutrition security at international, national, and household levels. To meet future demands for food, feed, and fiber, a new smart agriculture is required that produces more with less, including the reduction of food losses and waste. Technological innovations in postharvest handling and processing of agrofood products contributed significantly toward averting the 19th century apocalyptic Malthusian prediction of population outstripping food production, but it is only recently that the knowledge, infrastructure, and policy elements of a sound postharvest system have become mainstreamed in scientific research and practice.

Current realities

Due to a combination of factors including rising global population and demand for protein foods, especially in middle- and low-income countries, it is projected that food production will have to increase by more than 70% to meet future demands by 2050. Most of the projected increase in food production would have to come from the intensive application of technological innovations, given the increasing competition for fresh water and agricultural land for urbanization, and development of new infrastructure networks. Increasing globalization of the world food system has resulted in the emergence of a few, very large multinational food companies that source raw agrofood products from various climatic conditions to meet consumer demand for uninterrupted year-round supply of quality, nutritious, safe, and cheap foods. The increasing concentration of food systems brings new challenges in assuring the quality and safety of agrofood products and ingredients. Increases in the incidence of food-related diseases, safety hazards, and adulteration have raised public concerns about the physical security and defense of the food system. Incidence of food safety hazards contributes to health burdens and also reduces food availability because of the recall and disposal of affected products. Technologies and innovations are needed for rapid, real-time, and online surveillance, detection, analysis, and communication of potential hazards in the food system. Current technological advances in smart and intelligent packaging highlight the prospects for implementing effective intelligent controllers in food value chains.

The Food and Agriculture Organization (FAO) of the United Nations has reported high incidence of food losses and waste occurring in both developed and developing countries and affecting all types of food products. A study showed that up to one-third of global food production may be lost and wasted, amounting to billions of dollars in food value. Furthermore, these losses and waste exclude quality and nutritional losses as well as the cost of inputs and scarce natural resources such as fresh water used to produce, handle, and process the food. Technological innovations in postharvest handling, quality and safety control, preservation, packaging, storage, and distribution are essential to reduce these losses and add value along the supply chain, thereby contributing to food and nutrition security.

To address these challenges and harness the opportunities for global food security and safety, future needs for postharvest knowledge and infrastructure and related policy require attention. Novel knowledge is needed to develop cost-effective, resource-efficient, and environmentally friendly postharvest technologies of the future.

Scientific opportunities and challenges

Early studies in the 1960s and 1970s on postharvest losses and waste focused on addressing the food deficits in cereal grains in developing tropical countries. Small teams of consultants were usually dispatched from donor countries to conduct rapid reconnaissance field assessment of crop production and magnitude of on-farm losses. Though useful in providing broad estimates and identifying food insecurity hot spots, such data on losses relied heavily on expert opinion rather than on evidence. Debate on the accuracy and objectivity of the food-loss data emerged among economists and development practitioners. Overall, accurate data on the magnitude of losses and wastes along the entire food supply chain are still lacking and are needed for food security planning, intervention, and policy formulation.

More recently, global attention on the magnitude of postharvest food losses and waste has expanded to include both developed and developing countries and all types of food products. Various reports indicate that greater magnitude of losses occur in some countries and supply chains where postharvest infrastructure is lacking and where there is limited application of improved postharvest technologies for product handling and preservation. Food waste is higher in developed countries mainly at retail and consumer levels because of short "use-by" dates, excessively high standards for cosmetic quality attributes (e.g., consumer demand for perfect-looking food products), and excessive household food purchases and serving portions.

Mechanical, pathological, and physiological factors are among elements contributing to quality deterioration and food loss along the supply chain. Mechanical damage results from the presence of excessive forces on the food product because of impact, compression, and vibration during handling, storage, and distribution. These can be exacerbated by inappropriate handling systems, inadequate packaging, and bad road infrastructure networks.

Controlling the moisture content of cereal grains by drying and maintaining the cold chain of fresh food produce by refrigeration are critical factors in managing the physiological processes of food products and thus managing quality and safety. However, these key process technologies in food preservation are energy intensive, and thus remain major bottlenecks in efforts to reduce postharvest food losses and maintain quality and safety, especially in developing countries. The safety risks and health burden of hazards associated with improper drying of food products (such as aflatoxin contamination of grains) is a major food safety concern. Pathological causes of food loss due to diseases and pests can be controlled using hurdle postharvest technologies often involving thermal and chemical approaches. To effectively control food quality and safety and reduce losses and waste, intelligent monitoring involving data capture, analysis, and communication, is essential. Such feedback quality management systems allow for the implementation of effective traceability, including recall, when the safety and security of the food system is threatened or breached.

Policy issues

Reducing postharvest losses and waste and creating new food value propositions must become part of the broader food policy mix. Policy formulation on postharvest technology to improve food security and safety is complex and involves a wide range of disciplines and stakeholders.

- Quantifying the magnitude of food losses and waste needs to be carried out at various levels, from household to country level, since current evidence suggests that the amount of losses and waste vary widely. Improving the accuracy, reliability, and access to such data should be given urgent priority by national and regional policy makers.
- Gathering existing evidence on the cost-effectiveness and impacts of current and emerging postharvest technologies in reducing losses and waste and maintaining food safety deserves priority attention. A coordinated research program on postharvest technology for impact should be developed at national, regional, and international agricultural research centers.
- Greater coordination and involvement of global food chains in efforts to reduce food losses and waste through new multistakeholder platforms is needed. Meeting increased consumer demand for cosmetically perfect and safe food products can result in shorter "use-by" dates and rejection of otherwise safe and nutritious food products. Major food retailers, governments, and relevant global bodies should take the lead to revise and harmonize cosmetic quality standards of food products.
- Vigorous, sustained education and awareness campaigns targeting academic institutions, households, restaurants, and other food service outlets are required to promote better food habits and proper use of proven technological innovations to reduce food waste. Community organizations and governmental agencies dealing with food security and safety should take the lead in public-private partnership programs.
- New research initiatives are needed to promote the development of a new wave of novel, cost-effective postharvest technologies applicable to small- and medium-sized enterprises. Ministries of agriculture, development partners, and R&D organizations must take the lead.
- Major investments in economy-wide infrastructure such as roads, rail, and cold-storage facilities are urgently needed in developing countries, especially in Africa, to support storage and intraregional trade in agrofood products. A multistakeholder, high-level meeting of investors and public sector policy makers is recommended.

- Food safety surveillance systems need to be integrated at the national, regional, and international levels. Novel postharvest technologies exist that measure the quality and safety of food products, but the integration of these diverse systems into actionable food policy is lacking. National and local governments must cooperate with international development agencies such as the FAO and World Health Organization (WHO) to capitalize on this opportunity.

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? A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense: Focus on Technologies and Innovations, convened by the Institute on Science for Global Policy (ISGP) April 14–17, 2013, in Verona, Italy.**

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Prof. Linus Opara (see above). Prof. Opara 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 90-minute period. This Debate 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 Prof. Opara. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Prof. Opara, as evidenced by his policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- The development of an incentivized system to minimize food waste is critical to adequately address the problem of food security at various stages along the production and supply chain.

- To alleviate food insecurity in sub-Saharan Africa, it is necessary to develop methods by which industrialized agriculture can be developed in an African context. Unless self-sufficiency is understood on a national or regional level, rather than a local scale, limited progress will be made.
- Because effective governance is a critical factor in promoting food security, establishing an environment that is conducive to private-sector investment and the successful application of food technologies requires political commitment and stable government structures.

Current realities

The volume of food waste generated in both more- and less-affluent countries was viewed with concern. Because the food supply chain is structured in a way that encourages waste, a substantial amount of food is lost at numerous points along the food chain, including at the retail level, where supermarkets often discard large amounts of acceptable produce (e.g., because of over-handling). Since many private businesses are involved, it is also difficult to obtain an accurate estimate of the scale of such food losses.

Disagreement arose regarding the extent to which North America quantifies the scale of its food waste. Some suggested that North America neither quantified the amount nor analyzed the economic impact of this loss. Similarly, in other parts of the world, food waste might be quantified, but the impacts are not generally discussed. However, others countered that in recent years, considerable research has been devoted to quantifying and analyzing food waste and therefore it is now possible to determine the financial and environmental impacts of food waste in North America.

The extent to which food security concerns can be attributed to waste versus self-sufficiency is unclear. A number of organizations (e.g., the Gates Foundation) have committed considerable resources to addressing the issue of self-sufficiency in less-affluent countries. However, this focus can be problematic if it implies that individuals who need to be self-sufficient are not part of a global system. Care needs to be taken when defining self-sufficiency by considering what it means to be sufficient on a national and regional scale as well as at the individual level.

There are numerous examples of successful attempts to advance food security around the world. The Green Revolution in India enabled the country to move from relying on imported food from more-affluent countries to being able to independently produce sufficient for its population. Similarly, in China, concern is now focused on the quality and safety of foods rather than on whether there is enough food. It was noted that countries were successful in achieving food security when governments saw it as a national priority and garnered the political will to make it happen.

Discussions about the reasons for India's success in achieving food security focused on the pivotal role of the government in providing the political and economic impetus for this achievement. While in more recent years the private sector has driven much of India's economic growth, this advance was only possible because the government laid the groundwork and offered considerable support to enable industry to establish itself. Additionally, an investment in agricultural universities allowed for the development of homegrown expertise. Although not all of India's problems have been solved (e.g., many infrastructural deficiencies continue to exist), its experience during the Green Revolution can provide valuable lessons for other countries seeking to reduce food insecurity. In countries where governments have not laid such infrastructure foundations, food security efforts have been considerably less successful.

There was a significant focus on the realities currently facing sub-Saharan Africa. The level of political and social instability in many African countries is an underlying reason as to why the private food sector has been reluctant to invest in these countries. Such governance instability also explains why efforts to promote food security have not been successful. Although sub-Saharan Africa is more connected to the rest of the world than ever before, many farming practices and agricultural structures remain unchanged. These structures have hindered efforts to improve food security.

Scientific challenges and opportunities

To meet the challenge of addressing the issue of food waste, it is vital to understand not simply how much food is wasted, but also the human impact of that waste. Food is lost at numerous points along the supply chain, with causes ranging from insects in grain stores to restaurants preparing excessive amounts of food that is not consumed. Developing a system in which decreasing waste was incentivized would be the most effective method of encouraging reductions in food waste.

The prevailing notion that food security in sub-Saharan Africa can be addressed by ensuring individual level self-sufficiency was strongly contested. National food security has only ever been achieved through industrialized agriculture and it is both inappropriate and ineffectual to oblige people against their wishes to work as farmers. The current paradigm is not working in sub-Saharan Africa and many individuals who own land do not wish to retain it. There was general consensus on the need to move to "for-profit" rather than subsistence agriculture in sub-Saharan Africa. A challenge therefore lies in reconceptualizing self-sufficiency on a national or regional level and considering methods for industrialization in the context of sub-Saharan Africa.

Engaging local people to criticize and take action against ineffective governance that is stymieing food security efforts is both a considerable challenge and an opportunity. Concern was raised that many in sub-Saharan Africa do not have adequate tools or resources to challenge prevailing governance models. It was suggested that a variety of different stakeholders must play a role in enabling effective action. University professors could devote time to educating students on the policy issues related to their subjects, rather than focusing on purely academic material. In the context of agricultural studies, students would be able to better understand the reasons why the technologies do not necessarily have as much impact as anticipated. Engagement should extend beyond universities, however. Community groups, churches, and NGOs were all recommended as potential partners.

Encouraging the development and application of local solutions to the challenge of food insecurity is crucial in furthering the food security agenda worldwide, but especially in sub-Saharan Africa. There was considerable concern that activities emanating from outside of Africa (e.g., Gates Foundation-funded investments to encourage self-sufficiency or Chinese investment in agriculture) would, at best, do little to improve food security in a sustainable manner. In the worst cases, as represented by Chinese investments, these activities serve interests other than those of sub-Saharan Africa. As such, those in sub-Saharan Africa at both governmental and community levels need to be more effective at mobilizing the resources to build food security into the development agenda in a sustainable manner. These local efforts are needed to ensure that African interests and resources are given priority over those of outside causes.

Policy issues

There was agreement that policies to address food security in sub-Saharan Africa must start locally. Without government commitment as a starting point, food security will remain an unachievable goal. Additionally, until local systems are working coherently, international efforts will have limited success. Many international businesses are reluctant to invest in sub-Saharan Africa because of concerns that the local infrastructure is not sufficiently sound. A critical but under-discussed policy issue for establishing food security focused on the need to strengthen local infrastructure and to foster committed local leadership.

Considerable discussion focused on the specific issue of governance and its role in promoting food security in sub-Saharan Africa. Key aims of policy makers need to be (i) defining and understanding the role of governments in promoting food security, (ii) laying the foundations for private sector investment, and (iii) encouraging an environment in which various technologies can be deployed successfully. To achieve these aims, a heightened sense of awareness on the part of policy makers about their responsibilities in this arena is required. Often when government responsibility is discussed, commitments are made but without sufficient energy or commitment to ensure their actual enactment. Until governance is strengthened, technologies will not be used to their full potential.

It was generally agreed that the private sector has a crucial role to play in enhancing food security in sub-Saharan Africa. There was no clear consensus, however, regarding when this role needs to be played. Some argued that private sector contributions are valuable only once governments have laid the groundwork (e.g., the construction of railways and airports), and are in a position to assist private sector development (e.g., Vietnam and Cambodia). Others, however, emphasized the role that the private sector can play outside of governmental structures. The principle of mutuality has allowed both the private sector and individual farmers to benefit in a sustained manner, even when governance structures have not been entirely sound.

Negative consequences can emerge from unequal partnerships between countries in sub-Saharan Africa and other investors. While the Chinese model of agriculture in Africa might be a positive move toward industrialization and agricultural development, such partnerships have little to do with food security, and are rarely in the interests of individuals in sub-Saharan Africa. When land is sold, many other attributes are sold with it (e.g., water rights or control over what is grown), which may have significant negative implications for food security. In addition, there is very little transparency in these arrangements. Consequently, it is difficult to assess how popular these arrangements would be if subjected to a more open and transparent process. While trade partnerships are to be encouraged (e.g., it might be profitable for partnerships to enable resource sharing along the Nile), they must be conducted on a mutually beneficial basis.

Industrialization can be utilized as a model to foster food security in sub-Saharan Africa, because that it is the only model that has worked effectively in the past. The manner in which industrialization needs to manifest itself is yet to be determined, but it was considered essential to encourage nationwide agriculture rather than individual-level self-sufficiency (i.e., those who wish to engage in agriculture can do so, but not as their only choice). Numerous examples (e.g., India, China, Vietnam) were provided where government-led industrialization of agriculture has led to considerable improvements in national food security.

Improvements in agricultural infrastructure need to be integrated into the wider social development agenda to be successful. Investment in agricultural universities in India in the 1960s and 1970s led to India becoming one of the largest producers of tractors in the world, with many now being exported to sub-Saharan Africa. Such developments can be ensured only if agriculture is seen as a crucial part of development.

There are potential negative impacts of industrialization and concern was raised that industrialization could result in a large influx into cities of individuals who would then be unable to find employment. In this way, poverty and food insecurity would persist in a different form. Because there has been no precedent for this in previous industrialization processes, the concern was considered largely unfounded.

Technology, Society, and Food Security: Developing a Societally Inclusive Research and Policy Agenda**

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Summary

Policies developed to ensure global food security need to address not only innovations in agrifood technology, but also societal acceptance of these technologies and other issues associated with consumer behaviors. Societal acceptance and consumer behavior need to be incorporated into transdisciplinary research agendas focused on addressing problems in securing the future global food supply.

Current realities

It has been recognized by the scientific community and a range of different policy bodies that global food insecurity is an important global policy issue. Our ability to produce sufficient and healthy food is likely to be seriously compromised unless urgent remedial actions are taken to ensure the security and integrity of the global food supply. It is also recognized that the causes of food insecurity are associated with a range of different drivers and their potential interactions, which may exert influence locally, regionally, or globally. For example, the European Union Standing Committee on Agricultural Research (SCAR) identified eight major driving forces for agriculture in Europe that would be relevant over the next 20 years: climate change, environment, economy and trade, energy, societal changes, health, rural economy, and innovations in science and technology. However, one of the most important issues (and one which has hitherto been neglected in some areas of policy development) is that of consumer and/or citizen behaviors. This is particularly true in a policy domain, which has tended to focus on monodisciplinary, technological solutions to problems and issues that, in part, have their origins in social environments.

Consider the case of genetic modification (GM), which has been developed and applied within the agrifood sector to deliver benefits including improved food security, as well as safer and more nutritious foods derived from plants, animals, and other organisms. Technologically driven policy has, historically, assumed that society will unquestionably accept the application of GM in national, regional, and global food supplies as the issue of improved food security is an international priority. However, research within the social sciences has demonstrated that it is the public's risk (and benefit) perceptions that determine the acceptability of technologies applied to agriculture and food production to a much greater extent than in other domains (e.g., in medicine).

The E.U.-funded Pegasus project recently completed a meta-analysis of the available literature focused on global public opinion. It indicated considerable regional variation in public acceptance, as well as differences related to the nature of the application. In the case of agrifoods, plant-related or "general" applications (e.g., unspecified GM technology applied to improve food security) were more acceptable than those that were animal-related. Risk perceptions were greater in Europe than in North America and Asia, whereas the reverse was true of benefit perceptions. However, moral concerns were reported to be higher in North America and Asia. Communication and policy about agrifood GM would therefore need to take account of possible cross-cultural differences in information requirements and address this in the process of regulatory harmonization. Data about consumer perceptions and attitudes were collected between 1990 and 2011. Consumers tended to perceive more risks to be associated with GM animals as time progressed. However, at the same time, benefit perceptions associated with the same issue also increased over the time period. It is unclear whether consumer acceptance of GM animals is primarily driven by risk or benefit perceptions, in particular in relation to animals genetically modified for food use, which have yet to be widely commercialized and therefore are yet to be "market tested." The issue of perceived risk and benefit may be particularly relevant in regions where concerns about GM technologies are most profound, such as Europe.

The case of public attitudes toward GM in agriculture has inhibited the implementation of GM agrifood solutions globally (and particularly within Europe), and has been posited as a probable response to the use of other technologies in the agrifood sector more generally. For example, in the emerging applications of agrifood nanotechnology, expert and policy concerns about consumer attitudes associated with agrifood applications of nanotechnology have inhibited commercialization of products (but not necessarily *processes*). This has had concomitant impacts on exploitation of research and potential impacts on food security. However, the concerns about societal acceptance expressed by experts, policy makers, and industry stakeholders are not matched by consumer concerns about the same applications.

Scientific opportunities and challenges

Implementation of technological solutions to food security issues needs to be formally integrated with strategies addressing societal drivers (e.g., citizen behaviors and attitudes). Developing theoretical and practical approaches that can simultaneously address the range of different issues affecting food insecurity, from climate change (and its potential drivers) through to consumer behavior, is required if food security is to be delivered. For example, large multidisciplinary research programs that include biotechnological approaches to increasing the food availability and supply, integrated with economic and social psychological research addressing why consumers do, or do not, adopt sustainable food consumption patterns, could target the problem of food security from the perspective of the entire supply chain. Practical information interventions could be developed from the body of evidence resulting from the research activities. While challenging, such an approach is not impossible, assuming steps to integrate research approaches across disciplines are initiated (e.g., in the process of research agenda setting) and that sufficient weight is given to inclusion of behavioral change alongside technological innovation in the policy process.

Policy issues

- An effective communication strategy associated with novel and emerging technologies to improve food must take full account of broader issues of public concern in addition to consideration of technical risks and benefits. Such a strategy might originate from governments, industry, or public-private partnerships.
- An effective understanding of societal concerns requires the use of standardized research methods to collate information, which will facilitate the identification of changes in these terms over time and across different regions of the world.
- It is essential to address issues of consumer and/or citizen concern early in the process of technology development, implementation, and regulation, particularly in relation to ethical concerns and issues of consumer choice and control. Societal acceptance of innovative products of food technologies is not driven by technical risk assessments in isolation.
- Integrating knowledge of the factors that drive societal acceptance of emerging technologies into policies that facilitate the introduction of new technologies (e.g., within a standardized risk analysis framework) will ensure that societal as well as technological concerns are addressed.

- Research agenda-setting needs to formally address citizen priorities for technological development and its implementation early enough in the innovation trajectory for this information to "shape" emerging applications in line with societal expectations. For example, considering the issue of nanotechnology applied to agriculture, consumers are enthusiastic about nanoencapsulation of functional ingredients, but highly concerned about the use of "smart pesticides." This would suggest that innovation strategies should focus on the former application, which is acceptable to society.
- Transdisciplinary research (e.g., integrating the natural and social sciences) is needed to develop societally acceptable science and technology policies on food security issues. Unfortunately, such approaches are rarely applied in practice due to the imposition of monodisciplinary boundaries by research sponsors and research infrastructures. Forming teams drawn from relevant disciplines focused on solving existing and emerging societal problems appears to break down transdisciplinary barriers, for example, in areas such as food security.
- Alternative policy solutions to problems of food security should not be neglected. For example, communication interventions that address sustainable food consumption and policy measures targeting other food chain actors (e.g., package size in retail outlets) aimed at reducing consumer food wastage may be as relevant as technology-based policies in improving food security. Research is needed to identify what works and what does not work, for example in relation to interventions targeting consumer behaviors such as labeling or fiscal measures.
- Understanding similarities and differences in consumer behavior will facilitate harmonization of global regulation and trade among regions where societal priorities and preferences for technological development and implementation differ.

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Box 1: Implementing global food security

- Developing and maintaining global food security requires simultaneously addressing a range of drivers, originating in both the natural and social environments
- Technological solutions can only be utilized if these are accepted by society
- Factors other than technological solutions (e.g. developing interventions to tackle wasteful behaviors throughout the food chain) should not be neglected when striving to develop sustainable food production systems

Box 2: Policy objectives

- Develop communication strategies addressing societal concerns
- Standardize research methods internationally to understand and map citizen risk-benefit perceptions
- Integrate societal acceptance of emerging technologies into technology implementation policy
- Formally address citizen priorities for technological development and its implementation in research agenda setting
- Promote transdisciplinary research (integrating the natural and social sciences) to develop policy relevant to global food security
- Harmonize international governance and regulation regarding food security initiatives

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Prof. Lynn Frewer (see above). Prof. Frewer initiated the debate with a 5-minute statement of her views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate 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 Prof. Frewer. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Prof. Frewer, as evidenced by her policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- The complex issues associated with addressing food insecurity issues (e.g., social, cultural, technological, and economic) require a renewed effort to establish interdisciplinary cooperation and especially an appreciation for the contributions that social sciences can offer.
- Since social and cultural issues determine individuals' attitudes toward foods and food technologies (e.g., genetically modified [GM] foods), the process of producing and deploying new technologies must consider social and cultural variations to ensure that they are consistent with public understanding.
- To allay public mistrust, which often arises when individuals perceive they do not have a choice about accepting a certain product or technology, policy makers need to develop methods to clearly present the risks and benefits of any product or its associated technology, including an accurate description of any uncertainties.

Current realities

In addition to generating a large environmental impact, meat consumption has been linked to an increased risk of numerous diseases (e.g., coronary heart disease, type 2 diabetes). As such, reducing meat consumption has been suggested as a means to address the problems associated with these diseases. It was noted, however, that the greatest demand for meat production is in less-affluent countries, where there is a considerable need for high-density calorie sources. Additionally, meat production in many parts of the world is an important economic engine and carries much cultural significance.

There was general agreement that culture plays a central role in determining the relationships that individuals have with their food. Culture and emotion often come into conflict with what might be perceived as a "rational" food choice (e.g., meat produced by cloning technology is viewed as unappealing, even though it is likely safer than conventional meat). Additionally, cultural factors influence the concerns that individuals have worldwide. In Europe, most concerns related to genetically modified (GM) foods have been related to crops, whereas in the United States concern has focused on GM animals.

The reasons for previous food-related communication failures were discussed in detail. Concerns over GM foods in Europe increased when members of the public perceived they had no choice regarding what they were eating. The public assumed that a failure to label GM products, lack of transparency, and the muzzling of anti-GM scientists were evidence of an attempt to cover up dangers associated with GM. As a result, public attitudes hardened against GM. In contrast, in instances where foods have been clearly labeled and traceable (e.g., as happened with the Flavr Savr tomato), there have been largely positive public reactions and little negative publicity.

Further communication failures have taken place when governments have remained silent in the face of concerns about food products (e.g the 1999 Belgian dioxin crisis, in which high levels of dioxin were found in meat and eggs as a result of contaminated animal feed). It was noted that governments have found it particularly difficult to convey information effectively when the outcome of an incident is unclear, especially when they perceive the public as being unable to cope with uncertainty. It was asserted, however, that leaving an information vacuum is considerably more damaging, since the public perceives that something is being hidden.

The integration of public opinion into technology policy and deployment was also discussed. Often in the past, when dialogue with the public has taken place, the outputs from that dialogue have not been integrated into the policy or technology deployment process. This lack of integration significantly reduces trust in the sincerity of consultation exercises.

Public communications often treat entire populations as a monolithic entity, rather than a collection of individuals with varied cultures and priorities. For example, data have shown that if given information on risks and benefits, approximately 45% of consumers become more focused on the risks, 13% view the product more positively, and the remainder do not shift their position. A failure to appreciate these variations has created communication campaigns that are less effective than intended. An additional problem with this assumption that populations are a single entity is that the attitudes of one individual or group of individuals can be taken to represent the views of the population as a whole, so any responses based on this information might be inappropriate.

Negativity on the part of government and industry toward data collected by social scientists was noted to be an impediment to improving communication with the public on food issues. Examples exist where data collected by social scientists generated anger when it did not match with the intended message.

While increasingly important but difficult to manage, the role of social media was discussed. Currently there is insufficient understanding of how social media influences individuals to effectively harness it for communication strategies.

Scientific challenges and opportunities

Greater demand for increased meat consumption in less- rather than more- affluent countries was noted to be a challenge, since simply recommending reduced meat consumption does not address this demand for increased calories in food-insecure regions. However, it was suggested that it is necessary to consider all options for increasing food security rather than relying solely on greater meat production, and that behavioral and technological innovations need to be utilized in creating a comprehensive solution to food insecurity.

It was agreed that the efforts to increase food security and promote sustainability around the world must not impose values from one part of the world to another or remove access to product choices. Further concerns were raised about any suggestions to limit meat consumption, given the considerable levels of demand for meat around the world and the fact that it is often culturally and economically important. It was argued that this element of choice not be removed from those in less-affluent countries, nor that the values important in more-affluent countries (e.g., increasing rates of vegetarianism) be uncritically transferred to other parts of the world. However, it was also considered important to explore whether the current design of the food supply, which creates considerable amounts of waste, is ideal for ensuring sustainable nutrition, and whether practices in more-affluent parts of the world be extended without question.

While there was consensus that food insecurity is a considerable and growing problem, deciding how best to address this problem is a significant challenge. An initial challenge is to define what strategies are needed in different areas of the world (e.g., food security in sub-Saharan Africa will need to be addressed differently than potential food shortages in more-affluent parts of the world). Much discussion centered on proposals by the Food and Agriculture Organization of the United Nations (FAO) to promote insects as a source of protein. Although the benefits of consuming insects were appreciated (i.e., bugs being relatively high in protein and low in environmental impact), it was also recognized that many would likely find this option unappealing, and encouraging consumption in Europe and North America, in particular, would be difficult.

Questions were raised about the point at which cultural issues need to be incorporated into technology development and implementation. There was no consensus as to whether attention needs to be given to culture before technology is developed or at the end of the process. It was suggested, however, that the considerations of culture need to be integrated into the technology development process so that technologies are developed in conjunction with the public rather than imposed on people. This approach ensures that consumer concerns can be addressed during the development process.

Significant opportunity exists in the increased use of interdisciplinary practices to address food security challenges. Collaboration across disciplines (e.g., among technologists, social scientists, and ethicists) would enable food security issues to be addressed more effectively, given that many different factors affect food security (e.g., the policy environment, risk perception, and economics). Such collaboration is difficult, however, because there are few individuals with expertise in how to create and manage successful interdisciplinary partnerships. In addition, the benefits that social science disciplines can offer are often overlooked because results can be less immediately obvious than those offered by other disciplines.

Understanding how consumers perceive benefit and risk is vital during the production or deployment of new food technologies. It was unclear how to best assist consumers in understanding the risks and benefits of particular products and technologies, and subsequently how to encourage behavior change in the face of those risk/benefit perceptions amid the various social and cultural factors that also influence food choices. Although there has been considerable focus on the perception of risk (which inevitably varies from person to person), the perception of benefit generally has been overlooked, and therefore an opportunity lies in exploring this issue further.

Policy issues

Investment in new technologies is worthwhile only insofar as the resulting products are accepted by the target audience. Policies related to technology development must therefore consider how to integrate social and cultural understanding into the development process. A potential policy option would be to utilize the concept of coproduction, incorporating societal preferences into technology production, to ensure that new products address the needs of the target consumers.

Policies to involve the public in technology development are regularly unsuccessful because they often ignore the outputs generated from public engagement. Not only does this mean that the production process does not benefit from public input, but the public becomes distrustful of public consultation and is less likely to participate in the future or trust the subsequent products.

To be effective, public engagement needs to involve as broad a cross section of individuals as possible. In doing so, the policy agenda can be shaped by a representative sample of the population, reducing criticism that public consultations tend to be based on too small a sample.

Public distrust of new food technology does not necessarily emanate from lack of understanding, but rather from a sense that information is being withheld. Further complications arise when there are both risks and benefits associated with a product (e.g., people are encouraged to eat oily fish because of the health benefits, with the exceptions for pregnant women and those who are immune-compromised, because of the risks associated with mercury in the fish). It is the responsibility of policy makers to explicitly convey both the risks and benefits of a particular product so the public can make informed decisions. Presentation of information on both risks and benefits is also important in cases where individuals are making decisions based on information that is not scientifically credible.

Central to addressing food security issues is economics. There is often competition between the three desired attributes of food: that it be “good,” “abundant,” and “cheap.” Markets have generally been successful in securing two of these attributes, though rarely three. It is therefore necessary to consider weighted importance of each attribute. Abundant and cheap were considered the most important attributes in terms of achieving food security. It was cautioned, however, that simply driving down prices might create unforeseen challenges.

It was agreed that developing concerted policy with regard to food security was an international priority. However, there was no consensus over the best methods to achieve this goal. Since ensuring food security is not a competitive issue, regulations regarding food security need to be harmonized. It was questioned, however, as to how this would work in practice (e.g., would the regulations be mandatory or voluntary?), and which organizations would be involved, particularly as there is limited consensus on how to address the topic. It was suggested that the World Health Organization (WHO) and FAO need to lead such an effort, given their responsibilities in the area of food security.

Risk-based Decision-making to Improve Food Safety, Security, and Defense**

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Summary

The general public is comforted by certainty in all aspects of life, but science often disrupts that certainty. The public also expects a food supply that is affordable and safe from deliberate or accidental contamination. However, the food supply is complex and outbreaks do occur. Risk-based food safety decision-making is gaining visibility, and offers one means to ensure that limited resources are allocated in a cost-effective manner. The use of quantitative microbial risk assessment to describe the appropriate level of protection can offer advantages over more qualitative expressions of risk. The functional separation of risk-assessment and risk-management activities is not ideal. Instead, a more fluid exchange of information between risk-assessment and risk-management teams at the beginning and end of the risk analysis process offers some key advantages. National governments and the food industry should strive to make food safety policy based on quantitative assessment of risk. Where sufficient data are unavailable, national governments and the food industry need to provide funding to collect such data. The academic scientific community needs to train more students in quantitative microbial risk assessment and publish data that are quantitative wherever possible.

Current realities

The public expects a food supply that is affordable and safe from deliberate or accidental contamination and, generally, that is the food supply we have today. Problems do occur, however, and substantial problems generally garner widespread media attention. In 2012 alone, the United States Centers for Disease Control and Prevention (CDC) reported numerous multi-state outbreaks of pathogens such as *E. coli*, *Salmonella,* and *Listeria.*

The food supply is quite complex and includes agriculture, food processors of all sizes and types, wholesale and retail distributors, restaurants, and consumers. These supply chain components interact with local, state, and federal regulators, and are governed by state and federal regulations. When foods cross boundaries between countries (as they increasingly do) different national standards, the World Trade Organization (WTO), and Codex Alimentarius (a collection of internationally recognized standards, codes of practice, and guidelines) may be invoked.

Scientific opportunities and challenges

Risk-based decision-making is gaining visibility. The Uruguay Round of the General Agreement on Tariffs and Trade (GATT) talks led to the development of what became the WTO in 1995. The use of risk assessment to assist the development of food safety policy was elevated at the international level by these talks. The WTO Sanitary and Phytosanitary Measures (SPS) Agreement establishes the rights and obligations of WTO members regarding food safety (as well as animal and plant health). The SPS Agreement acknowledges that countries have the right to determine "appropriate levels of protection" (ALoPs) — sometimes called acceptable levels of risk (ALoRs) — but also notes that risk assessment should be used to ensure that SPS measures are not trade barriers in disguise.

The SPS Agreement further recognizes that Codex Alimentarius Commission (CAC) standards, guidelines, or recommendations can represent international "safe harbor" food safety measures. Importing countries must base their regulations on risk assessments, while exporting countries must demonstrate that their regulations achieve an equivalent level of protection to the importing country.

While risk-based decision-making may mean different things to different people, the SPS Agreement does not specifically distinguish between qualitative or quantitative risk assessments. Subsequent WTO guidelines note that "the comparison of the levels of protection considered appropriate in one situation with those considered appropriate in another situation can be facilitated if the potential damage is expressed in common terms, whether qualitative or quantitative." The same document goes on to note that "the use of quantitative terms, where feasible, to describe the appropriate level of protection can facilitate the identification of arbitrary or unjustified distinctions in levels deemed appropriate in different situations."

Risk analysis includes risk assessment, risk management, and risk communication. Risk assessment is a scientifically based process of formally evaluating risks (e.g., what is the risk of listeriosis from ready-to-eat foods in the United States?), and typically addresses questions posed by a risk manager. Risk management is the consideration (and selection) among different policy options (e.g., what changes can the regulatory agency make to its enforcement activities that would have the greatest effect on reducing death from listeriosis?). Risk managers make this choice by considering risk assessments, the interests of all relevant parties (regulated industry, consumers, etc.) and any other relevant factors (e.g., fair trade practices).

The experience of at least some regulatory agencies indicates that frequent exchange of information among risk assessment and risk management teams is necessary, particularly at the beginning of the process (to clarify the problem) and end of the process (when results are interpreted). The World Health Organization (WHO) has noted that there is also an emerging understanding that interaction between risk assessment and risk management is crucial. While risk managers should define risk assessment scope, risk assessors should be involved to advise on the scientific potential of what is being proposed. Similarly, risk assessors are primarily responsible for risk assessment, but need some mechanism to consult with risk managers when redirection or policy clarification is needed.

Policy issues

- National governments and the food industry need to strive to make food safety policy risk based, including allocation of more resources to areas of greater risk and setting standards that are based on risk rather than history.
- National governments and the food industry need to base such policy on quantitative assessment of risk. Qualitative and semiquantitative risk assessments may seem appealing because they seem easier to accomplish (fewer data needs) and understand (no complex math). The drawbacks to qualitative and semiquantitative risk assessment include the inability to differentiate relative risk from different scenarios. Qualitative analyses may not reveal what pieces of evidence were influential, how they were combined, and may produce ambiguous risk labels. Semiquantitative analyses are dependent on carefully constructed risk categories, and may introduce more inaccuracies when applied to a longer sequence of events.
- Where sufficient data are unavailable, national governments and the food industry need to provide funding to collect such data. There are numerous examples of such data, including consumer behaviors (e.g., “How often do American consumers eat hot dogs directly from the package?”), retail practices (e.g., “What are the temperature profiles of refrigerated food

cases in supermarkets?"), and microbial data (e.g., "What are prevalence and concentration of *Campylobacter* spp. in raw poultry?").

- The academic scientific community needs to train more students who are able to do quantitative microbial risk assessment.
- Risk managers and risk assessors (within national governments and within food industry companies) need to work together to ensure food safety policy is risk based.
- National governments need to develop regulations that encourage a risk-based approach by the food industry. Such regulations are typically phased by what is to be achieved, but not how to achieve it (e.g., "achieve a 5-log reduction in *Salmonella*" rather than "heat to 155 degrees for 15 seconds").
- Scientists need to recognize that, even if they do not consider themselves "risk researchers," their data may be used for risk assessment, and therefore they should strive to publish data that are quantitative wherever possible.

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Debate Summary

The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Prof. Don Schaffner (see above). Prof. Schaffner 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 90-minute period. This Debate 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 Prof. Schaffner. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Prof. Schaffner, as evidenced by his policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- To facilitate public acceptance of effective food policies, better communication and cooperation between risk assessors and managers is needed to ensure increased transparency in both the risk-assessment and risk-management processes. Given the diminishing levels of societal trust in governing institutions, account must be taken of a broad range of societal priorities when formulating results that can optimize public acceptance and result in general compliance.
- To significantly improve risk assessment and management processes in less-affluent countries, where food safety laws are typically less established or even nonexistent, economic growth, effective standards, and modernized infrastructures are critically needed.
- Despite additional resource burdens, uniform regulatory standards regarding international trade in food must be adopted by persuading governments to remove inconsistencies that diminish public health.
- Since industry plays a crucial role in decisions concerning food safety through its contributions to research and the dissemination of the results, industry needs to provide the intellectual and economic foundation on which to improve effective, evidence-based policies. Regulatory policies that currently limit industry support for research on risk assessments need to be modified.

Current realities

There has been evidence of progress in the acceptance of risk-based decisions concerning food (i.e., positive policy outcomes stemming from risk-assessment findings). Calculations derived from agreements among companies and regulators (e.g., Food and Drug Administration [FDA], United States Department of Agriculture [USDA]) have identified certain food products as posing negligible risk. These agreements have helped avoid expensive food product recalls.

Generally, the outcomes of qualitative risk assessments are described in terms of words (e.g., low risk, moderate risk, very low risk) while the outcomes of semiquantitative risk assessments are characterized as numbers. Full or partial quantitative risk assessment uses numbers through calculations to measure risk levels (e.g., determining what level of salmonella contamination in peanut butter might result in hospitalizations or deaths).

The importance of distinguishing between the outcomes from qualitative and semiquantitative risk assessments was characterized in terms of the impact on how the final results are communicated to policy makers, and eventually to the public. A quantitative approach is viewed as superior to a qualitative approach since the latter is normally used when there is either insufficient background data for a semiquantitative analysis or no resources to conduct a semiquantitative analysis. While qualitative assessments are often chosen for their speed and simplicity, they have the potential to be less accurate. However, not all quantitative calculations can claim to be based on accurate information or data because the calculations are often unduly influenced by expert opinion or surrogate data.

The United States was described as having more integration between risk assessment and risk management relative to the procedures in Europe where the roles have been kept largely separate. Clear procedures for risk assessment are in place within the European Union while the risk management process uses multiple factors that vary by country (e.g., reflecting differences in politics, the economy, needs of the industry, consumer demands). In both cases, risk management activities are not necessarily bound by science and often can be at odds with recommendations informed by risk assessments.

European-funded projects have considered alternative governance models that bring together various stakeholders early in the risk-assessment process, or "framing stage." These models assume that risk assessment is not necessarily purely objective, and that value-based judgments are needed to reach useful conclusions reflective of a variety of cultural and societal perspectives (e.g., deciding which risks to assess, whether to use a probabilistic or a deterministic approach).

Given that the precautionary principle is accepted to varying degrees around the world, it has been difficult to achieve consistency in the procedures used for risk management. However, risk assessment processes can be compared more easily because they are fundamentally quantitative. Specifically, microbial risk assessment is guided by the same set of principles regardless of the practitioner (e.g., academia, government agencies), and therefore, is relatively consistent internationally. Documents from international organizations (e.g., Food and Agriculture Organization [FAO], World Health Organization [WHO]) describing these common principles are shared and are available as educational and teaching tools.

Risk acceptance is the product of risk evaluations and assessments as presented to the public. Public acceptance of the results, however, depends on the societal tolerance of identifiable risk and varies from one case to another. While the precautionary principle emphasizes the need to avoid any degree of risk, choosing precaution does not necessarily equate to a reduction in risk.

Scientific opportunities and challenges

A lack of communication between risk assessors and managers has resulted in inappropriate attempts to scope the problem (i.e., generally characterize limits of the problem). To improve accuracy, an initial discussion of the scoping issues between these two parties can focus on producing an initial draft risk assessment to guide collective efforts.

It was questioned whether strict quantitative analysis could be applied to areas other than microbial hazards (e.g., chemical hazards) where the uncertainty is greater because the risks tend to be chronic and, thus, more difficult to verify. Consequently, quantifiable risk models used for pathogens might not be simply adapted to toxicology and chemical risk assessments.

Both national governments and the food industry need to develop practical methods to collect the data required for accurate risk assessments even when such data are difficult to obtain. Organized requests for such data generally are ineffective because there are no direct consequences for not responding. Effective requests for these data have previously resulted from industry efforts (e.g., in the case of *Listeria*). The global food industry, working with trade associations, has developed mechanisms to optimize the accuracy of risk assessments through blind data collection that does not implicate any specific company.

Companies find it difficult to comply with globally inconsistent regulatory standards (e.g., treatments for meat in the U.S. that are not required in the E.U.). Less-affluent countries often forego regulatory standards because they lack the resources required for implementation. Local regulatory authorities also must be convinced that globally consistent food standards can improve public health in their own countries by lowering microbiological threats. Consistent regulatory standards for food (e.g., treatment of meats with lactic acid) must be seen publicly as essential for healthy communities and not negatively as unnecessarily increasing costs and/or risks. (e.g., adulteration of meats). The potential for negative perceptions can be addressed through comprehensive public education campaigns.

Effectively reviewing risk assessments is increasingly challenging, particularly in regard to increasingly complex microbial risk assessments. Reviews of risk assessments will require access to any models used to obtain the data for reviewers to ensure that any recommendations are based on valid models and calculations.

The safe movement of food globally requires the recognition of the country and regional variations in the levels of sophistication of safety systems. The technologies required to maintain food safety standards are relatively simple (e.g., storage technologies, drying technologies, refrigerated warehouses), and because the global economy is rapidly expanding geographically, the infrastructure needed to implement even simple technologies is becoming more widely available. Consequently, there exists the opportunity to incentivize technological innovation and to introduce modernized infrastructure (e.g., power lines and roads) in less-affluent countries.

There is a general consensus worldwide regarding acceptable global regulatory standards for food safety. However, in practice, there is a lack of implementation of the agreed-upon standards (e.g., treatment of meat with chlorine in slaughterhouses). Mechanisms to ensure compliance (e.g., through inspections) must be in place within the regulatory structure. However, in situations where the infrastructure is not available for proactive enforcement, records need to be made available to support useful auditing procedures. Additional mechanisms (e.g., third party certifications) can also be utilized to ensure that standards are being maintained.

The lack of data in certain developing regions (e.g., Africa) makes the risk analysis process a challenge regardless of whether assessment and management are considered two separate processes. There have been efforts through international organizations (e.g., the International Commission on the Microbiological Specification for Foods) to address this absence of data that reflect serious consequences (e.g., food shortages). These efforts, however, are part of a gradual process of improvement.

It was argued that food insecurity is not unique to the developing world, and even in cases where there are numerous food options, a risk-based approach can still be applied to encourage behaviors that reduce risk (e.g., cutting mold off moldy bread, choosing dented cans without rust on the double seams).

Mathematical principles can be applied globally to justify food engineering and food safety improvements (e.g., the cost of investing in specific equipment can lead to feeding a specific number of additional people at a measurable higher level of safety). Such opportunities to develop quantitative risk assessments based on the outcomes can be achieved in less-affluent countries.

Policy issues

While trust in scientists and medical professionals appears to be diminishing in many societies, alternative governance models are being developed to help generate societal trust in specific institutions. These new models of governance integrate additional data (e.g., economic, social, ethical) early in the risk-assessment process so the data can inform decision-making. Support for these new models can help to address diminishing levels of societal trust.

Social science research indicates the public does not scrutinize data collection and analysis methods to determine perceptions of risk, but rather bases perceptions on levels of trust (i.e., less trust results in increased perceived severity of risk). To limit the perception that the interests of the public are being dismissed, there is a need for increased transparency in the acquisition of data, involvement of various stakeholders, maintenance of a continuous dialogue with the public, and the incorporation of public opinion throughout the decision-making process until a policy is implemented. Credibility and trust can also be addressed by increasing the number of experts in the risk-assessment and management process (e.g., through panels of scientists, as has been the case in Europe).

There was agreement that quantitative microbial risk assessment is not purely objective, and that explicative (e.g., assumed levels of a contaminant) and implicit (e.g., the weight assigned to a particular level of a contaminant during the assessment) assumptions are regularly made. For this reason, ensuring credible assessments will require improved peer review and transparent quantitative models. Increased transparency can also improve public trust in the scientists who are assessing the risks through mathematical models and other procedures (e.g., in relation to genetically modified organisms), which will generate greater confidence in the risk assessments produced.

There was disagreement regarding the relationship between risk assessors and risk managers and whether these roles need to be kept functionally separate. The functional separation between risk assessors and managers perhaps stemmed from early chemical risk assessments in which there was concern that risk assessors might assume the role of risk managers without having the necessary skill set. It was suggested that risk assessors and risk managers need to work more closely together, although the opposite has been recommended by a number of organizations (e.g., the U.S. National Academy of Sciences).

To address food safety in less-affluent countries, incentives are needed to encourage students who have studied abroad to return to their homelands and utilize their education in their respective countries. Global scientific training is increasingly available (e.g., food science and technology programs are developing in China) and, therefore, postgraduate training can be encouraged in less-affluent countries. While a lack of adequate quality controls remains a challenge, it was noted that during the 21st century many countries will progress through developmental stages similar to what the U.S. experienced during the 20th century.

Risk assessments were recommended as a tool for addressing both the challenge of missing data and for improving outcomes of decisions with limited and risky options (e.g., eating foods with known health risks as a result of food shortages). Risk assessment can be commissioned to generate data, improve upon existing data, and/or provide justification for the need for more data (e.g., net positive health benefits), which could then result in improved management options.

To prevent assumptions being made in quantitative risk assessments, it is necessary to release as much of the foundational data on which the assessments are based as possible. The risk-assessment process is itself fluid and can be adjusted in accordance with the emergence of new data. The models utilized must be simple enough for comprehension by a third-party auditor.

There is a plethora of industry data that has the potential to be utilized, but there are regulatory burdens that limit the contribution of data from industry. These regulatory burdens need to be reduced, and criticisms associated with bias in industry-commissioned research addressed. Whether results reflect favorably on industry or not, any type of data generated is tremendously useful for improving industry practice.

Public Perception of GM Food and Policy Implications**

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Summary

The development of genetically modified (GM) food has been a matter of considerable interest and worldwide public controversy. As a result, "uncertainties," "risks," and "benefits" that such new technologies offer to the food industry and consumers have been widely disseminated to the public. Evidence since the late 1990s has been reported on how consumers could potentially react to the introduction of GM food. This paper provides an understanding of the published findings on the public perception of GM food and proposes some research challenges. In light of such evidence, policy strategies are presented to deal with public uncertainty regarding GM food.

Current realities

Acceptance of new scientific developments, such as new biotechnology applications, is a matter of significant interest worldwide and has a huge impact on the extent of technology diffusion in key areas such as food production. The introduction of GM techniques in food production is an opportunity to improve food production technologies and/or product differentiation in the food chain, and ultimately fulfill consumer preferences for diversity. Interestingly, farmers and manufacturers perceive potential benefits from efficiency improvements despite some associated cost due to the reimbursement of intellectual property rights. On the other hand, public controversy has arisen as a result of the "uncertainties" and perceived "risks" — both to health and the environment — that the technology conveys. Consumers perceive GM food as potentially threatening the sustainability of traditional food markets. As a result, consumers might dread the expansion of GM food in supermarkets, and ultimately may refuse to consume any product made with this technology.

Indeed, the European Union maintained a long "de facto" moratorium against the importation of GM food that only ended in 2005. The rationale for this moratorium was the application of the precautionary principle with regard to health and environmental concerns, as well as the underlying protection of European agriculture. While new genetic modifications of maize and other crops are being authorized in Europe, the debate still remains as to whether individuals and their surrounding cultural society value these GM food products, (e.g., whether they perceive any risks and/or benefits for their health and the environment, and whether the development of biotechnology in food products will remain a controversial subject).

Evidence on worldwide consumer attitudes toward the food-related applications of GM technology have become clearer in European countries after the publication of the Eurobarometer series since 1991. The evidence suggests that some reluctance toward the introduction of GM foods still exists. While in 2002, 50% of E.U. citizens thought that GM technology was useful, this percentage decreased to 40% in 2010. However, while 70% thought this application was risky in 2002, this percentage decreased to 60% in 2010. The majority of the E.U. public perceives GM food as being not useful for them, neither for future generations nor the environment. But interestingly, with the exception of some southern European countries such as France, Greece, and Italy, the E.U. population perceives GM food as supportive of development in less-affluent countries and a possible tool to deal with famine.

Scientific opportunities and challenges

While most of the literature has proposed partial models to explain different aspects of consumer behavior toward GM food, Figure 1 aims to integrate them in a single model, trying to provide an overall picture of the different stages of the consumer decision-making process. The main implication of this figure is clear: policy makers and private firms' decision makers need more research specifically addressed to better understand the full process to adopt meaningful and efficient strategies and policies. This is clearly one of the main challenges for social science research.

As can be observed in Figure 1, consumer attitudes toward GM food are driven by three main elements:

First, the risk and benefit perceptions associated with GM food, as well as their relative significance, determine acceptance and final decisions. Indeed, in most European countries, and more specifically in Great Britain, Germany, and Nordic countries, consumers find benefits associated with GM food as insufficient to overcome their associated perceived risk. On the other hand, in the United States and some European countries (e.g., Spain and Italy), consumers recognize risks and benefits associated with GM foods, but generally consider that benefits can potentially outweigh risks. Socioeconomic and demographic attributes, such as age, ethnicity, residence, and income level, have been shown by many authors to be related to benefit perception and consumer acceptability of GM food at a worldwide level. Nevertheless, there are also some studies that do not support this statement. Therefore it will be important to further analyze this issue by means of a multinational study over time.

Second, individual values and attributes are key determinants underpinning consumer attitudes. Risk and benefit perceptions toward a GM product are found to be dependent on what is known as "individual values" (e.g., environmentalism, conservationism, materialism, and equity). Moreover, the stronger this association — determining the strength of the trade-off perception versus values — the more pervasive becomes the influence of underlying individual attitudes. The less important the role of values, the more important becomes the role of new information to shift consumer behavior.

Finally, knowledge or understanding, and its relationship with values, must be considered as a special and complex human attribute. Indeed, knowledge can be divided into "objective" and "subjective", the second being the most related with values and with more impact on individuals' attitude development. In countries where limited knowledge of GM food exists, one would expect to find more people searching for information while in those countries with very negative (or positive) information conveyed one might find pessimistic (or optimistic) attitudes. It can be argued that trust and confidence can influence how new information is understood or interpreted. Therefore, it is important to consider levels of consumer trust in different sources of information. Global consumers trust sources of information that are believed to be driven toward individual well-being and environmental rights (e.g., consumer organizations, environmental groups, physicians, and scientists). In contrast, the biotechnology industry and governments are less trusted.

These three elements are strongly connected and should be studied simultaneously to understand consumer behavior. It is a combination of how people perceive, learn, and process information on new food technology developments that ultimately determines acceptance. Therefore, to be effective, policies to tackle acceptance of new developments in the food industry not only should operate in different areas, including the media and the education system, but should be based on a better understanding of consumer behavior and societal trust-enhancing factors. Under such conditions, these policies will be able to communicate the benefits of new developments, especially when they overcome potential perceptions of risk, and to avoid the current ambiguity in the existing information channels.

Policy issues

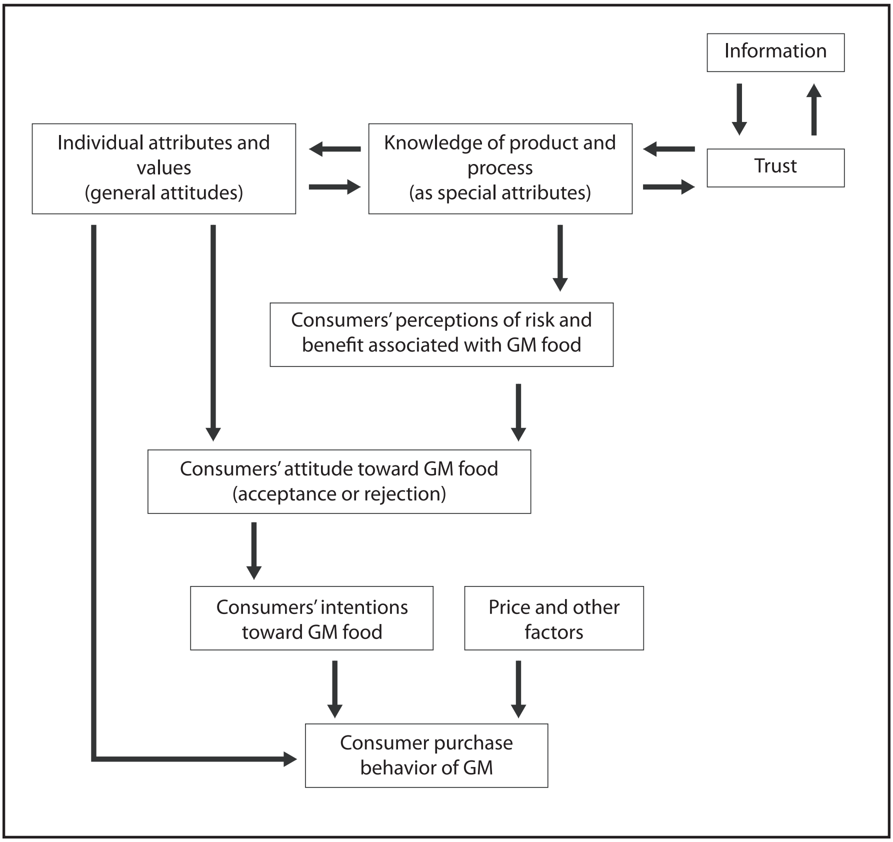
Besides the obvious need of further research to disentangle the behavioral mechanisms underlying consumer behavior, empirical evidence suggests a number of points that could be relevant for policy decision makers:

- Mandatory labeling of GM ingredients needs to be considered by policy makers. There seems to be an overall consensus among European consumers that they want to be informed in making their food choices.
- Threshold levels for informing about GM contamination are not a major issue from a consumer perspective. Consumers do not see a big difference between the 0.9% threshold level existing in Europe, or the 1% in China, Brazil, Australia, and New Zealand, among others.
- The inclusion of contact information in labels (e.g., telephone number, e-mail address) needs to be considered as it increases consumers' trust and confidence.
- Policies and campaigns should be addressed to specific target groups. In many studies, it appears that the most reluctant consumers are typically those more risk conscious and who exhibit attitudes favoring cautious innovation in the food sector, which may be attributable to the influence of mass media. If this is the case, and policy makers are not aware of any scientifically proven risks associated with GM food, then these products should become increasingly popular among those individuals who believe that the benefits of the new product outweigh the potential risks.
- To date, most of the commercial traits of GM food (e.g., insecticide resistance or herbicide tolerance) are aimed at reducing producer costs, while empirical studies indicate that such indirect benefits are not easy for consumers to understand in relation to the perceived increased risk. Hence, regulation needs to stimulate research in food products that have a direct benefit to consumers and their health.
- Policy makers need to promote the dissemination of objective GM scientific knowledge to assure a high level of objective knowledge among the population. Marketing claims about the non-GM nature of food products should be supervised as they increase consumers' perception of

risk. The role of the public sector in this area is fundamentally to provide objective information to consumers to allow them to undertake informed and ideally reasoned choices.

*** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense: Focus on Technologies and Innovations, convened by the Institute on Science for Global Policy (ISGP) April 14–17, 2013, in Verona, Italy.*

Figure 1. An explanatory process of GM food acceptance



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Debate Conclusions

- Decisions about what information should be displayed on food labels must be made based on the best available scientific evidence, rather than on political, industry, or consumer pressure. Regulation on labeling must be agreed upon by a wide range of stakeholders so that mixed messages from different bodies do not unjustifiably create consumer concern.
- Understanding public perception is critical to developing effective policies on food technologies, including genetic modification. Given the impact of cultural, social, economic, and cultural factors on individuals' perceptions and decision making, conclusions derived from one group cannot necessarily be extrapolated to another group.
- Current European regulation of genetic-modification technologies, based on products rather than process, both reflects and motivates unsupported concerns about the safety of all food, and especially genetically modified (GM) food. Such regulation makes it difficult to accurately compare the regulatory policies used in the United States and Europe.

Current realities

During the past 20 years, several hundred papers have been published on public perceptions of risk and benefit and public attitudes towards GM and GM-free foods. Using formal statistical methods, it was posited that it is now possible to analyze worldwide perceptions related to the risks and benefits of GM foods. Both the risks and benefits associated with genetic modification have been perceived to increase in recent years, especially with respect to influencing consumer behavior. The validity of much of this research was questioned, however, in part because methods used to assess consumer perception rely on hypothetical situations. It was felt that consumer behavior would likely be different if faced with actual products and prices (e.g., consumers might say they would not buy a GM product but if they were put in a situation where the GM product was the least expensive, they might behave differently).

Due to cultural, social, and economic differences, the applicability of studies on public perception beyond those specifically examined was questioned. For example, European concerns about genetic modification tend to be related to risk and benefit, whereas in the United States ethical issues are prominent.

Genetically modified organisms (GMOs) are perceived in a negative light by large sectors of the population in Europe. Evidence from the Eurobarometer (a European social survey conducted twice yearly) on genetic-modification technology shows that many Europeans still feel that GMOs are highly risky. However, it was cautioned that evidence from such studies should not be used to justify negative marketing campaigns (e.g., certain products being identified as "GMO free"), since this reinforces the notion that GMOs are inherently dangerous. It was viewed strongly that these negative attitudes are not based on any scientific evidence, but are the result of an irresponsible "propaganda" campaign that has greatly limited the use of GMOs in Europe.

Attitudes toward GM foods today were likened to attitudes to food additives in previous decades. Although food additives are often chemically identical to their "natural" counterparts, concerns about their potentially negative health effects led to many products being marketed as not containing food additives. While providing marketing opportunities for natural food products, this negative attitude reinforced the view that food additives were a matter of concern. That the same situation is occurring with GM foods today was suggested as evidence that scientists have not moved forward in the ways that they understand or address consumer concerns.

Although GM foods are still viewed warily in many parts of the world, there also are indications of increasingly positive attitudes. Research has shown that the potential benefits of GMOs are increasingly being acknowledged and there exists a growing interest in research in this field. Such knowledge can be harnessed for campaigns seeking to promote the positive attributes of GMOs.

Considerable debate centered on the differences in regulatory frameworks in Europe and the U.S. and the implications for the marketing of GM or non-GM products (e.g., in Europe, GMO labeling is compulsory whereas in the United States it is not). The labeling of products as "GMO free" was viewed as particularly problematic because it leads to assumptions that GM food is unsafe. In Europe, however, the regulatory system invokes the precautionary principle, which means that products must be labeled in certain ways (e.g., whether a product contains GM ingredients). However, it was suggested that because the precautionary principle is selectively applied and is not necessarily applied to other technologies or food-production methods, it creates a particular bias against GMOs.

Scientific opportunities and challenges

The potential for genes to spread into the environment from genetically modified organisms is unknown, and this uncertainty has implications regarding public trust. A challenge exists for scientists studying GMOs to accurately characterize the potential for spread so that any biosecurity concerns can be addressed. However, the extent to which uncertainty is a new or even significant challenge is unclear, given that genes historically have flowed among different organisms. More relevant may be the extent to which selective pressure is placed on organisms into which genetically modified genes have been transferred.

Determining who should hold responsibility for food labeling and how this relates to public trust is a significant challenge. Deciding who should be responsible for providing information to the public (e.g., the government or the manufacturer) was considered difficult, because it is not always obvious whom the most trusted source might be. A broad coalition of interests, from risk assessors to governmental bodies, working jointly to communicate risks to the public could help mitigate this challenge and reduce mistrust caused when different organizational bodies promote different messages.

A related labeling challenge lies in providing for the consumers' right and desire to know what they are purchasing without creating undue concern about food technologies (e.g., GM). The cumulative effect of food-safety incidents was provided as an example in which increased consumer knowledge may be helpful. Foodborne illness outbreaks present clear challenges for the food industry in terms of how they communicate food-related issues. While food-safety incidents reduce trust in a product for a finite amount of time, each subsequent food-related outbreak builds on previous episodes so the time taken to regain trust from subsequent food-related illnesses is greater. It is crucial to consider the implications of this in terms of risk communication. Increased openness about the origins of food could help address potential trust issues and therefore, broader labeling of products should not be dismissed summarily.

Incomplete research on public perceptions of various technologies (i.e., both gaps in research on certain regions of the world and gaps related to certain technologies) indicate there is currently insufficient knowledge about how individuals will respond to GM foods, even in countries that are moving forward with GM applications. Even within a single country, individuals may respond differently based on numerous factors (e.g., whether they have generally positive attitudes toward science). Since not all individuals will respond to messages in the same manner, a considerable challenge lies in determining optimal ways to communicate about food technologies to different sectors of the population. An important consideration is the various factors that contribute to consumer purchasing decisions because, as was noted, individuals do not necessarily buy products based on one factor, but on a variety of different attributes (e.g., a consumer may prefer to buy an organic cucumber but might choose otherwise if the price difference is considerable).

The use of words such as “contamination” or “tolerance,” when used by academics or government officials, serves to reinforce the notion that there is cause for concern about GMOs. Such language plays into the misinformation and fear that already exist regarding GMOs and could create further negativity in terms of public perception.

The development of a campaign that would focus on the positive aspects of GMOs (e.g., their potential to increase food security in less-affluent parts of the world) was suggested as a way to counter some of the negative perceptions associated with GMOs. It was suggested that the risk community within academia had a responsibility to contribute to a potential campaign, given its understanding of consumer perceptions.

Policy issues

While it was acknowledged that producers are responsible for providing contact information on packaging, producers are generally not able to trace ingredients along the entire supply chain due to its complexity (e.g., one particular ingredient may come from a variety of different sources). The usefulness of such contact information was called into question. No firm conclusions were reached on the amount of information producers need to provide, but it was noted that this issue has implications for risk communication strategies and public trust.

It is essential that food-labeling requirements be based, first and foremost, on scientific evidence instead of being a response to political or industry priorities. Regulatory bodies in various jurisdictions need to be responsible for determining what information is required on labels. However, to ensure the highest levels of trust (a critical aspect when conveying information to the public), a wide variety of stakeholders need to collectively determine labeling requirements. With a number of stakeholders working harmoniously, challenges arising from mixed messaging are minimized. This approach including stakeholder involvement is also relevant when conveying risk-related messages to the consumer. However, the language used when conveying such messages could exacerbate undue concerns about food risks (e.g., related to GMOs) unless particular care was taken to avoid this outcome.

Because other factors (e.g., use of pesticides) are not identified on product labels, requiring product labeling of GMOs was felt to be highly hypocritical and contributes to negative assumptions regarding GMOs. It was suggested that marketing which specifically identifies products as "GMO free" should be regulated since this description also contributes to the perception of risk related to GMOs. There was no consensus about the role regulatory agencies need to have on this specific matter. Concern was raised about regulatory agencies playing an overly dogmatic role rather than letting market forces take precedence.

Discussions about labeling recognized that varying regulatory structures worldwide have an impact on what is — or is not — labeled. Cultural differences within and among countries influence regulatory policies and often several levels of regulation must work together (e.g., in European countries where regional, national, and European priorities all come into play). Such regulatory variations make it difficult to establish comparisons among countries. One key difference lies in whether foods or other products developed through technological means are regulated via the product or the process. For example, in the U.S., ion exchange is a commonly used method in wine production. Because the composition of the resulting wine is identical to that produced via conventional methods, it is not necessary to label the wine as being produced in this manner. In contrast, the process in Europe is regulated and consequently it would be necessary to label the wine differently. The same is true for the approach to GM foods.

Understanding public perception is critical for the development of sound policies relating to GMOs. Although a considerable amount of data has been collected on this topic, funding for research into the implications of how the public perceives GMOs is decreasing significantly. As public perceptions vary considerably across social, cultural, political, and economic norms and also can change over time, the usefulness of pre-existing studies was questioned. Where the success of a policy relates entirely or partly to public perception, this research gap will have potentially negative effects.

Facilitating Technology Adoption**

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Summary

Increased global trade to provide food security to growing populations around the world has led to multiple challenges to food safety and defense. Policy development to deal with these challenges needs to consider the related developments in biotechnology, engineering, and information technology. Science continues to provide vital information to better understand the underlying mechanisms of new technologies that could provide options to deal with food-related challenges (e.g., the in-shell pasteurization of eggs.) However, effective deployment of appropriate technological solutions requires designing and implementing enabling policies to maximize the opportunities for realizing the benefits. The strengths of information technology tools need to be effectively utilized to harvest the knowledge generated by scientific research for food safety and defense operations. Increased involvement of the private sector in research and development at the forefront of innovation is critical for the success of government efforts.

Current realities

The challenge of providing nutritious food to nearly 9 billion humans by the year 2050 requires a more than 70% increase in the global food supply during the next four decades. This large increase will have to occur in the face of hurdles stemming from climate change, water scarcity, and competing requirements for resources to serve other needs, such as biofuel, as well as the need to maintain sustainability and biodiversity across the planet. Increases in food production have been achieved over the past five decades through intensive cultivation, mechanization, and application of genetics to breed crop varieties with higher yield. Although these efforts enhanced the quantity of the global food supply, broad opportunities still exist for enhancing the nutritional quality of crops.

Geographically disproportionate expansion of population and food production resources makes global trade critical to balance supply and demand across different regions. Food safety (protection of the food supply from *unintentional* contamination) and food defense (protection from *intentional* contamination) are growing in importance in a global network that supports food security (sustainability of a safe and sufficient food supply). Regulatory agencies across various jurisdictions have established science-based measures to ensure food safety and defense. The general policy has been moving away from inspection-driven regimes to an oversight-oriented approach or arrangement, in which regulators have taken on development and enforcement (through auditing) of safety/defense requirements while industry/importers are given the task of implementing them. This new oversight arrangement between regulator and industry depends upon an effective management structure for coordinating surveillance and sharing of information recorded during monitoring along the food chain continuum. Food safety/defense-related incidents over the past decade have challenged this arrangement and highlighted the weaknesses within the current system, pointing toward a greater role for traceability to aid recall operations and containment of food-related outbreaks. Various factors such as overlapping responsibilities and distribution of authority among multiple regulatory bodies, discrete data sources/information systems, and insufficient coordination of laboratory and surveillance resources contribute to the inherent latency between outbreak confirmation and identification of the cause and the subsequent response to contain or mitigate the problem. In addition, the costs of inspection and testing, and implementation of regulatory requirements and guidelines are often considered hurdles by industry. Adoption of hazard-based practices such as Hazard Analysis and Critical Control Points (HACCP), especially by small- and medium-sized enterprises, does not seem to carry much incentive in returns. Similarly, the high cost of an inspection-based regime forces regulators to reduce the intensity of enforcement.

Scientific opportunities and challenges

Impressive strides made in biotechnology over the past 15 years are increasingly directed toward not only the quantity but also the quality of food (e.g., the use of environmental stress on horticultural products such as tomatoes to increase their lycopene content). The application of genomic tools and knowledge could also lead to improved germplasm and development of a broad range of food crops with the ability to supply a wider range of nutrients (biofortification) in higher densities, to perform better under biotic and abiotic stresses, to develop characteristics that suit postharvest and processing requirements, and to adapt to new environments.

Opportunities to deal with issues of food security by increasing the supply and quality of food can be realized through (i) several improvements in water, soil, fertilizer, and pest management; (ii) techniques to reduce losses during harvesting, processing, postharvest handling and storage, transportation, and distribution; (iii) innovations in utilization of byproducts; and (iv) producing food ingredients from nonconventional sources. Energy availability is one of the key constraints to wider adoption of food processing, storage, and other practices that can reduce postharvest losses. Greater focus is required on developing options that are energy efficient or utilize alternative sources of power.

Extensive research continues in areas related to food safety, and several microorganisms and molecules that are of concern have been described in detail. There now exists the scientific capacity to easily identify specific subtypes and strains through genetic "fingerprinting." Capture, identification, and quantification of metabolites produced by the microorganisms of interest could be used to develop rapid techniques that can indicate contamination of foods at an early stage. Similarly, biosensors and transducers built to respond to the presence of foreign or undesired contaminants could be adopted in food processing operations in-line during the production process for timely warning of hazards. These technologies could be used to develop rapid and cheaper tests. However, these tests would need to be validated for their accuracy against established analytical methods and used as a preliminary means of detection by industry and regulators.

Advances in computers and information technology continue to offer numerous advantages for strengthening food safety and defense. The ability to gather, store, access, and manage large amounts of data that could be linked across the world electronically has made information the chief currency for progress and development. Vital pieces of information that lack clarity in isolation require attention and must be integrated with similar data from other sources to exhibit distinct clusters, providing timely alerts for early detection of food safety lapses.

Policy issues

- The lack of apparent incentive for the private sector to take part in long-term research and development has to be addressed with appropriate partnership arrangements that protect intellectual property rights without depriving the benefits of the results to the other stakeholders. Collaborations with private sector and international partners are essential to benefit from their experience and expertise. For example, research, especially in biotechnology to develop crop varieties with desired qualitative characteristics, needs the support of an enabling framework that brings together public and private sector resources. Governments have a major role to play in establishing such partnership arrangements.

- Food security policies need to be tied to broader development policies that deal with systemic issues. For instance, policies that stimulate increased food production should not be implemented in isolation but tied to related components of food security, such as transportation, processing, distribution, and storage-related policy issues. Similarly, developments in food processing need to be supported by energy policies as well as a supporting financial framework that supplies necessary investment and credit arrangements.
- Regulators need to mandate all levels of the food supply chain to record and maintain food safety/defense-related information (e.g., source of food, date, operating conditions) in an accessible format. However, if data are not made available on time (e.g., to safeguard company secrets), this will not serve a useful purpose, as illustrated by past food safety incidents in the United States. The guidelines need to separate proprietary information from safety-related information, submitted to a database that is linked to other regulatory-related systems. Establishment of databases residing on a distributed architecture that provides multiple access points to various levels of regulators will be instrumental in combining contextually relevant information to identify critical signals of food safety issues. The systematic storage and maintenance of records to identify the immediate previous source and immediate subsequent recipient (one up, one down) of all food components (including packaging) needs to be mandated.
- Research and development networks need to increase efforts to develop rapid and cheaper techniques that can be utilized in portable setups for timely detection of contaminants. These efforts must be jointly led by the public and private sector with the onus being on the private sector, since it supplies the food. The efforts also must aim to establish tools that can support an optimum level of inspection/testing in the current food safety arrangement. It is also important that these efforts be planned on a global scale to ensure their utility across the larger supply and distribution chains.

- Regulators need to streamline review of novel technologies to facilitate faster adoption of innovative processes. Harmonization of novel food regulations and approvals across international jurisdictions is clearly essential.

***** A policy position paper prepared for presentation at the conference on Food Safety, Security and Defense: Focus on Technologies and Innovations, convened by the Institute on Science for Global Policy (ISGP) April 14–17, 2013, in Verona, Italy.***

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the not-for-attribution debate of the policy position paper prepared by Prof. Vijaya Raghavan (see above). Prof. Raghavan 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 90-minute period. This Debate 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 Prof. Raghavan. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Prof. Raghavan, as evidenced by his policy position paper. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- To successfully address food security issues, it is essential to consider the global food system as a value chain, and afford equal attention to postproduction as well as production processes. Ensuring that food production is not wasted (e.g., through better postharvest storage) is vital for increasing food security.
- Since technological and infrastructural developments have the potential to considerably improve preproduction and postproduction agricultural processes and advance the livelihoods of farmers in less-affluent countries, it is critical that political policies coordinate with and promote technology implementation.
- The priorities of international development organizations regarding food production need to align with the cultural, economic, and political

priorities of people in less-affluent countries. While international organizations often promote small-scale farming, this production method does not necessarily correspond to the priorities of individuals in less-affluent countries, where small-scale farming has generally not proven successful.

Current realities

Development efforts have traditionally been focused on preproduction rather than postproduction agriculture. As a result, insufficient consideration has been given to postproduction issues (e.g., preservation of fresh produce).

Since food safety is considered a noncompetitive issue, there has been significant cooperation among private sector stakeholders. Additionally, industry members have often collaborated with international organizations to fund food-safety initiatives (e.g., efforts to move toward more rapid detection of pathogens), and have collaborated with countries in developing programs to ensure training across all food-safety fields. It was noted that industry is less likely to collaborate on infrastructure development (e.g., infrastructure to reduce waste), unless there is a clear business rationale for doing so.

Although the food industry has made concerted efforts to address unintentional contamination of food, its efforts on intentional contamination (i.e., food defense) are less developed. The food industry has not yet adapted its approaches and practices to determine how intentional contamination might be manifested and what steps would need to be taken to prevent this tampering.

India was cited as providing excellent opportunities for the development and deployment of food-related technologies. A key to agricultural progress in India has been the development of agricultural universities. The presence of homegrown expertise with strong links to universities abroad has greatly helped to strengthen the agricultural sector in India. There have also been numerous academic partnerships and collaborations in India that have helped to develop the use of postharvest technologies. Central to this has been strengthening links across the supply chain, and ensuring that various stakeholders along the supply chain are aware of the importance of postharvest issues. These links have provided an optimal environment in which to deploy relevant technologies.

Concerns were raised about the mistrust that exists regarding fresh produce grown in sub-Saharan Africa. A number of supermarkets and international restaurant chains there fly fresh produce into sub-Saharan Africa because of concerns about the safety of locally grown food, especially regarding the quality of the water used in the production process. Such concerns cast a negative light on current farming methods in sub-Saharan Africa.

Since small-scale farming is still the norm in many less-affluent countries, numerous development programs have placed small-scale farmers at the center of their efforts, with the goal of maintaining and strengthening this model of farming. There currently are many technologies, both being developed and in existence, that, if implemented, could be beneficial to small-scale farmers. However, small-scale farming systems were also strongly criticized. These systems have not been shown to succeed on a broad scale and smallholder farmers often are forced to rely on charity from family members employed in cities. In addition, many young people in less-affluent countries no longer wish to work as farmers, yet often are forced to do so. In recent years, cities have grown considerably as individuals have moved from rural to urban areas.

Scientific challenges and opportunities

Both new technologies and improved infrastructure are critical for ensuring successful postharvest practices. Since most farming takes place in rural areas, road and transportation infrastructure is essential for farm produce to be transported to cities. Technology development, particularly at the local level through agricultural universities, also provides important benefits.

Although challenges exist in developing and implementing technological solutions appropriate for small-scale farming, it was agreed that improved technologies would help overcome difficulties inherent to farming in less-affluent countries (e.g., using biogas to compensate for a lack of electricity, or developing decision-support systems to aid production choices). It was argued that the use of various technologies by individual farmers would considerably increase the value of the products being harvested.

Developing food safety-detection technologies (e.g., portable systems to allow timely detection of contaminants) is a considerable challenge. The high costs of developing such technologies are a considerable impediment to expeditious research and development. Patent protection issues further complicate the deployment of such technologies to less-affluent regions. As a result, it was acknowledged that although research in this area is an important goal, it is unlikely to progress quickly.

A considerable challenge for industry regarding food safety is combating both intentional and unintentional food contamination. There currently is limited understanding of how intentional contamination might manifest itself and what needs to be done to mitigate this potential hazard.

It is necessary for agricultural development projects to consider post-production efforts in addition to production to effectively avoid food insecurity. Since production appears to be an easier component to quantify (e.g., if more food is produced), most development assistance has focused on production. However, postproduction efforts (e.g., preventing the food grown from being wasted) are equally critical in ensuring that there is sufficient food. If postproduction infrastructure were improved, and postharvest loss is decreased, it would not be necessary to produce as much food initially to maintain food security.

Post-production issues in less-affluent countries are not necessarily the same as those in more-affluent countries (e.g., in North America, silos are used to store grain, whereas in India, gunny sacks are used for storage). Consequently the solutions to address postproduction challenges differ in more- and less-affluent countries and determine which physical solutions are most appropriate.

Insufficient infrastructure in Africa and Asia would hinder the effectiveness of postharvest technologies and consequently, it was questioned whether introducing more technologies would be efficacious. Significant investment in infrastructure would need to coincide with further implementation of technologies.

Since the cost of research and development for improved postharvest technologies often is prohibitive in less-affluent countries, financial considerations were recognized as being a significant impediment to the timely adoption of agricultural technologies to improve food security. Given the high economic costs, technological innovations need to be considered longer-term, not short-term, solutions to improving food security.

A related challenge is determining what to do not only with food waste, but also with other biological or organic waste. Numerous opportunities presented by biochar (i.e*, creating a soil enhancer from the carbonization of biomass)* require further consideration.

Discussion took place regarding the best ways to improve the livelihoods of the hundreds of millions of people living on small-scale farms. Technological development, which has the potential not only to increase productivity but also mitigate problems arising from climate and associated environmental changes, was identified as an option. However, it was cautioned that it could be unhelpful to speak of "appropriate" technologies, because it implies that less-affluent countries require a lower standard of effectiveness or safety than more-affluent nations.

Changing demographics from movement of people from rural to urban areas poses challenges for food security. Since many young individuals in developing countries no longer wish to work in agriculture, the number of small-scale farms is diminishing. Concern was expressed about the negative impacts this demographic change might have and it was suggested that various approaches for encouraging people to remain on smallholder farms must be considered. Methods to address this issue will vary depending on the social, political, cultural, and economic context of a given region. It was suggested, however, that one potential solution is to educate smallholder farmers so they are able to introduce a greater level of mechanization and technological innovation into their farms, which could increase the appeal of farming for young people.

While some viewed the departure from small-scale farming as a concern, others questioned whether small-scale farming is a desirable standard. It was suggested that instead of trying to deter individuals from moving to urban areas, the challenge is to consider how these people might successfully be absorbed into cities.

The question of the role of genetically modified organisms (GMOs) in reducing food insecurity was raised. It was suggested that GMOs could significantly contribute to efforts to produce food that is both more nutritious and more plentiful (e.g., biofortified staples such as rice and cassava), provided that opportunities exist for the use of these technologies.

Policy issues

Recommendations regarding the documenting of all levels of the supply chain were questioned in terms of how this might work in practice. Although not a realistic prospect at present, a more regulated supply chain might allow for better communications among farmers and more assistance in making effective production decisions (e.g., if one farmer is focusing on tomato production, a neighboring farmer can choose to focus on a different product). While such a decision-support system would be beneficial for farmers, concern was expressed about the suggestion of it being mandatory.

It was suggested that the private sector needs to be involved in funding food-safety initiatives and that development of public-private partnerships is crucial to effective solutions regarding food safety. Although food-safety issues are regarded by industry as noncompetitive, it was questioned whether the private sector currently is in a position to provide this funding.

In a similar vein, the potential for private sector contributions to infrastructural investments was discussed. It was noted that the private sector invests in infrastructure if there is a clear business case for doing so. As such, private-public collaboration is less likely on infrastructural issues than on food-safety issues.

While there may be a need for a concerted policy effort to elevate postproduction infrastructure to the same importance as production infrastructure, concern was raised that policy organizations (e.g., the World Health Organization [WHO]) do not consider postproduction infrastructure as vital as production infrastructure. Funding, consequently, is reflected by these organizations' priorities.

Although the introduction of technologies could assist in increased agricultural production, it was questioned whether less-affluent countries had sufficient infrastructure to be able to deploy those technologies. The receptiveness of the policy environment in any given country is critical to ensuring that technology implementation is sustainable and beneficial. As an example, India provides a positive environment for agricultural development. Since the Indian government is seeking to prevent postharvest losses, appropriate policies to facilitate this effort have been adopted. India was regarded as a positive model for supportive policies in technology implementation.

A strong case was made for sub-Saharan African agriculture to implement a more mechanized production system. Although the lack of confidence in African farming results in a large number of food products being imported, there is limited discussion regarding alternative methods for agriculture. Since there exists a strong policy focus on small-scale agriculture, most development projects seek to maintain and strengthen this model by equipping small-scale farmers with more "modern" farming tools. However, it was suggested that while small-scale farming may be a priority for international development organizations, those in sub-Saharan Africa do not necessarily share this preference.

There was limited consensus on the promotion of small-scale farming. While some felt that policies need to focus on developing incentives to keep individuals on farms and away from urban centers, others argued that people not be forced to work in farming against their wishes. While there is limited evidence to show that small-scale farming is an effective model, this argument was countered by those who suggested that the effectiveness of small-scale farming would be greatly increased through the deployment of modern technologies.

A case was made for encouraging policy makers to view the global food system in terms of a food value chain. The food system does not narrowly encompass only the production level, but includes the many stages between when animals are bred or seeds are planted and the end products that are consumed.

Acknowledgment

Numerous individuals and organizations have made important contributions to the Institute on Science for Global Policy (ISGP) program on Food Safety, Security, and Defense (FSSD). Some of these contributions directly supported the efforts needed to organize the invitation-only ISGP conference, *Focus on Technologies and Innovations,* convened at the Villa Quaranta Park Hotel near Verona, Italy, April 14–17, 2013. Other contributions aided the ISGP in preparing the material presented in this book, including the seven invited policy position papers and the summary record, without attribution, of the views presented in the discussions, critical debates, and caucuses that ensued.

We would specifically like to thank our Italian interlocutors Dr. Ranieri Guerra, Dr. Romano Marabelli, and Dr. Sergio Pecorrelli for their many critical contributions toward the success of this conference.

The ISGP greatly appreciates the willingness of those in the scientific and policy communities to be interviewed by the ISGP staff, who organized the content of this ISGP conference. The efforts of the scientific presenters with expertise concerning the innovations and technologies affecting FSSD invited by the ISGP to both prepare the seven policy position papers and engage policy makers in the vigorous debates and caucuses that comprise all ISGP conferences were especially appreciated. The biographies of these authors are provided in this ISGP book.

The success of every ISGP conference critically depends on the active engagement of all invited participants in the often-intense debates and caucuses. The exchange of strongly held views, innovative proposals, and critiques generated from questions and debates fosters an unusual, even unique, environment focused on clarifying understanding for the nonspecialist by addressing specific questions related to formulating and implementing effective public and private sector policies. The ISGP is greatly indebted to all those who participated in these not-for-attribution debates and caucuses.

The members of the ISGP Board of Directors also deserve recognition for their time and efforts in helping to create a vital and growing not-for-profit organization that has relevance to many of the most important societal questions of our time. Their brief biographical backgrounds are presented at the end of this book.

The energetic, highly professional work of the ISGP staff merits special acknowledgment. The staff's outstanding interviewing, organizing, and writing skills were essential to not only organizing the conference itself, but also to recording the often-diverse views and perspectives expressed in the critical debates, capturing the areas of consensus and actionable next steps from the caucuses, and persevering through the extensive editing process needed to assure the accuracy of the material published here. All of the staff members' work is gratefully acknowledged. Their biographies are provided in this book.

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Dr. George H. Atkinson
Founder and Executive Director
Institute on Science for Global Policy
July 3, 2013

ISGP books from previous ISGP conferences listed below are available to the public and can be downloaded from the ISGP Web site: www.scienceforglobalpolicy.org. Hardcopies of these books are available by contacting Jennifer Boice at jboice@scienceforglobalpolicy.org.

ISGP conferences on, or related to, Emerging and Persistent Infectious Diseases:

- *EPID: Focus on Antimicrobial Resistance,* convened Mar. 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 Oct. 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 Oct. 17–20, 2010, in Warrenton, Virginia, U.S.
- *EPID: Global Perspectives*, convened Dec. 6–9, 2009, in Tucson, Arizona, U.S.

Biographical information of Scientific Presenters and Keynote Speaker

Scientific Presenters

Prof. Felix Escher, Ph.D.

Prof. Felix Escher is Professor Emeritus of Food Technology at the Swiss Federal Institute of Technology Zurich (ETH Zurich), where he has been on the faculty since 1974. His research interests cover optimization of food quality during processing, preservation, and storage with emphasis on thermal processes (e.g., sterilization, frying, roasting, and dehydration) and on the relationship among structure, physical properties, and quality of foods, in particular of foods rich in starch. During his time at ETH Zurich he has served as Chairman of the Institute of Food Science and Nutrition, Dean of the Department of Agriculture, and President of the Centre for International Agriculture. Prof. Escher has also been involved with a variety of international scientific and technical organizations and is currently President of the Swiss National Committee to the International Union of Food Science and Technology (IUFoST). Additionally, he is former Vice-President of the Board of the Swiss Academy of Sciences and former Treasurer and Vice-President of IUFoST. He has served in advisory groups to the food industry and on editorial boards for journals including the *Journal of Food Engineering* and *LWT Food Science and Technology.* He is a member of American and Swiss scientific societies focusing on food science and technology.

Prof. Lynn Frewer, Ph.D.

Prof. Lynn Frewer is Professor of Food and Society at Newcastle University, United Kingdom. Previously, she spent eight years as Professor of Food Safety and Consumer Behaviour at Wageningen University, Netherlands, and headed the Consumer Research Group at the Institute of Food Research, U.K. Prof. Frewer has academic interests in all areas of food and society, including those that require transdisciplinary collaboration between the social and natural sciences. A central theme of her research relates to measuring societal and individual responses to risks and benefits associated with food, health, sustainability, and safety. She has received research grants from a variety of funding bodies, including the European

Commission, Netherlands Organisation for Scientific Research, and U.K. bodies including the Department of Health, Food Standards Agency (FSA) and the Biotechnology and Biological Sciences Research Council. Prof. Frewer is a member of numerous committees, including the Scientific Advisory Board of the European Joint Programming Initiative; the Joint Programming Initiative "A Healthy Diet for a Healthy Life"; the FSA Social Science Research Committee; the Swiss National Science Foundation steering group on sustainable food production; and the European Chemical Industry Council's Long-range Research Initiative (CEFIC LRI) External Science advisory panel. Additionally she is a member of the International Life Sciences Institute (ILSI) research foundation board of trustees.

Dr. José Gil, Ph.D.

Dr. José Gil is Director of the Centre for Research in Agri-Food Economics and Development at the Technical University of Catalonia, in Barcelona, Spain. Additionally he is Professor in the Department of Agro-food Engineering and Biotechnology also at the Technical University of Catalonia. Previously, he was a Researcher in the Department of Agricultural Economics and Sociology, Agricultural Research Service, Government of Aragon. His research focuses on economic and social issues related to agriculture, consumers, trade, and industry, and he has participated in multiple competitive international and national research projects on these topics. Additionally, he has published a large number of books, book chapters, and peer-reviewed journal articles. He is on the editorial board of numerous scientific journals including Agribusiness: an International Journal, EuroChoices edited by the United Kingdom Agricultural Economics Board and the European Association of Agricultural Economics, and Revista Economía Agraria y Recursos Naturales, edited by the Spanish Association of Agricultural Economics.

Dr. Martina Newell-McGloughlin, D.Sc.

Dr. Martina Newell McGloughlin is Director of the International Biotechnology Program at University of California, Davis. Additionally, she is co-Director of a National Institutes of Health (NIH) Training Grant in Biomolecular Technology and co-Director of the National Science Foundation (NSF) Integrative Graduate Education and Research Traineeship (IGERT) program in Collaborative Research and Education in Agricultural Technologies and Engineering, a UC Davis/Ireland collaboration. She is also Adjunct Associate Professor in the Department of Plant Pathology at UC Davis. She contributed to the formation of Science Foundation Ireland and is now a member of its Board of Directors. Dr. McGloughlin's research interests have been in the areas of disease resistance in plants, scale-up systems for industrial and pharmaceutical production in microbes, and microbiological mining. She has a special interest in developing world research and is part of the USAID Applied Biotechnology Research Program. She has published and edited numerous papers, articles, books, and book chapters and she speaks frequently before scientific and other associations, testifies before legislative bodies, and works with the media. Dr. McGloughlin was a recipient of a 2001 UC Davis James H. Meyer Distinguished Achievement Award and a 2005 Irish America Lifescience Award. Additionally, in 2003, the Council for Biotechnology named her one of the DNA Anniversary Year's Faces of Innovation.

Prof. Linus Opara, Ph.D. C.Eng.

Prof. Umezuruike Linus Opara is an agricultural engineer and holds the South African Research Chair in Postharvest Technology at Stellenbosch University, South Africa. Previously, he was Director of the Agricultural Experiment Station and Assistant Dean for Postgraduate Studies and Research at Sultan Qaboos University, Oman, and held research and academic positions in New Zealand. In addition to his teaching and research activities, Prof. Opara is a member of the Executive Board of the International Commission of Agricultural and Biosystems Engineering (CIGR) and Chair of Section VI: Bioprocesses. He is Vice-Chair of the Roots and Tuber Section of the International Society for Horticultural Science (ISHS); Chair for Engineering and Information Technology of the International Society for Food, Agriculture and Environment; former Vice-President, Postharvest Technology and Biotechnology, of the Asian Association for Agricultural Engineering (AAAE); and Convenor of the November 2012 International Conference on Postharvest Technology & Agro-Processing in Stellenbosch, South Africa. Prof. Opara is founding editor-in-chief of the International Journal of Postharvest Technology and has published more than 80 articles in peer-reviewed journals and book chapters, and made more than 150 oral presentations at international conferences. Additionally, Prof. Opara was co-author of the agricultural mechanization component of the 1989-2004 agricultural development plan of Nigeria.

Prof. Vijaya Raghavan, Ph.D.

Prof. Vijaya Raghavan is James McGill Professor in the department of Bioresource engineering at McGill University, where he has been part of the faculty since 1974. Between 1993 and 2003 he was also chair of the department at McGill. Prof. Raghavan's research focuses on studying and developing postharvest or postproduction processes and technologies for the storage and drying of produce and crops to minimize the amount of food that is lost postharvest. He also has expertise on the transfer of these technologies to developing countries. Together with his research group, he has published 445 peer-reviewed journal articles, 38 book chapters, and 710 conference papers on this topic, as well as securing four patents. Prof. Raghavan has been involved in numerous international collaborations in Asia, Africa, and South America. He currently is director of a Canadian International Development Agency (CIDA) funded scaling-up project, "Post-Harvest Enterprise for Rural Development," in collaboration with Tamil Nadu State University in South India.

Prof. Don Schaffner, Ph.D.

Prof. Don Schaffner is Extension Specialist in Food Science and Professor at Rutgers University. Prof. Schaffner's research interests include quantitative microbial risk assessment and predictive food microbiology, for which he has received more than $5 million in grants. Additionally, he has educated thousands of food industry professionals through numerous short courses and workshops in the United States and around the world. Prof. Schaffner was the recipient of the 2009 International Association for Food Protection (IAFP) Elmer Marth Educator Award and the 2008 Sustained Research and Impact Award from the Rutgers School of Environmental and Biological Sciences. He has served on numerous expert committees, including service to the U.S. National Academy of Sciences (NAS), the World Health Organization (WHO), the Food and Agriculture Organization (FAO) of the United Nations, the Institute of Food Technologist (IFT), and U.S. National Advisory Committee on Microbial Criteria for Foods (NACMCF). Prof. Schaffner is secretary of the IAFP and an editor for Applied and Environmental Microbiology published by the American Society for Microbiology (ASM). He is active in several other scientific associations including the IFT, Society for Risk Analysis (SRA), and the Conference for Food Protection (CFP).

Keynote Speaker

Dr. Ilaria Capua, D.V.M., Ph.D.

Dr. Ilaria Capua is a newly elected deputy for the Civic Choice Party in the Italian Parliament and is Head of the Division of Comparative Biomedical Science at the Istituto Zooprofilattico Sperimentale delle Venezie (Legnaro, Italy) which hosts the National, Food and Agriculture Organization (FAO), and World Organisation for Animal Health (OIE) Reference Laboratory for avian influenza and Newcastle disease, and the OIE Collaborating Centre for Diseases at the Human-Animal Interface. Her group provides diagnostic expertise globally and conducts cutting-edge research on influenza viruses and viral zoonoses. She has served as Chairman of OFFLU, the OIE/FAO network on animal influenza, and in 2006 she ignited an international debate on the sharing of genetic information of avian influenza H5N1 by depositing the genetic sequence of the first Nigerian H5N1 in GenBank rather than in a password protected database. This led to a greater awareness on data transparency and sharing across disciplines, which is now recommended by OIE, FAO and the World Health Organization (WHO). Dr. Capua also has extensive experience coordinating international research projects funded by the European Commission (EC) and has worked closely with FAO managing Technical Cooperation Projects covering 40 countries. She is a member of the WHO's Scientific and Technical Advisory Group on Influenza and a Stream leader within WHO's Global Research Agenda on Influenza. In 2007, she was among the Scientific American top 50 scientists; in 2008, she was included among Seed Magazine's Revolutionary Minds, for leadership in science policy, and she received the 2011 Penn Vet World Leadership Award, the first woman to receive the most prestigious award in veterinary medicine.

Biographical information of ISGP Board of Directors

Dr. George Atkinson, Chairman

Dr. George 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 the objective 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.

Ms. Loretta Peto, Secretary/Treasurer

Loretta Peto is the Founder and Managing Member at Peto & Company CPA's PLLC. She has experience in: consulting on business valuation and litigation, including valuing businesses for buy-sell agreements, estate and gift tax, marital dissolution and employee compensation; consulting with closely held businesses regarding business restructure, cash management, succession planning, performance enhancement and business growth, and managing tax-related projects, including specialty areas in corporate, partnership, estate and gift tax, business reorganizations, and multistate tax reporting. She is a Certified Public Accountant and accredited in Business Valuations. She is a member of the Finance Committee and Chair of the Audit Committee at Tucson Regional Economic Opportunities. She also is a member of the DM50 and Tucson Pima Arts Council. She received a Master of Accounting - Emphasis in Taxation degree from the University of Arizona in 1984, and was awarded the Outstanding Graduate Student Award.

Dr. Janet Bingham, Member

Dr. Janet Bingham has been President and CEO and a consultant to the Huntsman Cancer Foundation (HCF) since 2006. The foundation is a charitable organization that provides financial support to the Huntsman Cancer Institute, the largest cancer specialty research center and hospital in the Intermountain West. Dr. Bingham also has managed Huntsman Cancer Biotechnology Inc. In addition, she was appointed Executive Vice President and Chief Operating Officer with the Huntsman Foundation in 2008. The Huntsman Foundation is 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. Henry Koffler, Member

Dr. Henry Koffler is President Emeritus of the University of Arizona (UA). He served as President of the UA from 1982-1991. From 1982 he also held professorships in the Departments of Biochemistry, Molecular and Cellular Biology, and Microbiology and Immunology, positions from which he retired in 1997 as Professor Emeritus of Biochemistry. His personal research during these years concentrated on the physiology and molecular biology of microorganisms. He was Vice President for Academic Affairs, University of Minnesota, and Chancellor, University of Massachusetts/Amherst, before coming to the UA. He taught at Purdue University, where he was a Hovde Distinguished Professor, and the School of Medicine at Western Reserve University (now Case Western Reserve University). Dr. Koffler served as a founding Governor and founding Vice-Chairman of the American Academy of Microbiology, and as a member of the governing boards of Fermi National Accelerator Laboratory, the Argonne National Laboratory, and the Superconducting Super Collider Laboratory. He was also a board member of the Association of American Colleges and Universities, a member and Chairman of the Council of Presidents and a member of the executive committee of the National Association of Land Grant Colleges and Universities. He was also Founder, President and board member of the Arizona Senior Academy, the driving force in the development of the Academy Village, an innovative living and learning community. Among the honors that Dr. Koffler has received are a Guggenheim Fellowship and the Eli Lilly Award in Bacteriology and Immunology.

Mr. Jim Kolbe, Member

For 22 years, Mr. Jim 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. Charles Parmenter, Member

Dr. Charles 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. Thomas Pickering is Vice Chairman of Hills & Co, international consultants, and Strategic Adviser to NGP Energy Capital Management. 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.

Dr. Eugene Sander, Member

Dr. Eugene G. 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.

Biographical information of ISGP staff

Dr. George Atkinson, Executive Director

Dr. George Atkinson is the founder and Executive Director of the Institute on Science for Global Policy (ISGP) and is an Emeritus Professor of Chemistry, Biochemistry, and Optical Science at the University of Arizona. His professional career has involved academic teaching, research, and administration, roles as a corporate founder and executive, and public service at the federal level. 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. In 2013, he became the president-elect of the Sigma Xi Society. Based on principles derived from his personal experiences, he launched the ISGP in 2008 as a new type of international forum in which credible experts provide governmental and societal leaders with the objective understanding of the science and technology that can be reasonably anticipated to help shape the increasingly global societies of the 21st century.

Jessica Appert, M.S.P.H.

Jessica Appert is a Fellow with the ISGP. She graduated with a B.S. in Biology and an M.S. in Public Health from the University of Minnesota, where she is currently a Ph.D. candidate. Her graduate research focused on the role of airborne particles in spreading infectious diseases in human health settings and animal agriculture. Ms. Appert has previously worked with the Global Initiative for Food Systems Leadership and the National Center for Food Protection and Defense in roles examining zoonotic disease risks, food safety, and global food systems leadership.

Jennifer Boice, M.B.A.

Jennifer Boice is the Program Coordinator of the ISGP. 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. Ms. Boice received an M.B.A. from the University of Arizona and graduated from Pomona College in California with a degree in economics.

Sweta Chakraborty, Ph.D.

Sweta Chakraborty is a Senior Fellow with the ISGP. She recently completed post-doctoral research on pharmaceutical regulation and product liability at Oxford University's Centre for Socio-Legal Studies and remains an active member of Wolfson College. Dr. Chakraborty received her doctorate in Risk Management from King's College London and has helped to design and co-teach a summer course in London on Managing Hazards in Europe and the United States with Indiana University's School of Public and Environmental Affairs. Her undergraduate degrees are in Decision Science and International Relations from Carnegie Mellon University.

Anna Isaacs, M.Sc.

Anna Isaacs is a Senior Fellow with the ISGP. She has previously focused on minority health issues and is experienced in field and desk-based qualitative research. She has interned as a researcher at a variety of nonprofit institutions and also at the House of Commons in London. Ms. Isaacs received her M.Sc. with distinction in Medical Anthropology from University College London and a B.Sc. in Political Science from the University of Bristol.

Paul Lewis, J.D.

Paul Lewis is a Fellow with the ISGP. He worked as a Congressional Aide in Washington, D.C., and as a Legal Associate specializing in Federal Immigration Law before working with Google on Maps and Local Search products. Mr. Lewis came to Google through Immersive Media, the company behind Street View camera technology. He was involved in the rollout of Google Street View, and has managed projects involving 360-degree GPS embedded data worldwide. Mr. Lewis earned his Juris Doctor at the University of Arizona and graduated Magna Cum Laude with degrees in Journalism and Political Science from Northern Arizona University.

David Miller, M.B.A.

David Miller is a Scientific/Program Consultant with the ISGP. Previously, he was Director, Medical Advocacy, Policy, and Patient Programs at GlaxoSmithKline, where he led the company's U.S. efforts relating to science policy. In this role, he advised senior management on policy issues, and was the primary liaison between the company and the national trade associations, Pharmaceutical Research and Manufacturers of America (PhRMA) and Biotechnology Industry Organization (BIO). He also held management positions in business development and quality assurance operations. Mr. Miller received his B.S. in Chemistry and his M.B.A. from the University of North Carolina at Chapel Hill.

Harvey Morris, Ph.D.
Harvey Morris is a Fellow with the ISGP. As a Licensed Psychologist, he began his work on staff at the New York Health and Hospitals Corporation, and eventually became Director of Clinical Services at a private 100-bed hospital. In the late 1970s he founded and managed a midsized specialty consulting firm that assisted major global corporations and national governmental agencies in accelerating strategy implementation. After retiring, he founded and served as Executive Director of a not-for-profit foundation, and served on an advisory board at the University of Arizona. Dr. Morris received a B.A. in Psychology from the City University of New York, and a Ph.D. in Clinical Psychology from the University of Nebraska.

Arthur Rotstein, M.S.J.
Arthur Rotstein is Copy Editor with the ISGP. Prior to joining the ISGP, Mr. Rotstein worked for the Washington D.C. Daily News, held a fellowship at the University of Chicago, and spent more than 35 years working as a journalist with The Associated Press. His writings have covered diverse topics that include politics, immigration, border issues, heart transplant and artificial heart developments, Biosphere 2, college athletics, features, papal visits, and the Mexico City earthquake. Mr. Rotstein holds a M.S.J. from Northwestern University's Medill School of Journalism.

Raymond Schmidt, Ph.D.
Ray Schmidt is a Senior Fellow with the ISGP. In addition, he is a physical chemist/chemical engineer with a strong interest in organizational effectiveness and community health care outcomes. While teaching at the university level, his research focused on using laser light scattering to study liquids, polymer flow, and biological transport phenomena. Upon moving to the upstream petroleum industry, he concentrated on research and development (R&D) and leading multidisciplinary teams from numerous companies to investigate future enhanced oil recovery ideas and to pilot/commercialize innovative recovery methods in domestic and foreign locations. Dr. Schmidt received his Ph.D. in chemistry from Emory University.

Ramiro Soto

Ramiro Soto is a Fellow at the ISGP. He currently is an undergraduate student at the University of Arizona College of Science seeking a Bachelor of Science degree in General Applied Mathematics. Beyond his academic curriculum, Mr. Soto is an active member of the Pride of Arizona marching band since 2010 and a member of the athletic pep band. He completed an internship with the Walt Disney Company Parks and Resorts segment in 2011. After completing his undergraduate education, he plans to apply for a doctoral program furthering his studies in mathematics.

Matt Wenham, D.Phil.

Matt Wenham is Associate Director of the ISGP. He formerly was a postdoctoral research fellow at the National Institutes of Health in Bethesda, Maryland. His research involved studying the interaction of protein toxins produced by pathogenic E. coli strains with human cells. Dr. Wenham received his D. Phil. from the Sir William Dunn School of Pathology, University of Oxford, United Kingdom, where he was a Rhodes Scholar. Prior to this, he worked in research positions at universities in Adelaide and Melbourne, Australia. Dr. Wenham received his bachelor's and honors degrees in biochemistry from the University of Adelaide, South Australia, and holds a Graduate Diploma of Education from Monash University, Victoria.