Enhancing Food Security in an Era of Global Climate Change

An Executive Session on Grand Challenges of the Sustainability Transition
San Servolo Island, Venice – June 6-9, 2010

Sustainability Science Program, Harvard Kennedy School of Government

Italy's Ministry for Environment, Land & Sea

Venice International University

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Abstract

The goal of the workshop was to build a more strategic and integrated perspective on the threats and opportunities latent in the food / climate issue, and to discuss the hard challenges of moving forward toward common goals in a private, off-the-record setting. An executive session convened by the John F. Kennedy School of Government at Harvard University and the Venice International University on June 6-9, 2010 attracted more than 25 of the world's leading experts from the fields of policy, science, and business to San Servolo Island for an intensive three day session (see text for a list of the participants). The discussions were off-the-record, with each participant present in his or her own capacity, rather than representing an organization. The session was one in a series on Grand Challenges of the Sustainability Transition organized by the Sustainability Science Program at Harvard University with the generous support of the Italy's Ministry for Environment, Land and Sea. This particular session was held in cooperation with the new Mega Program on Climate Change, Agriculture and Food Security being developed by the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership. This summary report of the session is our synthesis of the main points and arguments that emerged from the discussions. It does not represent a consensus document, since no effort was made at the Session to arrive at a single consensus view. Rather, we report here on what we heard to be the major themes discussed at the session. Any errors or misrepresentations remain solely our responsibility.

Keywords: food security, agricultural production, livelihood security, climate change, sustainable development, environmental policy, sustainability

JEL subject codes: Q1 (Agriculture); Q18 (Agriculture Policy; Food Policy) ; Q54 (Climate; Natural Disasters; Global Warming); Q56 (Environment and Development; Environment and Trade; Sustainability; Environmental Accounting)

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Grand Challenges of the Sustainability Transition:

This report emerges from the fourth in a series of intense workshops and study sessions on Grand Challenges of the Sustainability Transition, organized by the Sustainability Science Program at Harvard University, hosted by Venice International University, and supported by the Italy's Ministry for Environment, Land and Sea.

The first session in the series addressed Grand Challenges in Sustainability Science. It was convened in October 2006 by William Clark, Co-Director, Sustainability Science Program at Harvard University; John Holdren, President, American Association for the Advancement of Science and Professor, Harvard University; and Robert Kates, Co-Chair, Initiative on Science and Technology for Sustainability.

The second session held addressed goals and concerns surrounding the debate over government policies related to the greater use and production of biofuels. It was convened in 2008 by Henry Lee, Ricardo Hausmann, and Robert Lawrence at Harvard University and Melinda Kimble, United Nations Foundation.

The third session held addressed actionable solutions for making water a force for improved human health and well being in the development agenda. It was convened in 2009 by Michael Kremer at Harvard University; Alix Zwane at Global Development, Bill and Melinda Gates Foundation; and Azzam Alwash at Nature Iraq.

The reports of these workshops are available at:
http://www.hks.harvard.edu/centers/cid/programs/sustsci/events/san-servolo-roundtables

The Sustainability Science Program at Harvard University: The Sustainability Science Program at the Center for International Development harnesses Harvard University's strengths to promote the design of institutions, policies, and practices that support sustainable development. The Program addresses the challenge of sustainable development by: advancing scientific understanding of human-environment systems; improving linkages between research and policy communities; and building capacity for linking knowledge with action to promote sustainability. The Program supports major initiatives in policy-relevant research, faculty research, training of students and fellows, teaching, and outreach. Further information is available though the Program web site at www.cid.harvard.edu/sustsci/, or from co-Directors William C. Clark (william_clark@harvard.edu or Nancy Dickson (nancy_dickson@harvard.edu), at the Center for International Development, Harvard Kennedy School, 79 JFK Street, Cambridge, MA 02138 USA.

Venice International University: Venice International University (VIU) is an association made up of ten universities, the Foundation of Venice, the Province of Venice, the Italian Ministry for the Environment and Territory (IMET) and the Italian National Research Council. The aim of this international center is to manage higher education and research centers on the island of San Servolo in Venice. VIU's work on sustainability is pursued through The Center for Thematic Environmental Networks (TEN). Further information is available through the TEN web site at www.univiu.org/research/ten, or from Professor Ignazio Musu (ten@univiu.org), at VIU, Isola di San Servolo 30100 Venice, Italy.

Author Acknowledgements

A session of this type is made possible by the commitment and hard work of many people. We are deeply appreciative of the advice and guidance provided by Corrado Clini and Ganesan Balachander and for the logistics support provided by Elisa Carlotto and Giovanna Pietrobon at Venice International University and Mary Anne Baumgartner at Harvard University.

Table of Contents

Enhancing Food Security in an Era of Global Climate Change

1 The Challenge

The nexus of climate change, agriculture and food security is one of the quintessential challenges of sustainable development. Rapid growth in many of the world's populations and economies is increasing the demand for food, energy, fiber, water and land for housing. But efforts to meet these and other essential human needs are transforming the global environment and driving dangerous changes in the world's climate. Many of these changes are in turn increasing the vulnerability of society—especially the poor—to disruption, and are undermining the food and livelihood security of billions of people. Policy responses that mitigate some of these challenges may exacerbate others, as illustrated by the repercussions of recent efforts to support biofuel production.

Despite the complex interdependence among these various dimensions of the sustainability challenge, most initiatives to address them remain centered in their own silos: the global climate negotiations, different world summits for food and water, the separate task forces of the UN Millennium Project. Much good work is being done through such focused initiatives. But they may also leave untapped much potential for synergies and complementarities across issues.

A welcome exception to the common segregation of sustainability issues is the set of initiatives that has begun to focus on the challenges arising from the interactions among agriculture, development and climate change. Several large scale meetings of the communities dealing with climate change, agriculture and poverty alleviation in the spring of 2010 provided an overview of challenges facing leaders grappling with their interactions, and of the state of knowledge and know-how available to address those challenges. These meetings, while inclusive, comprehensive, and public, had to walk carefully around some of the politics, interests and diplomatic niceties latent in the intersection of climate, agriculture and development issues. The challenge remains of bringing such delicate but fundamental considerations into serious discussions of what needs to be done, and by whom.

2 The Workshop

The San Servolo Workshop[1] reported on here was held in the early summer of 2010 to complement those public sessions with a private, off-the-record opportunity for an intimate and informal dialogue among top scholars, business leaders, civil society advocates and policy advisers working at the intersection of climate, agriculture and development issues. The general goal of the workshop was to build a more strategic and integrated perspective on the threats and opportunities latent in the interactions among those issues, and to promote a frank discussion of the prospects for more effectively harnessing science and technology to contribute to the understanding and management of their interactions. The specific goal was to provide input to

[1] The Workshop was convened by the Sustainability Science Program at Harvard University's John F. Kennedy School of Government in cooperation with the new Mega Program on Climate Change, Agriculture and Food Security being developed by the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership. It is the fourth annual Executive Session on Grand Challenges of the Sustainability Transition convened by the Sustainability Science Program in cooperation with the Venice International University and Italy's Ministry for Environment, Land and Sea.

the major new research initiative on Climate Change, Agriculture and Food Security (CCAFS) being developed by the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP).[2] In pursuit of these goals, the workshop explored 3 broad questions: i) What new knowledge (data, models, technologies, processes) is most needed to improve society's understanding of and options for managing the interrelationships between food security and climate change? ii) How can that knowledge be better linked with action? iii) Who needs to do what in order to implement an effective program of research–based action to address food/climate issues?

Invitees to the workshop were selected to reflect a wide range of perspectives and experience, within the constraint of keeping the total number of participants small enough to enable real engagement and interaction of all. Due partly to our own choices, and partly to availability, the ultimate list of participants[3] was relatively thin in several areas that would need to be represented for a comprehensive look at the subject of the workshop. As our discussions evolved, we felt particularly the relative shortage of i) experience in Latin America or E and SE Asia; and ii) expertise in nutrition security as opposed to food security. These limitations of the workshop design should be kept in mind in interpreting the results of our discussions, and in the planning of follow-up activities.

The participants in the workshop were asked to attend and contribute in their individual capacities, rather than as representatives of programs, organizations, or disciplines. The workshop was conducted with the understanding that no remarks made at it were to be attributed to particular individuals or organizations. This report was prepared by the workshop steering committee[4] to highlight what we viewed to be some of the most interesting themes explored and ideas raised at the workshop. We begin with a short summary of what we view to be the major take-home messages of the workshop, followed by more detailed summaries of each of the workshop's individual sessions.

3 Major themes of the workshop

3.1 *Integrated systems perspective*

Climate change and agriculture are increasingly tightly interconnected in ways that have implications for food and livelihood security of people around the world. Agriculture has always been a major driver of environmental change. Current practices are a substantial contributor to the risk of global climate change, but agriculture and land use also provide significant opportunities for mitigating environmentally harmful emissions. Climate change and variability already pose major threats to agricultural production and food security, with particularly negative impacts for the world's most vulnerable peoples and places. These threats will intensify and become ubiquitous over the next several decades.

The simple concepts such as yield maximization that have dominated the agricultural world for

[2] See http://www.cgiar.org/ and http://www.essp.org/.

[3] See list, p. 14.

[4] Ibid.

decades are not adequate to deal with these complex interconnections. New thinking and new, integrative models are needed to define a more sustainable path forward. For both research and policy, the crucial need is to move beyond conventionally siloed perspectives on climate, agriculture and food security and instead to address them and their interactions from an integrated systems perspective.

3.2 *Creating useful knowledge*

Seizing the opportunities and managing the risks inherent in the interactions of climate change, agriculture and food security will require many things, including good governance, good luck, and massive increase in the mobilization of appropriate science, technology, and monitoring data. We focused in this workshop on the latter of these needs: the identification, creation and utilization of knowledge that would be useful to promote food security in a time of global climate change.

There are few R&D systems geared to the breadth of the questions that are being asked and will be asked over the next 20 years regarding the food-climate nexus. Some of the needed advances in knowledge are obvious and currently being pursued, including work drought tolerant varieties of the most commercially important crops, improved soil and water management practices, cultivation practices that are more nitrogen/soil conserving, and land use management strategies that are better at sequestering and securely storing carbon. Novel R&D efforts towards engineering more efficient photosynthesis are also underway. But the range of needs unaddressed by current systems is alarming. There is a need, for example, for deeper, context-sensitive understanding of which sets of rights, held at which levels of control and management (e.g., the state or the farmer), provide the best combinations of incentives consistent with "commons" character of many aspects of agricultural and environmental systems. System-level analysis that incorporates cultural components is needed to underpin consideration of farmers' technology choices or their potential for livelihood diversification. There is also a growing demand for systems that would link farmers to data about weather and climate, thus enabling them to make tactical decisions related to climatic variability, but the available climate information is too coarse in terms in spatial scale to be useful at the community or individual-farmer level. A next generation of flexible, user-friendly spatial analysis tools is long overdue. Many other specific challenges and opportunities for future R&D were identified in the workshop discussions and are summarized in the rapporteurs' reports. Here are some highlights of more general areas where more knowledge is needed to facilitate effective action, but seemed unlikely to emerge from existing R&D systems:

1) **Better scenarios:** Current "business as usual" scenarios for likely agricultural production are confusing, under even specified patterns of climate change. This is at least in part due to surprisingly large differences in assumptions made by different groups about the rate and pattern of future yield and demand changes in the food and agriculture sectors, and about the nature and limitations of adaptation strategies used by farmers, consumers and industry. When the focus of concern is expanded to encompass nutrition or livelihood security there seems to be even less of a widely shared consensus on the range of possibilities and their sensitivity to modeling assumptions. There is a need to improve the quality, availability and transparency of alternative models used to produce such scenarios, and to understand the sources of differences in their outcomes.

2) **More explicit consideration of the time dimensions of climate-related changes**. Climate-related changes threaten food systems through two distinct if often interacting pathways: chronic stresses and acute shocks. These threats will develop in the future not only through their direct impacts on agricultural production, but also through indirect pathways such as climate-induced changes in disease, migration, and labor availability. There is a need to better identify where and when climate stresses, climate shocks, and combinations of the two are likely to pose the most serious risk to food and livelihood security. And to develop, test and deploy appropriately differentiated response strategies for each. These strategies may be quite different. For example, a focus on enhancing the productivity of sustainable agricultural is needed as part of the response to chronic stress. For acute shocks, however, a focus on enhancing the resilience of livelihoods is required.

3) **More strategic options to reduce carbon emissions from agriculture without compromising food security.** While there is a desire for "win-win" interventions that could significantly increase food production and decrease greenhouse gas emissions from agriculture, identified options are surprisingly scarce. There is a need to think outside the box to build a list of "science fictions" that could then be further developed and evaluated as possible options, e.g., wheat with a time clock/ phenology changed to match the thermal time period of rice, frost tolerance for tropical crops, better ways of using phosphorus in the soil, etc. etc. R&D needs to focus on solving the problem of achieving a menu of "wins," at least some of them of the "win-win" variety, rather than assuming that optimizing on single dimensions of the climate-agriculture-food security problem will produce—through some sort of "trickle down" -- the needed capabilities. That said, the vast majority of realizable interventions are likely to involve tradeoffs and a "middle ground" of least-bad or generally-better needs to be sought. In order to identify such strategic options, tools that enable decision-makers to compare how particular choices would score on multiple criteria (such as the framework sketched below) might be an appropriate research outcome.

	Evaluation criteria -->	**Food production**	**Livelihood security**	**GHG Emissions**
Policy instruments	**Specific Interventions**			
Economic	Carbon price			
	Green economy tie-ins (regional, other)			
	Price supports for (some) small farmers			
	Payment for ecosystem services	*Cells to contain evidence on impact of specific interventions on specific criteria*		
	…			
Technical	Water conservation			
	Rural infrastructure			
	…			
Regulatory	(De)centralized control of land use			
	…			
Information	Certification, standards			
	Decision-support tools			
	Farmer development index			
	…			

4) **Targeted, trustworthy measuring, monitoring, verification and reporting (MMVR) systems.** Effective MMVR systems are those that provide users with timely information of reliable quality relevant to their needs. Given the diversity of users (farmers, agricultural planners, market agents, politicians, consumers and many more groups) demanding information relevant to food security and climate change, a range of MMVR systems will be needed. Some aspects of the food-climate-livelihood system are regularly measured, but there appears to be a lack of confidence in much of the reported data—with consequent discounting of its utility in guiding action. Effective systems can be built, as shown by the impressive progress in developing strategies for managing aboveground carbon stocks for Reducing Deforestation and Degradation (REDD). These strategies have gained a place at the climate change negotiating table because of scientific and technological developments that allow aboveground carbon to be measured, monitored, verified, and reported reliably. Even with REDD, however, it is clear that without strong science, effective MMVR systems cannot be built. (For example, it is widely recognized that managing soil organic matter is a potentially bigger part of the REDD response, but it is has yet to play much a role in policy discussions because it is so difficult to monitor at scale). There are other key properties of the food-climate-livelihoods systems that are simply unobserved in ways that are generally accessible to researchers, policy makers, and other stakeholders. The example of plummeting livelihood security for large numbers of Indian farmers experiencing both agricultural and climate change—a trend missed by many formal monitoring efforts but picked up in ad hoc social surveys—is particularly sobering. A mapping of priority MMVR needs for advancing the development of scenarios, strategic options, and public awareness might be a useful next step in this critical area.

3.3 *Linking knowledge with action*

Knowledge must be linked with action if it is to help to enhance food security while limiting the environmental impacts of agricultural production. The workshop explored ways of assuring that the knowledge most needed by action-oriented stakeholders will be given adequate attention in R&D efforts, and will be communicated in ways that best support decision making, management and policy.

Both experience and scholarship cited at the workshop suggest that people allow their behavior and beliefs to be influenced by knowledge that they trust. And knowledge is perceived to be trustworthy by a particular user to the extent that s/he sees it (and the process that produce and present it) as being not only technically *credible* but also practically *relevant* and politically *legitimate* (disinterested or unbiased). Successful efforts to create influential knowledge generally require active collaborations between researchers and particular decision makers, with trusted intermediaries or "boundary spanners" often playing a crucial integrative role.[5] Many specific suggestions for better linking knowledge with action on food security / climate issues were advanced at the workshop and are summarized in the rapporteurs' reports. Some more general challenges and opportunities facing emerging research programs are summarized below:

[5] See, for example, Cash, D.W., et al. 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences* 100 (14): 8086-91.

1) **Research and monitoring programs are more likely to influence action if their goals, strategies and criteria for evaluation are developed in close collaboration with specific stakeholders**. Those stakeholders may involve farming communities, the private sector, governments, non-governmental organizations, international negotiators or combinations of all of these. But unless the stakeholder groups selected for collaboration are committed to integrated goals of raising agricultural production, enhancing food security and limiting environmental emissions, the demand for new knowledge is likely to relapse into its traditional siloed categories, and the potential for needed out-of-the-box innovations is unlikely to be realized. A particular challenge arises in finding or creating strong, multidimensional stakeholder groups with integrated goals for periods beyond the immediate future, say 2030. The experience of REDD initiatives described at the workshop showed that the challenge can be met, creating a "market" for integrated, policy relevant R&D. But a substantial and sustained effort may be necessary to build and maintain such unconventional, multi-objective, long term collaborations.

2) **Integrated systems of decision support (aka management, policy, or learning support) for specific stakeholders are more likely to link new knowledge with effective action** than a more conventional focus on technology transfer. Examples of such systems discussed at the workshop ranged from the integrated platforms for sharing best practice experience developed by the Sustainable Agriculture Initiative (SAI), to the models for reducing vulnerability to climate change created for local planners by the Regional Integrated Sciences and Assessments (RISA) program, to the more general role of the Intergovernmental Panel on Climate Change (IPCC) in bringing science to the global climate negotiations.[6] Successful programs of decision support pay close attention to forging agreements not only on *what* knowledge is most needed by particular stakeholders, but also on the *form* of knowledge they are most likely to use (e.g., best practice lists, or models, or one page briefings) and on *when* their decision system is most open to uptake of new knowledge (e.g., during annual planning for farm-level planting or national budgeting, or in support of periodic intergovernmental meetings). This latter issue of timing was singled out for particular attention at the workshop. Many international research programs were felt to be at risk of being left behind by events, operating on time cycles much slower than the pace of change in real farming and policy environments. For most stakeholders some form of annual scientific and technical update—scheduled to match their decision cycle—seems a necessary component of meaningful support systems.

3) **Capacity building across all elements of the decision support system will be needed to improve the effectiveness of collaborations for linking knowledge with action.** Particular attention was given by participants to improving capacity for the development, deployment and communication skills needed to bridge the "valley of death" separating initial discoveries from adoption at scale[7]. Also noted was the importance of strengthening local and national capacities

[6] For SAI, see http://www.saiplatform.org/; for RISA, see http://www.climate.noaa.gov/cpo_pa/risa/; for IPCC, see http://ipcc.ch.

[7] One observation on the inability of agricultural R&D to bridge the gap to commercialisation is the huge amount of effort going into predominantly lab-based "agricultural" research that is completely disconnected from application; e.g., there are 6000 patents that invoke "plant breeding" and "drought resistance" yet none of them has yet resulted in an improved commercial variety.

for analyzing climate issues and, more generally, for participating in global climate negotiations. Other areas highlighted for capacity building included integrated modeling and landscape-level models and the enhancement, improvement and some standardization of data collection and modeling efforts (e.g., bringing together crop modelers from various institutes while improving local modeling and analytical capabilities). Many participants emphasized that capacity building efforts are generally more successful when they build on, strengthen and link to key elements of existing structures, rather than reinventing or circumventing and thus undermining them. (Key candidates for inclusion are organizations of land users, local universities, the policy and planning staffs of states and regions, news channels, and people's science movements). This is in part an efficiency argument. Even more important, however, may be the need for local partners in order to tap local knowledge, to articulate locally viable goals, and more generally to build the trust that is so essential in linking research knowledge with meaningful action. Several workshop participants emphasized the importance of including younger professionals in training and capacity building efforts. Doing this in ways that cut across, rather than accentuate, typical silos of later professional life seemed particularly important.

3.4 *Toward implementation: Who does what?*

The issue of *who does what* was understood to be complex due to the integrated and systemic nature of linkages between agriculture, sustainable food security, and climate change. It was recognized that much of the current work is characterized by transactions between discrete and isolated actors rather than focusing on fundamental change or transformation. Many called for a transformational approach, requiring a better understanding of the key functions that need to be performed (such as information gathering and analysis, advocacy and implementation).

1) Three key functions of information gathering and analysis, advocacy and organization, and implementation need to be addressed by programs seeking a transformational approach to improving food security in an era of global change.

* Improvements in agricultural and environmental **information gathering and analysis**—with respect to quantity, quality and timeliness—are needed throughout the developing world. Little attention is paid to collecting longitudinal, or time series, information and as a result it is difficult to discern long-term trends and impact. Such data as are collected are strongly biased toward the state of plants rather than the state of people. In addition, information is poorly gathered and its use is constrained by a variety of intellectual property restrictions. Many data are not collected in ways that can be readily shared. The lack of tools and standards that facilitate interoperability further restrict multiple uses of the data that is collected. Many participants felt that there is a pressing need for a multi-stakeholder analysis of priority monitoring issues, centered on the food security part of the climate change / agriculture / food security nexus.

* **Advocacy**: Using existing information to influence change requires the existence of advocacy groups (civil society and private entrepreneurs alike) that share a common language. There is a need to foster interactions among such groups. Universities, especially in developing countries, need to play a bigger role not only in information gathering but also in advocacy.

* At the level of **implementation**, it is important to focus on long-term mobilization efforts, and not simply rely on campaigns that have defined timeframes. More importantly, the mobilization effort should be comprehensive, efficient and recognize the importance of learning over time. This is important considering the urgent need not only to raise agricultural

productivity but also to expand access to food.

2) Bundle assets and align activities: A central finding of the session was the importance of shifting from isolated actions to coordinated approaches that rely on bundling existing capabilities and assets. This approach will require innovative new approaches to enhance collaboration, involving improved communication (e.g., through the use of new information and communication technologies) open-mindedness, and novel partnerships among public and private actors. There is a need to align key actors around common interests and themes. Articulating common outcomes that various parties are seeking is one way of doing this. With improved understanding of the competence of the various actors it is possible to determine who can lead, follow or complement the efforts of others. A special need and opportunity exists in the climate change / agriculture / food security nexus to redefine historical presumptions about the respective roles. Transnational agriculture corporations now have a significant fraction of relevant crop breeding capacity. Global, largely academic, research communities have developed a unique capacity for understanding global environmental change. Local universities and research institutes have key role to play in contextualizing and integrating such knowledge. The CGIAR could -- and in the view of some participants should -- come to see itself as quintessentially the integrator of these distinctive communities and their unique capacities.

3) Share information: In the area of information gathering and analysis, those working on agricultural development need to interact more closely with people tackling climate and environmental challenges, and to inform one another of their information needs in a systematic and timely manner. Timeliness is particularly important because many of the studies on themes such as farm yields tend to focus on today's plant breeding practices and fail to take into account future breeding possibilities. Likewise, International research programs such as those of the CGIAR could play a role in serving as a critical link between these two communities.

4) Improve communication: In communicating complex issues such as climate change and food security, it is important to formulate clear messages that can capture public imagination. The health sector, which focuses on specific diseases, might offer some lessons on how to do this. But simplifying the messages so that it can lead to action should be done in a wider context that recognizes the systemic nature of the challenge. Such improved communication will entail improving access of the media to research findings as well as training them to strengthen their competence. Institutions such as the people's science movement in Asia and many other existing civil society organizations could play key roles as agents of public communication and education.

4 Participants in the San Servolo Workshop

The following individuals participated in the workshop in their individual capacities. Institutional affiliations are provided only for the purpose of identification. Members of the workshop steering group are indicated with an asterisk (*).

Jon Anderson, Resident Country Director, Millennium Challenge Corporation, Mali
*Ganesan Balachander, Science Task Force Leader, Consortium Board, CGIAR
*Bruce Campbell, Director, Climate Change, Agriculture & Food Security Program; University of Copenhagen
Ken Cassman, Professor of Agronomy, University of Nebraska at Lincoln
*William Clark, Professor, Kennedy School of Government, Harvard University
Corrado Clini, Director General, Italy's Ministry for Environment, Land and Sea
Gordon Conway, Professor, Centre for Environmental Policy, Imperial College London
Theodore Crosbie, Vice President, Global Plant Breeding, Monsanto, Inc.
*Nancy Dickson, Co-director, Sustainability Science Program, Harvard University
Erick Fernandes, Advisor of Agriculture and Rural Development, The World Bank
Tanja Havemann, Director, Beyond Carbon GmbH
*N. Michele Holbrook, Professor, Dept of Organismic and Evolutionary Biology, Harvard University
Hans Jöhr, Corporate Head of Agriculture, Nestlé
*Calestous Juma, Professor, Kennedy School of Government, Harvard University
*Patti Kristjanson, Climate Change, Agriculture & Food Security Program; World Agroforestry Centre
Hiroyuki Kubota, Executive Advisor to DG, Japan International Cooperation Agency
Diana Liverman, Professor of Geography and Development, Universities of Arizona and Oxford
Wendy Mann, Senior Adviser, UN Food and Agriculture Organization
Luke Mumba, Director, Southern African Network for Biosciences, New Partnership for Africa's Development
*Gerald Nelson, Climate Change, Agriculture & Food Security Program; Intl Food Policy Research Institute
Dan Nepstad, Senior Scientist, Woods Hole Research Center
John Passioura, Research Fellow, Australia's Commonwealth Scientific and Industrial Research Organisation
Palagummi Sainath, Rural Affairs Editor, *The Hindu*
Mihir Shah, Member, Planning Commission, Government of India
Howard-Yana Shapiro, Global Staff Officer, Plant Science and External Research, Mars, Inc.
Lindiwe Majele Sibanda, CEO, Food, Agriculture and Natural Resources Policy Analysis Network
Emmy Simmons, Former Co-Chair, US National Academies' Roundtable on S&T for Sustainability
Terry Vogt, Managing Director, Terra Global Capital
George Wamukoya, Climate Change Advisor, Secretariat, Common Market for Eastern & Southern Africa

5 ANNEX: Rapporteur reports from the workshop sessions

5.1 *Day 1: New knowledge and know-how*

What new knowledge and know-how are most needed to improve society's understanding of, and ability to manage, the interrelationships among climate change, agricultural production, and food security? In particular, where do the greatest practical needs and the realizable potential for discovery intersect?

Rapporteurs: Missy Holbrook, Harvard University and Bruce Campbell, CGIAR Challenge Program for Climate Change, Agriculture and Food Security (CCAFS), CCAFS Secretariat, University of Copenhagen

Session 1.1 What are the prospects for enhancing agricultural productivity in ways that limit the food system's vulnerability to weather, climate and environmental change?

Discussants: Gordon Conway, Imperial College London, **Ted Crosbie,** Monsanto Company, and **Luke Mumba**, Southern African Network for Biosciences, New Partnership for Africa's Development

1. Purpose of session:

To discuss what combination of technological, ecological, and policy/institutional strategies stand the best chance of enhancing agricultural production and food security around the world in an era of intensifying environmental change.

2. Main themes:

Food and livelihood security of peoples around the world are threatened by ongoing and intensifying changes in the nature and location of both chronic stresses and acute shocks. Much recent attention has properly been focused on the portion of these threats that come from climate change and variability. But—as illustrated by the world food crises of 2008/9—other factors are also implicated, involving increasingly global interactions among our political, economic and environmental systems.

Extreme events (shocks) are harder to research, and to cope with than the slow and relatively predictable changes (stresses) that receive much of the attention in research on the climate / food security nexus. Yet such extremes, while transient, can have dramatic and far-reaching impacts. It is important to determine whether there are places in which the major threats to livelihood and food security over the next decades are likely to be from increases in chronic stresses, as opposed to places in which the principle threats will be from acute shocks. More generally, we need a more balanced approach that addresses the threats to food security over the coming decades posed by coming changes in both chronic stresses and acute shocks.

Increasing yields is fundamental to food security, as well as to limiting environmental impacts of agriculture (e.g., through extensification). We need to have new ways and strategies for developing genetic varieties for a 2030 world. Yield gains are critical for planning, but poorly incorporated into current models. Yield gaps represent an important place to start, as major

gains for food security could be achieved in a shorter time than with many other approaches.

More research is also needed on risk and its relation to decision making by farmers and other key actors in the food system. Livelihood diversification was discussed as an important means to deal with climatic variability/lack of predictability. One barrier to diversification is land tenure. It is generally accepted that investments in soils, trees, infrastructure that can improve agricultural sustainability and resilience will be limited without appropriate property rights. But there is a need for deeper, context sensitive understanding of which sets of rights, held at which levels of control and management (e.g., from state to farmer), provide the best combinations of incentives consistent with the "commons" character of many aspects of relevant agricultural and environmental systems. System level analyses that incorporate cultural components are needed to understand technology choices by farmers, as is a better understanding of the type of institutions needed to support livelihood diversification. More broadly, we need a better understanding of the political economy of land use and agriculture, and how it interacts with climate and environmental changes to determine food (in)security for particular peoples and places.

Substantial knowledge and capacity gaps in understanding climate processes exist at all scales. The importance of linking farmers to data, thus allowing them to make tactical decisions related to climatic variability (e.g., planting date) was recognized, but in many parts of the world the available climate information is too coarse in terms of spatial scale to be useful on the ground. More relevant data, including more satellite platforms with greater coverage, are needed. However, equally important is a way to get information into the hands of farmers and local agricultural planners. A next generation of flexible, user-friendly spatial analysis tools is long overdue. While it is developing, mobile phones could allow the distribution of local information on climate, soils, prices, seed availability. However, issues of who controls data relevant to farmers and how quality control and verification will be ensured represent significant issues.

Many of the tools and technologies needed to deal with climate change and variability take substantial time to develop and implement. Useful would be a more widely shared appreciation of realistic time scales of possible responses meant to enhance food security in a time of environmental and especially climate change. Once again, more integrated approaches are needed to adaptation and response, with modeling efforts particularly needing further development, e.g., land-use changes are poorly represented, genetic gains poorly represented in most current efforts.

Managing the complexity of the real world interactions among agriculture, food security and climate will require complex, context-appropriate responses and an ability to address inevitable trade-offs. Viewing alternatives in terms of binary frameworks (e.g., "livestock is bad for climate change") will let the "perfect" become the enemy of the "good". We need to learn to grapple with multiple middle grounds, and with integrated solutions involving tradeoffs along multiple axes: climate protection/food security; intellectual property/public goods; mitigation/adaptation; efficiency/resilience; developed/developing countries; intensification/extensification; centralized/decentralized control; voluntary/mandated standards.

Other issues raised but not discussed at length included:

- What is the future for mixed cropping? (Ecological and potential social benefits; but challenges of mechanization).
- What could be the role of tree crops as insurance against climate shocks? (Need for research on orphan crops, many of which are trees).
- How to deal with public perceptions of risk and the role of the media with respect to controversial science and technology (e.g., by the biotech/breeding community and climate scientists facing a backlash against IPCC)?
- What are the opportunities to improve the efficiency of nitrogen uptake in fertilized systems? It was noted that in non-subsistence agriculture large gains in efficiency will be made by increasing the price of N fertilizer, evident during the 2008 spike in the price of natural gas that led to a huge price increase for N fertilizer. What is lacking is incentive rather than technology - though there is much global activity on the latter, which will surely lead to novel opportunities for improvements in the next decade or two. Phosphorus supply is likely to be more critical, and its efficiency is also being actively researched.
- What are the real challenges and opportunities for dealing with methane emissions from livestock?

3. Findings:

IT will massively affect farmers and thus is an important tool for food security. Need to improve data acquisition and information availability so as to be available at a scale relevant to farmers.

More research is needed on climate processes so as to better predict current variability (e.g., monsoons). Investments in spatial technology are needed, linked with decision support tools (e.g., World Bank distributed hydrologic model).

Information is essential, but rights issues and land tenure may limit the ability of farmers to invest and to change behavior. Research is needed on farmer risk management strategies, including institutional capacity to support livelihood diversification.

We need a better understanding of why yield gaps persist. One observation as to a contributing factor is that international researchers concentrate much more on breeding new varieties than on getting the best out of existing ones, with an estimated current ratio of effort on breeding to that of agronomy of at least 2 to 1, yet in current circumstances the reverse may be required. A second reason is that a large proportion of farmers don't know what yields they are capable of and therefore have little incentive to improve their management. A third reason is that many who do know that they can get better yields can't afford to take the risk of aiming for higher yields, which usually requires higher inputs. Much research has gone into this question, the bottom line being that smallholders are acting rationally given the economic, infrastructural, policy and institutional constraints they face.

Session 1.2 What are the prospects for agricultural development strategies that could lower carbon and other damaging emissions without compromising food security?

Discussants: Dan Nepstad, Woods Hole Research Center and **Tanja Havemann**, Beyond Carbon GmbH

1. Purpose of session:
To stimulate exchange of ideas on (i) the greatest opportunities for increasing the net uptake of carbon by agriculture, forestry and other land uses, (ii) the technological and institutional solutions that can be brought to bear on reducing agricultural emissions of carbon dioxide, methane and other pollutants, and (iii) what will this mean for livelihoods and other environmental benefits?

2. Main themes:

Land use change represents a critical component in the agriculture/climate change nexus. A substantial fraction of emissions causing climate change trace back to land use, while climate change will shift the use of both more and less managed lands. Development strategies for achieving food security while protecting the environment require a systematic theory for understanding the role of agriculture and of climate in driving land use change. Such a theory is presently lacking; the contemporary focus on increasing yields is not enough.

One of the big surprises for many at the workshop was the dearth of strategic options that have been assessed for their potential to reduce carbon and other damaging emissions from land use without compromising food security. Reducing deforestation and forest degradation is the only major exception to this generalization, discussions about its potential and challenges are summarized below. Additional technical options have been suggested and, again, are noted below. But an urgent need is to move from suggestions about what can be done on a test plot or demonstration project to systematic assessment of the prospects for—and implications of—scaling up such interventions.

In thinking about such strategies, it is important to realize that *the world may well have entered an era of sustained higher prices for food, fiber and fuel derived from the land*. This transition, if robust, could provide numerous opportunities to revitalize agriculture and the lives of farmers, and to adopt innovations that reduce the impact of agriculture on the environment in general and on the global climate in particular. But realizing those opportunities will require strategies that couple measures to reduce carbon emissions from agriculture with measures to increase production from agriculture. Any such "wall-to-wall" planning will need to be dynamic, however, due to the uncertainties in predicting future climate change and responses to it. This is a tall order.

Turning to specifics, progress in developing strategies for managing aboveground carbon stocks for REDD has been impressive. But such strategies have gained a place at the negotiating table because of scientific and technological developments that allow above ground carbon to be measured, monitored and reported reliably. Managing soil organic matter (SOM) is a potentially

bigger part of the REDD response, but has yet to play much of a role in policy discussions because it is so much more difficult to monitor at scale. (One suggestion is to reward farmers for practices known to conserve soil C, rather than trying to monitor soil carbon directly). More generally, a significant REDD strategy seems likely to require a return toward centralized control of forest resources. This raises concerns due to previous experience that natural resource management is most effective when some of its functions are decentralized. There is a need for balance in the degree of centralization involved in REDD, but little understanding of what kind of balance is needed or how to achieve it.

Livestock raise concerns about land use and degradation as well as methane emissions. But they also play an important role in food security in relation to extreme events—they can be sold in case of emergencies, for example. And while poor women typically cannot own land, they often own or manage chickens, sheep, goats or pigs, critical assets that provide a regular source of both nutrition and income for their families. Livestock issues thus need to be understood within a farming systems context. There is potential for genetic improvements for meat and milk productivity and resistance to climatic stresses and disease, along with higher feed use efficiency if the opportunities that livestock offer for sustainable agricultural development and poverty alleviation are to be optimized.

Water may become a limiting issue long before trends toward higher temperatures impose significant impacts on agriculture. More effort is certainly needed on hydrologic models. But given the high uncertainty in predictions of trends in rainfall associated with climate change, the R&D agenda related to water, climate change and agriculture should almost certainly be a broad one, emphasizing resilience in the face of shocks as much as adaptation to long term changes in stress.

But the list of possible interventions noted above is short, while the need is great, and growing. Participants emphasized the need to think big—or at least outside of the box—to build a list of "science fictions" that could then be further developed and evaluated in search of viable options. These might include radical change in water and nutrient use efficiency of crops; increase the nutritive value of food; find better ways of using phosphorous in the soil; change phenology/time clock of wheat into the thermal time period of rice; small-scale aquaculture; salinity tolerance; flooding tolerance (oxygen deprivation tolerance); apomictic hybridization (e.g., as exists in buffalo grass); perennialization; C3-to-C4 conversion; frost tolerance for tropical crops; and so on.

More generally, transparency is needed in the models and monitoring strategies used to investigate the feasibility and tradeoffs involved in scaling up technical possibilities into viable options for policy negotiation. The workshop noted much confusion over what specific models, measures and forecasts included and what they left out, what they were relatively certain of and what was little more than informed guesswork. Future efforts to model and measure key elements of the agriculture/climate nexus would almost certainly be more useful for policy if the community were to develop a "due diligence" list of how such issues as CO2 fertilization, varietal choice, ozone damage, etc. are handled. The utility and credibility of energy modeling has benefited substantially from the adoption of such measures. In the agriculture/food security/climate change domain, they are almost certainly long overdue.

Other issues raised but not discussed at length included:

- Ozone impacts on crops important, likely to be affected by energy policy linked to climate change, but are not sufficiently incorporated into most models of future crop production.
- China needs to be in the discussion of issues discussed here.
- The possibility of shaping diets (specifically meat) needs to be considered in the context of efforts to shape a highly productive, low impact agriculture.
- Most efforts to improve soil organic matter accumulation will also sequester nutrients such as sulfur and phosphorous. Thus, strategies to stimulate soil carbon accumulation may involve tradeoffs with crop production.
- Biochar has been suggested as a means for improving soil fertility while promoting carbon sequestration. How does this potential look from the climate change perspective when energy and technology requirements are taken into account?
- Biofuels development is almost certain to affect tradeoffs between agriculture, food security and climate change. The topic was not discussed at any length in this workshop.

3. Findings:

Increasing yields on cultivated lands is a critical component of reducing the overall carbon footprint of agriculture. Need research on closing yield gaps and improving yields, better utilizing inputs, and reducing losses.

Increasing agricultural production while decreasing carbon emissions is challenging, although in systems with inputs of water and fertilization, opportunities for improved efficiency exist. Linking agricultural development with funds for reduced carbon emission via REDD is an exciting opportunity; but requires comprehensive (and dynamic) land-use planning.

5.2 *Day 2: Linking knowledge with action*

Linking knowledge with action for food security in a time of climate change

Rapporteurs: Gerald Nelson, International Food Policy Research Institute and Patti Kristjanson, World Agroforestry Centre

Session 2.1 How could the global community do a better job of assessing and making available what is known about the food security – climate nexus and the options for addressing it? What are the strengths, weaknesses and complementarities of alternative approaches?

Discussants: Hans Jöhr, Nestle Ltd and Wendy Mann, FAO

1. Purpose of session:
Generate ideas and experiences as to what kinds of processes and institutions can best bridge the great diversity of perspectives on climate change, agriculture and food security. To synthesize what is known and identify gaps and what actions/approaches are most needed to facilitate effective action in promoting food security in a time of climate change. To explore the strengths and weaknesses of big international assessments such as IPCC, and compare them with more regionalized, flexible and targeted approaches.

2. Main themes:

- **Private sector approach.** As an example the Sustainable Agriculture Initiative was mentioned. It created working groups around the most relevant crops, so as to develop guidelines, principles, and good practices and indicators. Road maps were prepared showing how supply can be ensured and brands are sustainable. It now has 60-70 projects in 30 countries. They undertake life cycle analysis that elaborates, then tests, with feedback, all within the crop cycle.
- **Challenges to integration**: Still little agriculture discussion in climate change negotiations, and little climate change inputs in food security/agriculture policy initiatives. UN processes slow, but the UN do have convening power—the need to streamline processes is recognised; but we may also need to go outside these processes. At national level, separate policy tracks and rivalries across Ministries exist. E.g. Poverty Reduction Strategy Papers, National development plans, National Adaptation Plans of Action, Non Agricultural Market Access, the Comprehensive Africa Agriculture Development Programme, a programme of the New Partnership for Africa's Development. The United Nations Food and Agriculture Organization is working on aligning these various processes. What is the best way to support Ministries of Agriculture and the Environment? One idea is to help Min. of Ag prepare proposals that tap into funds going directly to Min. of Finance. What are some of the science fiction scenarios we should pursue for more joint actions? Is there scope for having more virtual teams?

- **Lessons from GECAFS (Global Environmental Change and Food Security Program of the Earth System Science Partnership, ESSP)**: Focus has been on long term climate change impacts rather than impacts of climate variability or other environmental changes, especially atmospheric ones, e.g., ozone, shade-out problems in rice, brown clouds in SE Asia responsible for yield declines. Should CCAFS focus on 'bundles' of transnational impacts, or just on climate change? Frustration of GECAFS to connect big assessments to operations on the ground. How many people in government, or involved in operational running of ag—private sector, farmers—have ever read an IPCC report? International assessment operational issues and agricultural production issues—what we can measure will drive it. Need to include more agricultural value chain participants in the assessments, linking climate and food security. Need to decide where to focus our attention vis a vis long term trends (stresses) versus shorter-term variability and shocks (radically underplayed relative to the damage they are causing).

- **Population growth, *food* subsidies, investments in ag research and extension** are key issues. Ag productivity growth is only 1.5-2%/year in India (with other sectors experiencing 8% growth). There is lots of rural out-migration, farmer suicides and land being lost to non-ag use. There are some serious problems in the ag sector.

- **Data issues –** not enough investment going into data collection to be used in assessments.

- **Credibility, relevance and legitimacy of assessments/approaches and tools/data:** These need to be perceived to have technical credibility by whatever standards the user group (those whose behavior you want to change) holds; relevance (salience) to decision needs; legitimacy (do you trust the data)—the process that generated the data was generated in my interest or in a transparent way. Process is too often not trusted. How do we optimize a process that tries to balance all three?

- **Global approaches with standardized methods vs. regional data collection**: Standard methods, huge global approaches needed for some things but not everything. Some things need to be done with the people/experts from the region in approaches that make sense to them

3. Findings:

- Need to shift donor agendas to support Ministries of Agriculture rather than such a huge focus on education, e.g., DFID; and to work with Ministries of Finance (who have power)
- Need more attention to gray literature in big assessments. The political economy of food security needs research.
- Develop a 'farm development index' (similar to human development index), or a series of indices to capture what's happening in the agricultural sector, how it impacts food security, and where vulnerability to weather variability and shocks and other factors such as infrastructure play a role; lots of potential uses by different communities
- CG to ask what 2-3 papers could be produced in the next few years about: how much land will be needed; what are the expected crop yield growth rates and what does that mean; how does this relate to non-yield based initiatives that can have a big impact on the amount of land required (e.g., storage); what are the potential gains from just using better land management

practices (e.g., through access to information / extension services vs. introducing new breeds)? how much fertilizer is needed; e.g., jointly produce (e.g., with regional organizations such as COMESA) an annual authoritative paper with statistics on performance, interface with climate, and predictions. Outputs should be synchronized with climate negotiations.

- Help develop in-country capacity (for negotiations, assessments, etc.); these are the people that will influence their policymakers (there was concern that outside agencies were coming in to do the assessments)

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Session 2.2 To what extent can various policy instruments available to us from local to global levels help drive the shift to agriculture that has win-win outcomes for emission targets and food security?

Discussants: Lindiwe Majele Sibanda, Food, Agriculture and Natural Resources Policy Analysis Network and **Mihir Shah,** India Planning Commission,

1. Purpose of session:

To discuss what, if anything, is most needed from the development of international treaties, agreements or norms? What can market mechanisms do best? Where can information in the form of certification or related approaches play a useful role? Where is the best case for regulatory action? Realigning property or procedural rights? What should be the role of funders, whether through grants, loans, or investments?

2. Main themes:

Issue of how best to inform food security, agriculture and climate policy in Africa. Who monitors? Need to inform frameworks like the Comprehensive African Agriculture Development Programme (CAADP)—endorsed in 2003 by African presidents and addresses sustainable land and water use, food security, vulnerable populations, research and technology adoption. 18 countries have development investment programs, signed by government, researchers, traditional chiefs (West Africa). Two regional communities have their CAADP compacts: West Africa's focus: improved food production, safety nets. COMESA focus—improved productivity, enhanced markets and trade and human and institutional capacity. AGRA goals are to make sure 20 countries in Africa have a reduction of 50% in 'food insecurity' by 2020, with 20 million small-holder farmers doubling their income. Science-based evidence is missing though, e.g., we need data on livelihoods and household welfare dynamics. NARS are largely dysfunctional as a result of under-investment. Need to link national universities to the development agenda. Let those closest to the issue be the ones to collect data to inform national and global levels. Questions: Can we afford to plan on wrong data? Can Africa meet its targets for MDG's without damaging the environment? What are the levers? Should we be looking for new opportunities?

Carbon finance. GHG mitigation-related policy instruments to leverage funding. Carbon credits are just one of a suite of many other types of policies that can be used – both within the country itself (domestic policies, e.g., Costa Rica's forest policy) or taking advantage of the existence of other policies & trade agreements through certification. Soil carbon sequestration potential is there, REDD and soil credits programs exist, but there has been little research as to what type of incentives would be most effective. Institutional issues are critical. Traditional carbon payment schemes won't work in many places.

Leveraging domestic resources. Tap into the money that is generated through the national lottery funds. Where is lottery located? Ministry of Home Affairs. Bring that into Ministry of Finance, since Office of President is asking for sources of funds for food security.

Opportunities for carbon credits? (tapping the green economy). Potential income depends on a compliance mechanism coming in. 'toe dippers' and speculators are financing carbon payments to date.

3. Findings:

Back win-win interventions that lead to more resilient systems at scale (agricultural intensification that is 'climate smart').

Learn from lessons of the Green Revolution in India; e.g., drinking water and irrigation water need to be jointly managed.

Credit and price support is needed, along with more innovative credit options and solutions such as water harvesting.

Invest in developing knowledge networks and awareness about CC.

Experiment with international forestry offsets.

Pay attention to governance, scaling-up and effective scaling-down of policy instruments and national investment schemes, policy, land tenure/property rights issues.

Identify the policy levers that we can influence - Monitoring, reporting and verification (MRV); Massive science gaps for adaptation regimes; CG policy lever; private sector lever – certification schemes.

Help develop property rights for the atmosphere – rights generate rents; carbon pricing will be important.

Develop practical guides for scaling up.

Develop metrics for food – there is an opportunity to build upon the base that has been built by REDD to get agriculture into the UNFCC process.

How should we think about possible 'win-win-win' interventions?

The following framework was suggested for policy analysis at the nexus of climate change and food-security. The rows suggest possible interventions, the columns possible criteria for evaluation, and the cell entries (missing) the evidence based assessment needed to populate the trade-off matrix in a way relevant and useful to decision makers.

	Metrics (Criteria) -->	**Food production**	**Livelihood security**	**GHG reduction**
	or	Production	Adaptation	Mitigation
	Interventions (Policy)			
Type of Instrument				
Economic	Carbon price			
	Green economy tie-ins (regional, other)			
	Price supports for (some) small farmers			
	Payment for ecosystem services			
Technical	Water conservation			
	Rural infrastructure			
Regulatory	(De)centralized control of land use			
Information	Certification, standards			
	Decision-support tools			
	Farmer development index			

5.3 *Day 3: Toward implementation…*

The workshop closed with a look toward pathways and barriers to implementation of the ideas discussed in earlier sessions. The first session focused on discussing which tasks or functions needed leadership from which stakeholders or sectors. The second session provided an opportunity for participants to articulate their own take home agendas.

Rapporteurs: Calestous Juma and Nancy Dickson, Harvard University

Session 3.1 Who does what?

Discussants: Emmy Simmons, US National Academies' Roundtable on Science and Technology for Sustainability and **Howard-Yana Shapiro**, Mars, Inc.

1. Purpose of session:

To determine which of the tasks involved in tackling the climate-food security nexus are best done, and by whom? It was guided by the following specific questions: What are the most important things that must be done or led by formal international programs? Where should national or regional programs lead, with others following? What role can the private sector play either alone or in partnerships with the public sector and other actors? What are the most important partnerships that are needed?

2. Main themes

Three key themes emerged from the session. First, determining who does what requires a detailed understanding or the integrated and systemic nature of the climate-food security nexus. Second, much of the current efforts to address the challenge is characterized by discrete and isolated actors. Their relationships tend to focus more on figuring out how to transact with each other rather than how they address solve the problem at hand. Third, problem solving in this complex area requires a transformational approach, involving a better understanding of the functions that need to be performed. These include information gathering and analysis, advocacy and organization, and implementation.

Information gathering has tended to be global whereas the actions that need to be performed are local. Little attention is paid to collecting longitudinal information and a result it is difficult to discern long-term trends and impact. In addition, information is poorly gathered and it is used restricted by a variety of intellectual property restrictions and in some cases commercial restrictions (e.g., private companies may not wish to give away information that they do not have to make public and that may influence their business). Much of the data available is not collected in way that can be readily shared. The lack of tools and standards that focus on interoperability further restrict the multiple-use of the data that is collected.

Advocacy: Using existing information to influence change requires the existence of *advocacy* groups (civil society and private entrepreneurs alike) that share a common language. There is a need to foster interactions between such groups. Universities, especially in developing countries, need to play a bigger role not only in information gathering but also in advocacy.

At the level of *implementation*, it is important to focus on long-term mobilization efforts, and not simply rely on campaigns that have defined timeframes. More importantly, the mobilization effort should comprehensive, efficient and recognize the importance of learning over time. This is important considering the urgent need not only to raise agricultural productivity but also expand access to food.

It is from such an understanding that existing capabilities can be bundled and directed at solving specific problems. The choice of actors therefore needs to be determined based on their competence in key functions that need to be performed.

3. Findings

Bundle assets and align activities
The central finding of the session was the importance of shifting from isolated actions to coordinated approaches that rely on bundling existing capabilities and assets. This approach will require create collaboration, improved communication and open-mindedness. There is a need to align the interests of the key actors around common themes. With improved understanding of the competence of the various actors it is necessary to determine who can lead, follow or complement the efforts of others.

Share information
In the area of information gathering and analysis, it is necessary to find ways by which agricultural and global change communities can interact. They need to inform each other what their information needs are in a systematic and timely manner. Timeliness is particularly important because many of the studies on themes such as farm yields tend to focus on today's plant breeding practices and fail to take into account future breeding possibilities. The CGIAR could play a role in serving as a critical link between these two communities.

Improve communication
In communicating complex issues such as climate change and food security, it is important to formulate clear messages that can capture public imagination. The health sector which focuses of specific diseases might offer some lessons on how to do this. But simplifying the messages so that it can lead to action should be done in a wider context that recognizes the systemic nature of the challenge. Such improved communication will entail improving access of the media to research findings as well as training them to strengthen their competence. Institutions such as the people's science movement in Asia and many other existing civil society organizations could play key roles as agents of public communication and education.

Build capacity
It is essential to build research and policy analysis capacity in developing countries. In addition to traditional sources of support such as public sector institutions, the private sector could also

contribution to such efforts. It is particularly critical that such capacity in available to support on-going negotiations on climate change. Building individual capacity needs to be complemented by building relevant institutions, especially through support to universities and think tanks.

Additional/missed topics highlighted and discussed briefly were:

- Opportunities for more widespread efforts re: training/recruitment/involving young people (e.g., in climate negotiations), particularly at MSc, PhD, post doc levels
- Monitoring/baselines (opportunity for financing from private sector investors?)
- Access to technologies/knowledge (from private sector)

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Session 3.2: Personal take home messages

The meeting wrapped up with each participant asked to identify a single personal 'take home message' that would inform his or her own implementation agenda emerging from the workshop. These included the following observations and proposed actions:

1) We haven't yet made a strong link from earth/climate science communities to agriculture/food/development/CG communities.

2) Non-agriculture climate change work is well-developed. There is some work underway on agriculture -climate change mitigation (non food security). The climate change-food security area is a desert.

3) There is a poor understanding of trade-offs between different, technical opportunities to increase food security, increase carbon sequestration, reduce emissions—e.g., examples of net climate impact of implemented activities to increase food security (inputs, yields/management, post-harvest and distribution).

4) Surprised at how little appreciation there was among the group about how difficult it will be to increase food production while also reducing greenhouse gas emissions in agriculture. Land use change related to agriculture and nitrogen use as fertilizers will determine the success or failure in mitigating climate change.

5) The range of "opinion" on future yield trajectories is greater than expected. Current models are not grappling with this variation—in contrast to climate models. The envelope of interaction (climate-ag production) will be very large.

6) Nutrition is largely missing from the agenda. For the public/private partnerships this is a keystone moving forward. By 2030 the poorest populations may/will be worse off and any shock will create catastrophes on unprecedented scale. Collaborations are needed to be the early warning system for action at scale. Failure is missing for those unable to accomplish basic nutritional needs given their current and future buying power. Animal protein will only become more complicating, the need to work on vegetative protein becomes paramount.

7) There needs to be a defined, funded and marketed shared space in the community of international (including regional) organizations for food security-climate change.

8) Donors are not supporting climate-ag nexus research.

9) A continued skepticism regarding the ability of the development community and multilateral donors to positively facilitate a climate accord, let along link that to food security. Good idea, stellar intentions, but murky pathways.

10) The really tough regions for climate science are East and West Africa and the Indo-Gange plain. South Africa, Central America, Andes, or Indonesia are easier as they have stronger climate/carbon signals.

11) An authoritative review of REDD/offsets is needed.

12) A network of reporting from agricultural research/development agencies/citizen scientists to improve evidence based for climate impacts and climate adaptation is needed.

13) There is a major "private" interest in better monitoring and base-line data that could be targeted in financing such systems.

14) Information on the typical investment profiles of critical actors is needed to understand how different types and sources of finance could help them increase food security/increase greenhouse gas mitigation.

15) Intellectual property rights are a barrier.

16) Need better monitoring, reporting and verification.

17) The incompatibility of research methods for monitoring, reporting and verification, e.g., land use classification systems, soil bulk density.

18) There is a consensus that we don't trust the data provided by an international research organization v the private sector (e.g., FAO v Google). Need quality control of data.

19) There is a need to strengthen local data collection systems. Invest in longitudinal databases and strong involvement of local institutions in data collection, analysis and journal publications.

20) Shared and more open data architecture/suite of models/ tools is needed.

21) We have not been able to say, and define, what the climate smart tipping point for improved productivity for Africa's green revolution is.

22) Communicating different policy instruments to increase food security and greenhouse

gas mitigation (e.g., taxes, carbon price, certification requirements) is crucial.

23) Appreciation of the importance of building the capacity of users of research products.

24) Global negotiations on climate change are not going to be a key mover on ag-climate change mitigation/adaptation issues, so no waiting is necessary.

25) Linking global to local is crucial and this work needs to be accelerated.

26) Missing from the discussion is labor and migration issues that will emerge from climate change and failure to assure local food security.

END