

The CGIAR's Science Forum 2009 was organized by the Science Council in partnership with the CGIAR Secretariat, the Alliance of the CGIAR Centres, the Global Forum on Agricultural Research (GFAR) and Wageningen University and Research Centre. All the CGIAR centers were represented at the event.

The forum highlighted advances in science that offer significant opportunities for agricultural development. Its deliberations will contribute to the 2010 Global Conference on Agricultural Research for Development (GCARD) and to both regional and global debates on international development. They should also be considered in the design of the new megaprograms emerging from the CGIAR reform process. A special edition of the journal *Crop Science*, based on 12 selected papers presented at the Science Forum, will be published in early 2010.

Nourishing the Future through Scientific Excellence

Science for Development: The CGIAR Science Forum 2009

Held 16–17 June in Wageningen, the Netherlands, the CGIAR's Science Forum 2009 brought together more than 300 scientists from 55 countries to explore recent scientific advances and new ways of working together to exploit them.

The discussion of research advances covered six domains where there are opportunities to enhance food security, improve nutrition and better manage natural resources. Parallel workshops, each focussing on a single domain, were held on:

- Resilient natural resource systems
- The future of food: developing more nutritious diets and safer food
- ICTs transforming agricultural science, research and technology generation
- Beyond the yield curve: exerting the power of genetics, genomics and synthetic biology
- Eco-efficiencies in agro-ecosystems; and
- Agriculture beyond food: science for a bio-based economy.

Background papers, circulated in advance, focussed attention on the key issues and the potential in each domain. A lively and challenging debate ensued, in both the workshops and the plenary sessions, which examined where potential exists for science to deliver an impact on development, what the most pressing research needs are, and what kinds of partnerships should be encouraged for these to come to fruition.

There was widespread agreement that the major challenge is to double primary production over the next three decades. These increases must be achieved primarily through improved productivity. To address this challenge, participants concluded that there is a pressing need for the introduction of new paradigms for agricultural productivity and agricultural research. One example is the concept of resilience, which is relevant to research programs throughout the CGIAR. This concept may lead to ways of monitoring and evaluating research that differ from traditional methods. The participants

concluded that the introduction of this and other concepts, which are applicable to both socio-economic and technically oriented research, should be explicitly addressed by CGIAR centers.

The key issues and main messages for the CGIAR that emerged during the two-day forum are:

Resilient natural resource systems

Many plans and strategies from individual CGIAR centers and challenge programs claim that their research will enhance the 'resilience' of production systems. However, in almost all cases these claims are not supported by clear research hypotheses. It is not clear whether resilience will be enhanced through the way research products are packaged, combined or delivered, or whether scientists believe that they can develop new technologies or management approaches that will lead to greater resilience.

The vision statement proposed by the CGIAR in its draft strategic results framework refers to 'resilient ecosystems'. Resilience is determined at least as much by institutions, social learning and other socio-economic factors as by the biophysical attributes of systems. The participants in this workshop preferred the terms 'resilient social-ecological systems' or 'human-environmental systems'.

In principle, considerations of resilience – and also of transformation, a more necessary objective in some settings – should be mainstreamed throughout the CGIAR's research and should not be singled out as a separate research endeavor. However, given the significance of the issues involved there was support for the idea of a megaprogram dealing with the goal of 'understanding the management of complex, adaptive human-environment systems', perhaps termed 'the science of human-environment systems'.

Evaluating the impact of adopting a resilience approach involves assessing the counterfactual – the consequences of *not* making the resilience intervention. Classic CGIAR *ex-post* assessment of changes in a small number of variables is less suited to this than learning that is embedded in the research process. Large-scale action research in target landscapes and settings is required. Criteria for measuring transformation and transformability are also needed.

It is much easier to address issues of resilience and transformation in programs defined around 'place'

rather than commodities, center mandates or disciplines. The logic underlying earlier CGIAR attempts to work on farming systems, eco-regions, cropping systems etc was thought to have been valid. However, these integrated approaches have met with mixed success. The CGIAR's strategic framework should revisit some of these concepts in its consideration of the organizing logic for the megaprograms.

The future of food

The pursuit of frontier science is emphasized throughout the CGIAR and effective, affordable solutions are sought through the integration of modern science (genomics, transgenics) and traditional technologies (agronomy, plant health management).

Food security and nutrition security must be addressed holistically. As well as yields, it is important to consider nutritional problems, including both nutrient deficiencies and chronic diseases from over-nutrition, as well as related problems such as toxins and other food contaminants. One idea for future programming design is the concept of 'enhancing safe nutrition in the food basket by improving food systems across ecosystems'.

The *contents* of the food basket include staples, which are the major focus and strength of the CGIAR, plus products outside the CGIAR mandated commodities, which could considerably enlarge nutritional options. Decisions on the emphasis given to different research objectives (food security versus nutrition security, biofortification versus diversification, etc) will affect the range of contents of the basket to be addressed in a given program of research. The *basket* itself is made up of the various environmental, socio-cultural, political, economic and consumer (including health and nutrition) factors that condition its contents and determine the outcome – the nutritional situation. The concepts of both the basket and its contents should be adapted to tackle needs at country level. Ways of linking development partners and catalyzing new partnerships to ensure impact are vital.

The concept of the food basket should be supported by innovation systems, involving multidisciplinary and cross-sectoral approaches. This will mean working more strategically with the existing initiatives of agencies such as the World Health Organization (WHO), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Programme (UNEP). Increased cooperation is also needed with policymakers, farmers' organiza-

tions, non-government organizations (NGOs), traders and processors. In particular, strong public–private partnerships are essential to add value through income generation and to ensure effective food processing and storage.

Information and communication

Knowledge, information and data – and the social and physical infrastructures that carry them – are widely recognized as key building blocks for more sustainable agriculture, more effective agricultural science and more productive research partnerships.

Developments in information and communication technologies (ICTs) are transforming, even re-inventing, the processes by which knowledge, information and data are generated and shared. This transformation provides significant opportunities for the agricultural research community. Catching and successfully harnessing these ‘waves’ requires strategic investments in capacities, infrastructure, skills, tools and applications, and the adoption of an ‘open innovation’ mindset that breaks down barriers, links data and knowledge, and ensures public accessibility of the goods generated through science. The future contribution of ICTs to research and development is likely to include greater connectivity along value chains and increasingly precise applications and tools (e.g. digital signatures or labels will be used to track products from producer to consumer or to monitor local soil, weather and market conditions). Vast quantities of public data and information held by institutions and individuals will become more accessible. Increasingly diverse sets of applications will be available across digital ‘clouds.’ Tools and knowledge bases will become increasingly interconnected. Different communities and their knowledge will more easily be able to connect and share with each other, along the research continuum and across disciplines, including people with different levels of engagement in science, such as farmers, traders and politicians.

The availability of new ICTs may lead to new modes of operation and new ways of doing research that may explore completely new fields. Participants concluded that CGIAR centers and their partners need to mobilize this capacity more efficiently and effectively for the benefit of the end-users of their products.

Beyond the yield curve

Increasing crop yields requires a combination of improved genotypes and optimal management, including

timely availability of appropriate inputs. Genetic improvement research therefore needs to advance hand in hand with physiological knowledge and abilities to define the phenotypic responses of plants in specific agronomic, climate and input market settings. Programs should be designed around this interactive framework and not viewed in disciplinary isolation.

There is considerable opportunity to improve plant genotypes. Emerging opportunities can combine the analytical power of molecular biology in trait identification and capture with traditional breeding to shorten the time-frame of research. New technologies include whole genome selection (WGS) for analysing complex traits with reduced phenotyping costs, gene knockout for identifying gene function, and marker-assisted recurrent selection (MARS) for pyramiding elite genes. With the help of molecular technologies, plant breeding can continue to contribute significantly to the achievement of yield increases in the coming decades. The CGIAR should continue to strengthen its links with other institutions in this area.

The cost of molecular biology has declined and speed has increased, greatly enhancing its potential contribution to research in such applications as genome sequencing, genetic diversity maps, gene function and trait identification. This enables the CGIAR to move ahead with its agenda more swiftly, especially through partnerships and outsourcing, and to increase the power of analysis in broader comparative approaches (across related species of cereals, for instance).

The success of breeding programs, both conventional and advanced, relies on the diversity of the germplasm available. There is a continuing need to maintain and characterise the biodiversity of wild relatives of key species. A role for the CGIAR and other genebanks should be included in megaprogram design, and access and sharing of genetic resources kept open through enforcement of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

In the context of genotype x environment interactions, the most damaging aspect of climate change will be the increased variability and uncertainty it brings. The uncertainty inherent in climate scenarios is often overlooked by decision-makers; this is perilous. We must incorporate climate risk management into breeding programs (both traditional and advanced), so as to develop crops that will better tolerate future conditions. One way in which breeding strategies can

take climate change and variability into account is to develop varieties that are more broadly adaptable to variable environmental conditions, a consideration the CGIAR should take into account in developing its future breeding programs.

There will be a continuing need for support for capacity building, not only in genetics and genomics but also in plant physiology. Researchers in different fields will need to learn to 'speak each others' language', gaining sufficient understanding of each others' fields to facilitate essential collaborative work. The absence of this is one barrier to effective collaborative work across disciplines.

Eco-efficiencies in agro-ecosystems

The need to increase the efficiency with which natural resources are used is evident and urgent. In theory, agricultural systems that comply with ecological principles will yield the highest returns on inputs. In practice, social-institutional and economic conditions determine management practices, which often deviate from this ecological optimum. These conditions should be taken into consideration in designing agricultural options.

Participants identified four main elements that should frame future work: triggering farmer enthusiasm, which can be achieved by involving farmers in research on efficiency thresholds, process design and effective methods of technology transfer; decreasing yield gaps – an aim that must accompany the drive for eco-efficiency gains; improving methodologies for the assessment of risk and environmental impact (for example, information on environmental impact should be visualized in order to convey it more compellingly to stakeholders); and breakthroughs in research, including advances in such areas as apomixis, N-fixing cereals, desalinization and photosynthetic efficiency.

Agriculture beyond food

The term 'biobased economy' encapsulates the vision of a society no longer completely dependent on fossil resources for energy and industrial raw materials. Already growing fast, this economy will continue to

expand and has much to offer rural communities in the developing world.

Through strategic research and its application, the biobased economy can add value to 'waste' biomass and provide farmers with new income streams, while avoiding competition for resources for food production. Research programs in this area must focus on both these parallel goals. Although hopeful, many new technologies in this field are still a long way from practical application. Participants concluded that key areas for future R&D focus should include initiatives that complement or enhance solar energy, the concept of bio-refineries (developing multiple co-products and value-added uses for biomass, while eliminating waste) and the shift into second- and third-generation bio-fuels. Innovative research and creative partnerships will be needed if the CGIAR is to play a role in capitalizing on these opportunities.

Cross-cutting themes

In addition to the above points raised by participants, which may serve as signposts for the future evolution of the CGIAR's research agenda, various other themes occurred regularly across the workshops and discussions.

Scale is an important consideration in many research domains, particularly for the CGIAR, where much research is oriented to the micro or lower levels. Up-scaling and downscaling with spatiotemporal models is vital for research oriented to eco-efficiency or to the better use of crop traits, for example. There is also a need for more research on the interactions between nutrition and health, which have important implications for the future of agriculture. Detailed reductionist research should be combined with holistic research, which would offer guidance at the systems level.

If better integrated, the CGIAR system could play a crucial role as 'honest broker' in a world where policy makers need good information to make the necessary policy choices. Adopting this role would strengthen the CGIAR's position in international debates and allow it to speak with a unified voice on important global issues.

