BREAKTHROUGH PARTNERSHIPS:
ILAC'S CONTRIBUTION TO THE CHANGE PROCESS IN THE CGIAR

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Executive summary

Two defining traits of the CGIAR system have characterized it since its inception: the development of partnerships and frequent change, both of them often implemented without a clear direction because they resulted from many competing and independent decisions. The current change process, especially the establishment of the Consortium office seeks to address these weaknesses.

Over the decades, several stakeholders have understood that the socioeconomic environment (especially the expansion of high-value agricultural markets), the dynamics of poverty and the way science is conducted have changed fundamentally. It also became clear that these changes rendered some of the CGIAR's traditional partnerships and the original scientific model obsolete.

In response, the CGIAR has been searching for new partnership models and new ways to conduct its research. Many ideas have been tried, but they have not been effectively incorporated into the system's mode of operation, and nor have they been used to redefine the CGIAR's role in the 21st century.

The establishment of the Consortium office can now provide the leadership needed to steer the CGIAR's change process more effectively. This leadership needs to be based on a clear understanding of the most important trends currently influencing the agricultural sector, poverty dynamics and agricultural research on the one hand, and the CGIAR's core capacities and strategic assets on the other.

ILAC's overarching objective is to support the CGIAR Consortium and centers, the Fund Council and other stakeholders in guiding the change process more effectively by:

- helping to develop i) new types of partnerships and new models of science; ii) monitoring systems to track these partnerships; and iii) new incentives that can be offered to researchers to increase the effectiveness of their participation in innovation networks
- implementing an ideation process that will allow the Consortium, directors-general (DGs), researchers and other stakeholders to think collectively about the niches the CGIAR should occupy, the types of partnerships it should engage in and the type of science it should conduct
- drawing lessons from past experiences of organizational change and learning in the CGIAR, private firms and non-profit organizations, and participating in change processes in the Consortium and its centers (e.g., assessing methodologies to foster organizational change and facilitate access to specialized information on organizational change)

With these objectives in mind, ILAC will focus on:

- implementing *action-research projects* to explore interventions that have a proven impact on the system's performance
- supporting the Consortium's *leadership-building effort* by actively engaging stakeholders in the development of a new and compelling destination for the change process
- promoting the *exchange of valuable experiences* and lessons, among centers and stakeholders, that will underpin the CGIAR change process

ILAC is already implementing some of the actions described above in partnership with researchers, donors, DGs and other stakeholders.

1. Introduction

Two features have distinguished the CGIAR since its inception: its focus on partnerships and its continuous change (sometimes slowly, sometimes very fast), but both features have lacked a clear direction because they resulted from many competing and independent decisions. The current change process, especially the establishment of the Consortium office seeks to address these weaknesses. For some time, a number of stakeholders have noted that changes in the socioeconomic environment (especially the expansion of high-value agricultural markets), in the dynamics of poverty and in the way science is conducted have rendered some of the CGIAR's traditional partnerships and the original scientific model obsolete.

Over the past 20 years, the CGIAR has been searching for new partnerships and new ways to conduct its research; although many ideas have been tried (e.g., the networks that developed no-till farming in three continents, the Challenge Program on Water and Food [CPWF] and the Papa Andina initiative to foster pro-poor innovation), they have not been effectively incorporated into the system's normal operations and, more importantly, they have not been used to update the dominant vision of what the CGIAR should be doing. Alongside the isolated trials of new research patterns, there were a few efforts to discuss the CGIAR's future; these discussions, however, did not result in a widely agreed definition of new niches for the CGIAR, or in new business models (i.e., new approaches for conducting research or establishing partnerships).

The establishment of the Consortium office provides the leadership needed to address these shortcomings and to steer the CGIAR's change process more effectively. Taking into account the most important trends currently influencing the agricultural sector, poverty dynamics and agricultural research on the one hand, and the CGIAR's core capacities and strategic assets on the other, ILAC's objective is to support the efforts of the CGIAR Consortium and centers, the Fund Council and other stakeholders to steer the change process by:

- helping to develop new types of partnerships and new research models that foster the diffusion of research products generated by the centers, devise indicators for monitoring the evolution and management of these partnerships, and explore new incentives that can be offered to researchers to increase the effectiveness of their participation in innovation networks
- creating a space for reflection where the Consortium, DGs, researchers and other stakeholders can think collectively about the dynamics of poverty and agriculture, the niches the CGIAR should occupy, the types of partnerships it should engage in and the type of research it should conduct
- contributing to the change process by i) drawing lessons from past and recent experiences of organizational change and learning in the CGIAR, private firms, non-profit organizations and learning networks; and ii) participating in change processes in the Consortium and individual centers (e.g., assessing methodologies and facilitating access to specialized information on organizational change)

With these objectives in mind, ILAC will focus on:

- implementing *action-research projects* to explore interventions that have a proven impact on the system's performance
- supporting the Consortium's *leadership-building effort* by actively engaging stakeholders in the identification of new and compelling directions for the change process

- promoting the *exchange of valuable experiences* and lessons, among centers and stakeholders, that will underpin the CGIAR change process

Section 2 describes ILAC's evolution and past strategy; Section 3 outlines how the CGIAR has changed over the years; Section 4 discusses the main organizational features of the CGIAR; and Section 5 details ILAC's future work. Appendix 1 provides more detail on some recent advances in the management of science and innovation; Appendix 2 contains background information on organizational learning and change; and Appendix 3 describes the evolution of the CGIAR.

2. ILAC's evolution and past strategy

ILAC was created in 2003 during an impact assessment meeting hosted by the International Food and Policy Research Institute (IFPRI) in Washington DC. At the meeting, participants advocated shifting project monitoring and evaluation approaches:

- from being product-focused to being focused on people and institutions
- from using external expert reviews to conducting internal critical self-reflection
- from documenting successes to learning from failures

A community of practice around this vision was formed, with institutional support from the International Service for National Agricultural Research (ISNAR) and the International Plant Genetic Research Institute (now called Bioversity International) and financial support from the Rockefeller Foundation. ILAC also received funds from the German Society for Technical Cooperation and the German Federal Ministry for Economic Development Cooperation (GTZ-BMZ), the International Fund for Agricultural Development (IFAD) and the Netherlands Ministry of Foreign Affairs (DGIS). In 2006, the DGIS provided a grant that enabled ILAC to have three full-time staff and to work on four main activities:

- developing applied research and evaluation methods
- supporting capacity development
- fostering leadership for pro-poor innovation
- strengthening communications and knowledge-sharing

In 2010, IFAD provided a further grant to enable ILAC to work on impact evaluation approaches for agricultural research for development.

Over the years, ILAC has developed important partnerships with organizations and individuals in various disciplines, including participatory research, impact assessment, evaluation and organizational learning. More information about its partners and collaborators can be found at http://www.cgiar-ilac.org/content/partners-and-collaborators. The approaches developed and tested in partnership with many regional and national partners include:

- facilitation of participatory decision-making
- preparation of innovation and institutional histories
- participatory evaluation
- establishing and managing learning alliances

- impact assessment
- developing collaborative agreements
- outcome mapping

These and other ILAC approaches have been outlined in a series of ILAC Briefs and working papers that will be relevant to ILAC's future work. These publications include:

- *The Participatory Market Chain Approach: Stimulating Pro-poor Market-chain Innovation*
- *Innovation Histories: A Method from Learning from Experience*
- *Collaborative Agreements: A 'How To' Guide*
- *Learning Alliances: An Approach for Building Multistakeholder Innovation Systems*
- *Engaging Scientists through Institutional Histories*
- *Brokering Innovation for Sustainable Development: The Papa Andina Case*
- *The CGIAR at a Crossroads: Assessing the Role of International Agricultural Research in Poverty Alleviation from an Innovations Systems Perspective*

These publications are available on the ILAC website (http://www.cgiar-ilac.org/content/ilac-publications)

A mid-term review of ILAC, completed in early 2010, recommended focusing its activities on assessing new methods for monitoring and evaluation, and supporting CGIAR centers in the application of these methods. After consideration of the recent dynamics of the CGIAR change process and consultations with donors and major stakeholders, it was concluded that ILAC needs to focus on the three main activities mentioned earlier – action-research, leadership-building and the exchange of experiences.

3. Changes in the CGIAR over the years[1]

The thread that has run through the work of the CGIAR over the past four decades is an evolving research model based on partnerships. In the 1960s, a coalition of donors supported a network of plant breeders in international agricultural research centers and national agricultural research organizations (NAROs) that led to the creation of the CGIAR. Over the years, other types of partnerships were implemented, but they were seldom recognized as new research models that should be mainstreamed by the system. Understanding how the system has changed is important for exploring new research models to meet current and future challenges.

3.1 Initial focus on high-yielding varieties of staple crops

The first partnership that paved the way for the CGIAR included a coalition of donors (the Ford and Rockefeller Foundations) and the governments of Mexico and the Philippines supporting a network of breeders in two international centers and many NAROs; this network bred high-yielding varieties (HYVs) of wheat and rice that were then diffused by public sector extension agents; some researchers and donors also provided policy advice to national governments who, in turn, implemented policies to promote the diffusion of HYVs. However,

[1] This section is developed in greater detail in Appendix 3.

the network had limited interaction with other actors in the agricultural innovation system, notably farmers and private firms.

3.2 Expanding the mandate

When agronomic problems (e.g., pests, weeds and soil erosion) were identified as barriers to the diffusion of HYVs, new activities (e.g., agronomy and entomology) were incorporated. When it was realized that HYVs were hardly used outside South Asia, social scientists were hired to study their diffusion. At the same time, new centers were created to research and develop technologies for new products (e.g., the International Potato Center [CIP] and the International Livestock Research Institute [ILRI]) or for specific regions (e.g., the International Center for Agricultural Research in the Dry Areas [ICARDA] and the International Crops Research Institute for the Semi-Arid Tropics [ICRISAT]). As the CGIAR's mandate expanded in the 1970s, partnerships were developed in other scientific areas (e.g., pasture management), mostly involving CGIAR centers, advanced research institutions (ARIs) and NAROs. A few CGIAR agronomists started to participate in broader partnerships based on various patterns of scientific collaboration that developed important crop management technologies, but these networks were not recognized officially by the CGIAR as alternative scientific models for the centers.

3.3 Funding reductions and the requirement evidence of impact

In the late 1980s and 1990s, many countries reduced their public funding for research and international aid, especially in the agricultural sector; they also started to ask for evidence of research impact. These changes profoundly affected the CGIAR. In order to justify their existence, several centers created teams to assess the impact of their activities and to conduct research on patterns of technology diffusion, natural resources management and the livelihood strategies of poor households. [2]

Some of these activities stimulated innovative research projects that explored novel approaches to poverty alleviation and the sustainable use of natural resources. Unfortunately, there were no mechanisms for the centers and researchers not directly involved in these projects to learn from them. The system also lacked the resources and organizational capacity to scale up successful experiences. And there was no collective reflection on what these changes meant for the CGIAR system.

3.4 Re-evaluation of the traditional research model

In the 1990s, four factors forced the CGIAR to re-evaluate its partnership model. First, when most developing countries reduced their support for agricultural research, the consequent weakening of the NAROs deprived the CGIAR of its traditional partners. Second, the increasing complexity of science and the rising costs of research forced the CGIAR to partner with other actors who could contribute valuable research assets, such as expensive equipment. Third, new actors (especially private firms and NGOs) started to play important roles in the expansion of the most dynamic agricultural sectors. Fourth, the limited diffusion of HYVs and other 'modern technologies' in many developing countries led to a questioning of the vision of science as an enterprise best conducted in research stations by researchers who had little interaction with social and economic actors. The new vision of science that emerged called for new partnerships with scientists from other disciplines, private firms, farmers, NGOs and public sector organizations. However, most research managers, researchers and donors lacked a clear understanding of how the new model of science could

[2] Anderson and Dalrymple (1999) provided a retrospective of the initial impact assessment studies carried out in the CGIAR in the 1990s.

be used by the CGIAR to implement new research activities, what types of partnerships should be developed or how they could be managed and monitored.

Changes in the CGIAR were not restricted to partnership models; they also included the system's mandate, areas of expertise, research models and financing. Most of these changes did not result from a clear, deliberate plan and sustained implementation, because the system had – and still has – a diffuse decision-making structure, loose governance and weak learning capabilities. Thus, the system evolved through a series of often disconnected decisions – big and small – made by many independent stakeholders (see Section 4).[3]

3.5 Major system-wide reforms

In addition to the decentralized exploration of new partnership models and research methods, the CGIAR implemented several major reforms, such as the Ecoregional Programs, the Challenge Programs and the Megaprograms (now referred to as CGIAR Research Programs [CRP]). These reforms sought to bring a focus to the research portfolio and to foster greater collaboration among centers and with external partners, but they had a limited impact on how the CGIAR conducted its business, mainly because:

- little analysis of past problems was made before each new program was introduced
- the changes were concerned mostly with the way activities were financed, but there was little change in the incentives offered to researchers
- no other actions were implemented to induce changes in CGIAR research activities
- the new arrangements were not given time to mature

The current change process seeks to address these shortcomings. A critical factor in the process will be the consolidation of the Consortium office leadership based on intellectual recognition, provision of valuable services to the centers and its ability to be an effective intermediary between the donors and the centers.

4. Main organizational features of the CGIAR[4]

The CGIAR is a complex organization that has evolved through interactions among many actors of different types, conditioned by their history, the socioeconomic environment in which they operate, and random events. These factors resulted in an organization that has had loose governance, diffuse leadership, the flexibility to explore new types of projects, and weak learning mechanisms. Recognizing the complexity of the system's mandate and structure helps in assessing what strategies for organizational change are likely to succeed.

4.1 Governance and leadership

The loose governance and diffuse leadership has meant a frail leadership for the whole system (although intellectual leaders emerged from time to time). This was because many stakeholders (i.e., donors, DGs, researchers, NARIs and NGOs) had – and, to a large extent, still have – the power to:

- leave the system if their priorities differed from what the system offered (e.g., the donors that ended their support for the CGIAR)

[3] Even when important changes were planned (e.g., the Challenge Programs), the end results often did not reflect what had been envisaged.

[4] The most important concepts used in this section are discussed in Appendices 1 and 2.

- make big and small decisions that affected the organization (e.g., donors influenced the research portfolio by funding the projects they were interested in; their influence on the system was therefore related to the amount of funds they contributed and the conditions they attached to them – whether the funds were restricted or unrestricted; similarly, senior managers in the centers were free to negotiate initiatives with individual donors, and senior researchers could raise funds for their research, giving them a degree of independence from system and center priorities)

This 'decentralized market' for funds and research projects has had a major influence on how the CGIAR functions as an organization:

- The research portfolio has changed 'autonomously' in response to scientific opportunities, emerging social and economic problems, and donors' and stakeholders' policy concerns. In other words, the many types of projects the CGIAR implemented gave the system great flexibility in responding to emerging issues. It should be noted that through this mechanism the CGIAR's portfolio of projects has evolved faster than the conceptual model many stakeholders had of what the system should do (see Appendix 3).
- The system has lacked the ability to effectively integrate emergent conceptual frameworks of science, innovation and development policies into the definition of its strategic axis (i.e., mission, objectives and a shared vision; see Appendix 2). Although in the past two decades several centers and the CGIAR have conducted strategic planning exercises, and major changes in the system's priorities and funding mechanisms have been introduced (e.g., the Ecoregional Programs, the Challenge Programs and the Megaprograms), the strategy recommendations have seldom been successfully implemented or given enough time to show results; in addition, each change has seldom built on the strengths and weaknesses of the previous scheme and, because changes have not been accompanied by adjustments in incentives offered to researchers and managers, there has been little impact on research methods.
- Despite the many evaluations that have been conducted of research programs and centers, the CGIAR lacks the resources to derive lessons from its activities and to facilitate the sharing of lessons learned in individual projects. Therefore, changes have come slowly and without a proper assessment of their value. In other words, most of the changes have resulted from emergent strategies, but the system lacks the ability to define a flexible, deliberate strategy based on emerging problems and opportunities (see box 1 and Appendix 3). It should be noted that this is a common deficiency in public and private organizations (Ekboir *et al.,* 2009; Skarzynski and Gibson, 2008; Davila *et al.*, 2006; Christensen and Raynor, 2003).

- **Box 1: Top-down and bottom-up approaches to organizational change**

The distinction between top-down and bottom-up approaches to organizational change is key to understanding the evolution of the CGIAR and the challenges it faces in the current change process (this issue is discussed in greater detail in Appendix 2).

All complex organizations find designing change strategies a major challenge. The relatively few organizations that have been able to develop effective change strategies built them on strong learning mechanisms that combined top-down and bottom-up experimentation and reflection. Learning is essential for effective guided change because organizations have limited resources and abilities and cannot explore all possible options.

Organizational strategies can be defined as 'deliberate' or 'emergent'. Deliberate strategies are those consciously defined by the organization (top-down). Emergent strategies are those that result from the day-to-day, decentralized actions of all decision-makers within the organization, such as top and middle managers, sales people and shop floor workers (bottom-up).

Decentralized, bottom-up actions tend to be tactical and to include, for example, allocating resources within divisions or deciding which clients to prioritize. The combination of these operational decisions results in the organization's actual resource allocation, which may differ from the allocation decided in deliberate strategies. Without strong leadership and effective learning mechanisms, emergent strategies control the evolution of organizations even when a deliberate strategy is being implemented. In such cases, organizations cannot take full advantage of opportunities and cannot learn from experience.

Although the CGIAR has implemented major top-down changes, for the most part it is the bottom-up strategies that have dominated. How to combine top-down and bottom-up approaches, and decide which one should be dominant, constitutes one of the most important decisions for the management of an organization.

It should be noted that the current change process has differed from the previous ones because it has involved a large number of stakeholders and has introduced a major change in the structure of the system – the Consortium of the CGIAR centers. The outcome of this process will depend on its consolidation.

4.2 Learning and planning mechanisms

The CGIAR has had weak learning mechanisms. Most of the changes deliberately introduced in the way the system operated were restricted to operational issues such as administrative or IT processes. Simultaneously, the system has had few mechanisms for reflecting on whether new types of research and new capabilities should be developed. Although several centers and the CGIAR itself have conducted strategic planning exercises in the past two decades, and major changes in priorities and funding mechanisms have been introduced, strategies have seldom been successfully implemented or given enough time to show results. New initiatives did not build on the strengths and weaknesses of previous schemes, with the result that the new schemes did not have the intended impact on how research was conducted.

In essence, the CGIAR has had many bottom-up changes facilitated by the decentralized funding mechanism, but it has lacked the ability to implement top-down programs to help it focus its activities and define new lines of work.

4.3 Core capacities and strategic assets

A *core capacity* is something that an organization knows how to do better than anybody else in its line of work or in the geographic areas in which it operates; a *strategic asset* is something an organization has that few 'competitors' have or can easily buy or copy.

The CGIAR's most important core capacities are its abilities to:

- facilitate communications between researchers from ARIs and good research teams in developing countries on the one hand, and other stakeholders, including researchers in weaker institutions, farmers and their organizations, on the other hand
- organize multidisciplinary research teams that can focus on products that are important for poor households but are neglected by the private sector
- work simultaneously in several countries and exchange technical and scientific information among distant locations (i.e., to work locally with a global perspective)
- catalyze the emergence of, and/or participate in, breeding and innovation networks that require scientific input for their operations
- conduct applied research in farmers' fields in several locations simultaneously
- manage genebanks and their use for poverty alleviation across many locations

- understand the features of crop varieties, especially those neglected by the private sector, thus enhancing the effectiveness of seed exchange across regions
- play the role of honest broker with a strong scientific background

The system's most important strategic assets are its:

- pool of top researchers who are well respected in their fields and in developing countries
- reputation as an honest broker among many stakeholders, including research organizations, donors, international organizations, private firms, farmer organizations and NGOs
- germplasm banks, especially of crops that are important for poor households but are neglected by the private sector
- international and diverse network of collaborators
- recognition of the centers as a system among research organizations, donors, international organizations, private firms, farmer organizations and NGOs
- reputation as an advisor on and advocate for the public ownership of genetic resources

The lists of capacities and assets show that the system's unique strengths are only partially related to its research capabilities. In other words, although the CGIAR's research capabilities are strong, they are not substantially stronger than those of good ARIs (e.g., Iowa State University or Wageningen University) or strong national agricultural research systems (NARS) (e.g., Brazil or China). The major factors that determine the CGIAR's core capacities and strategic assets are its ability to mobilize partnerships for research-intensive interventions, its ability to simultaneously operate related projects in several locations around the world and its widely accepted role in advocacy. However, many of its traditional networks (e.g., breeding networks) are no longer viable because a large number of NAROs have weakened.

Although the core capacities and strategic assets should be used to define new types of partnerships and research methods through which the CGIAR can strengthen its contribution to poverty alleviation and the sustainable use of natural resources, the system currently lacks the ability to assess the new research models it is implementing or to explore new partnership models.

5. ILAC's future work

ILAC's work plan is based on the CGIAR's identified core capacities and strategic assets, on new understandings of the organization of science, and on perceived areas where the CGIAR can maximize its impact. Using adaptive management approaches, ILAC's activities in 2011 and 2012 will be organized along three lines of work:

- helping to develop new types of partnerships that foster the diffusion of the research products generated by the CGIAR, devise indicators for monitoring the evolution and management of these partnerships, and explore new incentives that can be offered to researchers to increase the effectiveness of their participation in innovation networks through i) the study of past partnerships and ii) the use of pilot projects to test alternative partnership models

- creating a space for reflection where CGIAR stakeholders and experts can think collectively about the dynamics of poverty and agriculture, the niches the CGIAR should occupy, the types of partnerships it should engage in and the type of science it should conduct
- contributing to the change process by i) drawing lessons from past and recent experiences of organizational change and learning in the CGIAR, private firms, non-profit organizations and learning networks, and ii) participating in change processes in the Consortium and individual centers (e.g., assessing methodologies to foster organizational change and facilitating access to specialized information on organizational change)

5.1 Exploring new types of partnerships and their management and monitoring

ILAC will partner with CGIAR centers and the CRPs to explore new types of research and partnership models that require important science inputs, and to develop indicators for monitoring their evolution and impact. ILAC will also foster the creation of a network of researchers to learn how to manage partnerships in the system and in the Consortium. Within this context, ILAC has already set up two pilot projects: improving the local management of maize biodiversity threatened by climate change; and establishing a mechanism of decentralized experimentation with centralized learning in the CPWF.

Improving the local management of maize biodiversity

In situ conservation of valuable crops is important because it enables more effective adaptation to changing environmental conditions than what can be achieved through natural variation and selection, or through gene banks and conventional breeding.[5] Small farmers already play a critical role in this process by actively managing their landraces. A key instrument in farmers' management strategies is the exchange of seeds through social networks, where most of the exchanges occur locally (Badstue *et al*., 2007). Climate change is expected to eliminate many locations that are rich in biodiversity and, therefore, to reduce the opportunities for effectively managing crop adaptation (Bellon *et al*., 2010).

By facilitating the exchange of seeds among farmers in distant locations (and even in different continents), the project will increase the biodiversity available to farmers. The facilitation will not be random, but will use GIS methods developed by CGIAR centers to identify areas with similar environmental conditions, and plant breeders and geneticists to identify crop varieties that can be exchanged across locations. Extension agents and CGIAR researchers will then facilitate the exchange of seeds, train the farmers in effective methods to cross-pollinate varieties and select seeds, and monitor the crops' evolution. Social scientists will monitor the effect of the new patterns of seed exchange on the livelihood strategies of rural families. The process of building the network will be documented and indicators for measuring the network's performance and consolidation will be developed; the learning facilitated by the network will also be monitored in order to derive lessons of general applicability in the CGIAR.

The pilot project will be implemented in Mexico and is expected to include researchers from Bioversity, the International Maize and Wheat Improvement Center (CIMMYT), ILAC and Mexican universities; the Mexican Produce Foundations, state governments and the federal Secretary of Agriculture have also been invited to participate.

[5] Because seeds in gene banks are not subjected to environmental pressures, they cannot adapt to new conditions. Searching for varieties adapted to new conditions among stored seeds requires a wider search than among varieties that are permanently subjected to the environmental pressure.

Facilitating organizational learning through decentralized experimentation with centralized learning

Most changes in the CGIAR have occurred in a decentralized manner and few lessons have been drawn from these various experiences. To change in a more deliberate way, the CGIAR needs to develop the capacity to use adaptive management approaches (i.e., to learn during implementation and adapt the strategies as problems and opportunities emerge). To learn how to develop this capacity, ILAC has teamed up with the CPWF to try out a structure for decentralized experimentation with centralized learning.

The CPWF is establishing six research-for-development programs in six basins, aimed at tackling pressing development challenges. Each program consists of four to five projects, providing about 30 simultaneous experiments on the management of water resources for agriculture and development. Each project will prepare its own strategy and interventions (i.e., decentralized experimentation), and the CPWF and ILAC will then draw common lessons on project management and adaptation from each project and share them with all the projects (i.e., centralized learning). This approach will provide the opportunity to systematically compare different experiences and to derive lessons as the projects are implemented. The lessons will form the basis of discussions to identify new actions that could be implemented. The learning cycle will continue over the life of the projects.

Structuring centralized learning requires the development of appropriate routines and incentives. As the structure has to be adapted to the particular requirements and constraints of the implementing networks and, due to the complexity of the processes, no recipes on how to do it can be developed, adaptive management approaches will be used. The CPWF and ILAC will jointly devise new methods and instruments that would complement those already in use. These methods will include visits to the project sites and directed conversations with stakeholders, more frequent interaction among the partners in different projects, documentation of the institutional development of each project, and the identification of indicators for monitoring project implementation.

The 30 projects are also being considered as experiments in development. The CPWF and ILAC will prepare a set of research questions that can be answered by comparing the projects, and a set of indicators that will be used for the empirical analysis.

5.2 Creating space for reflection on the CGIAR's role in the 21st century

The dynamics of science and agriculture in developing countries has changed substantially since the days of the Green Revolution. Migration and remittances, the expansion of high-value agriculture, the creation of off-farm employment in rural areas, urbanization and diet changes are some of the phenomena that have helped poor rural households to diversify their livelihood strategies. At the same time, the increasing complexity and cost of research, technical change and new research policies have changed the ways in which research is conducted. Because of these two trends, the CGIAR needs to adapt its working routines to more dynamic and complex environments. The adaption has to combine top-down and bottom-up approaches; although the CGIAR has had an active bottom-up mode of operation, it has lacked strong top-down learning capabilities. ILAC will work with the Consortium on an ideation process and on linking the CGIAR with other organizations and networks whose goals or structures are similar to those of the CGIAR.

Identifying new ways in which the CGIAR can contribute to its goals (ideation)

Using various technologies for communication and techniques for ideation and social interaction, ILAC will lead a discussion on the main trends shaping agriculture, poverty and

science and on how the CGIAR can better accomplish its goals. In essence, an ideation process involves members of an organization, stakeholders and external experts in the discussion of topics relevant to the organization and of ways to solve the main problems identified, without reference to what the organization can do to solve them. The process does not replace strategic planning or the definition of the organization's vision and mission, but contributes original ideas to these processes. The ideation process will help the CGIAR to achieve a consensus on the directions it should take in its research.

Liaising with organizations that can contribute useful lessons to the CGIAR

Many organizations working in development are investing important resources in building the capacity for organizational change and learning. The CGIAR can learn valuable lessons by interacting with them. ILAC will identify these organizations and arrange a dialog to discuss experiences and instruments for organizational learning and change.

5.3 Contributing to the change process

In addition to the change process in the CGIAR, some centers are implementing change processes of their own, trying to redefine their identity and their role in the new system. ILAC will contribute to these processes by:

- working with the CGIAR and the centers to define what their new roles should be
- helping to identify consultants who can assist in various aspects of organizational change
- organizing workshops to support organizational change and facilitating the implementation of workshop conclusions
- facilitating access to the technical literature on organizational change and engaging in continuous discussions with the managers responsible for steering change in the centers

ILAC is already collaborating with Bioversity in these activities, and will seek similar collaboration with other centers.

Appendix 1: The importance of relating research to innovation

There are many definitions of 'innovation' in the specialized literature (Fagerberg, 2005). In this document, an innovation is defined as anything new that is successfully introduced into an economic or social process (Ekboir *et al*., 2009).

An **innovation** is anything new successfully introduced into an economic or social process. (Ekboir *et al.,* 2009)

This definition implies that researchers do not generate innovations but information, whether codified (e.g., a paper or blueprint), embedded (e.g., an improved seed) or tacit (e.g., why an experiment failed). Information becomes an innovation only when someone uses it to improve what s/he is doing. This difference is critical for understanding the uptake of research outputs and why off-the-shelf technologies are not adopted by farmers. The use of scientific information by economic and social agents (including small farmers) depends on their absorptive capabilities (i.e., on their ability to search for and use information; see Appendix 2). Innovators (including farmers) use different sources of information; most of it, however, does not originate in science but in everyday activities and in interactions with other actors (Fagerberg, 2005). This does not mean that research plays no role in innovation; although it may not be quantitatively a dominant factor, it is qualitatively essential because it opens new market and technological opportunities.

Globalization, new regulations and advanced technologies are redefining how research is conducted. Increasing interdependence between knowledge-based economies leads to an ever-expanding international flow of technology, scientific knowledge and know-how; it also means that innovators who are able to find scientific information and understand it can more easily access information not generated in their countries (see Appendix 2). This new situation is changing the organization of science in three ways. First, new problems and opportunities are emerging at a faster peace and research systems need to be flexible in reacting to this more dynamic environment. But individual institutions cannot respond fast enough because of organizational inertias (see Appendix 2). Due to these inertias, flexibility can be achieved only when a research system has many good research teams that can form multi-institutional groups to solve emerging problems; this type of structure has been one of the major strengths of the American research system (Kraemer, 2006). Creating such a flexible structure is one of the major challenges the CGIAR faces (see Appendix 3).

Second, effective research systems resulted when researchers interacted closely with innovative agents (Fagerberg, 2005), but the CGIAR has had problems developing stable partnerships with other actors other than the NAROs (see Appendix 3).[6]

Third, formal research has traditionally been conducted by stable teams within an institution and discipline; Gibbons *et al.* (1994) called this organization the mode 1 of research. This mode describes most of the CGIAR in its early days, except that instead of just one institution, the centers coordinated breeding networks. In mode 2, teams are multidisciplinary, multi-institutional (often involving researchers from the public and private

[6] Although this has been true for the CGIAR as a whole and for most research programs, some researchers were able to participate in very effective innovation networks that had important impacts on poverty and the sustainable use of natural resources (see Box 1).

sectors and other stakeholders), increasingly scattered in remote locations and relatively ephemeral because they are formed to respond to specific issues. Action-research and partnerships with ARIs and civil society organizations are examples of mode 2 research. The flexible organization that results from mode 2 enables research institutions to react rapidly to emerging technological, economic or social needs or opportunities. It must be stressed that the main difference between research modes 1 and 2 is not what is researched but how it is done. How to switch to mode 2 is a major challenge facing the CGIAR today.

Appendix 2: How organizational learning and change occur

An organization, as defined by ILAC, is a group of actors who collaborate over a sustained period. Collaborations may take different forms, including frequent exchanges of information, repeated transactions, joint priority setting for policies and programs, and joint implementation of innovation projects. Through their collaboration, the actors develop shared cultures, communication codes, incentives and routines; in other words, they form formal or informal organizations (Ekboir, 2011).

Many types of organizations operate at different levels of the agricultural sector, and each one has particular arrangements regarding governance, leadership, priority setting, resource allocations, membership and learning mechanisms. At the micro level, farmers form producer organizations or join private firms and other actors in innovation networks and value chains. At the meso level, farmers form regional associations to conduct applied research (e.g., the regional associations of no-till farmers in Brazil), provide services, lobby decision-makers or influence the agenda of public research institutes (e.g., the Mexican Produce Foundations). Another type of organization at this level is the international breeding networks. At the macro level, many countries have formal councils that assist the government in the design and implementation of research policies, and they also coordinate public research and extension organizations.

Organizational capabilities for change

To survive, organizations need to respond to changes in the environment in which they operate; these changes may be positive (i.e., opportunities), such as marker-assisted breeding, or negative (i.e., challenges), such as the emergence of more agile competitors. An organization's ability to respond to these changes depends on the interaction between its motivation on the one side and its core competencies and strategic assets on the other, conditioned by the enabling environment. Motivation results from the opportunities or needs for change. In private firms, these are mainly market or technological opportunities or challenges. For rural agents (including small farmers), opportunities or needs for change include the links to rural markets created by globalization, technical change and improved infrastructure. For non-profit organizations, the main drivers are the funding opportunities (because they determine what the organizations need to do to survive), a sense of duty and the importance of the socioeconomic problems the organizations seek to address.

A **core competence** is a "unique (or rare) bundle of skills, knowledge, and experience that delivers a valued customer benefit and competitive differentiation". (Skarzynski and Gibson, 2008:62)

A core competence is not just something the organization does well, but something at which it is among the best in its line of business and market, and that competitors cannot easily acquire (e.g., by hiring one of the organization's professionals or buying it in the market).

A **strategic asset** is a "corporate possession that is difficult to imitate, develop, or acquire and that

provides a basis for competitive advantage". (Skarzynski and Gibson, 2008: 62)

In other words, core competencies are what an organization *knows* better than anybody else in its area of work, and strategic assets are what an organization *owns* that almost nobody else has. The CGIAR's core competencies and strategic assets are discussed in Section 4.

Organizational innovation capabilities are the skills to integrate external resources and information, core competencies and strategic assets in order to take advantage of emerging opportunities or address problems

Organizational innovation capabilities are the key factor that explains why some organizations succeed where many others fail (e.g., the success of Apple and Dell compared with many other computer technology companies).[7]

Organizational capabilities for change depend on a number of factors, including an organization's history, culture, governance structure (especially leadership style and quality), work routines, incentives offered to members, collective learning mechanisms, presence of innovative individuals, investments and the environment in which it operates. The influence of each of these factors on an organization's capabilities changes over time, and variables that have a positive effect at a particular point in time may be detrimental later; organizational capabilities therefore have to be continually rebuilt (Skarzynski and Gibson, 2008; Davila *et al*., 2006; Christensen and Raynor, 2003).

Organizational capabilities cannot be easily bought or built and must be constructed through sustained investments over long periods, strong leadership, adequate selection of those responsible for new projects and appropriate incentives for learning and change. It is also necessary that top managers embed a 'vision' of the changes to be introduced and develop approaches to reduce uncertainty, obtain effective feedback and encourage discussions to reach a consensus about what is desirable and acceptable (Davila *et al*., 2006; Crutchfield and Schuster, 2003; Dosi *et al*., 2000; Levinthal, 2000). Whirlpool, a company that transformed itself from selling commoditized appliances in mature markets to generating a stream of breakthrough innovations that multiplied the company's revenue twentyfold in just 3 years, is an example of a menu of actions implemented to build the capability for innovation (see Box 2).

Box 2. Building innovation capabilities in a traditional company in a mature sector

"Instilling innovation as a core competence at Whirlpool took a massive, broad-based effort over several years, involving major changes to leader accountability and development, cultural values, resource allocation, knowledge management, rewards and recognition systems, and a whole host of other management practices and policies.

Here are just a few examples of these changes:

- The appointment of vice presidents of innovation at both the global and regional level
- The creation of large, cross functional "innovation teams" in each region employed solely in the search for breakthrough ideas
- The introduction of a companywide training program aimed at developing and distributing the mind-set and skills of innovation.
- The appointment of more than six hundred part-time "innovation mentors" and twenty-five full-time "innovation consultants," who act as highly skilled advisers to new project development teams around the world
- The creation of "innovation boards" in each region and each major business unit, made up of senior

[7] For a thorough discussion of organizational capabilities, see Ekboir *et al*. (2009); Skarzynski and Gibson (2008); Davila *et al*., (2006); Christensen (2003); and Christensen and Raynor (2003).

staff who meet monthly not just to review ideas and projects, set goals and allocate resources, but to oversee the continuing innovation capability-building process

- The organization of big communication events called Innovation Days where innovation teams showcase their ideas to other Whirlpool people, the media, and even Wall Street analysts. Sometimes, these events are also held in suburban shopping malls as a way of collecting feedback and additional ideas from potential users
- The creation of a comprehensive set of metrics to continually measure the company's innovation performance as well as its progress in embedding innovation as a core competence
- The establishment of a sophisticated IT infrastructure called Innovation E-Space, which integrates all of Whirlpool's people into the innovation effort and allows them to track progress on innovation activities across the corporation"

Source: Skarzynski and Gibson, (2008:7).

The menu of interventions in Box 2 shows the importance of strong leadership, building a culture that appreciates calculated-risk taking, combining top-down and bottom-up initiatives, allocating resources for exploration and creating dedicated teams to foster learning. Similarly, studies of organizational change in public organizations highlight the following factors as change enablers (Horton *et al*., 2007):

1. "An external environment that encourages change (e.g., strong external pressures for change).
2. Top managers provide leadership for change.
3. The change process is adequately managed.
4. A critical mass of staff members are involved in the change process and are committed to it.
5. Appropriate institutional innovations are provided are developed.
6. Resources are provided for change (e.g., dedicated time of key staff members and budgets for training and facilitation)" (Horton et al., 2007: 21).

Given its complexity and the major investments required, it is unlikely that the CGIAR will be able to implement a program similar to Whirlpool's; however, the implementation of a few key actions combined with sustained adaptive management can trigger a virtuous cycle that builds up organizational capabilities for change and innovation (Axelrod and Cohen, 1999). The continuity of the effort to develop the capabilities is very important. Many organizations, including the CGIAR and centers, conduct strategic planning exercises, brainstorming sessions on organizational change and discussion on the new roles the system should undertake, but these activities are seldom followed up with a sustained effort and adequate resources for implementation, and are not adapted when the initial plan proves to have design problems (see Appendix 3).

Two of the most important institutional features that influence organizational capabilities for change are the learning mechanisms (because they determine how fast new information can be developed and used) and governance structures (because they define the flexibility an organization has in organizing activities and resolving conflicts) (Ekboir *et al*., 2009).

Organizational learning

The specialized literature differentiates between information and knowledge (Quantas, 2002). Information is organized data (e.g., published materials, blueprints or physical objects), whereas knowledge is the use of information to create unique interpretations of reality. For example, a research report is knowledge for the researchers who wrote it, but it is information for everybody else; other people use the report to develop their own knowledge. Because of

its personal nature, two actors can learn different things from the same information, or the same thing from different sources. Knowledge is very difficult to share, whereas information can be disseminated quite easily (Ekboir *et al*., 2009).

Organizational learning is the process whereby knowledge is created and distributed across the organization, is communicated among its members and is integrated into the organization's operations.

Because the information stock is complex, diverse, short-lived and fast-growing, learning requires strong capabilities to search for useful information and to digest it in order to build knowledge (Ekboir *et al.,* 2009; Cohen and Levinthal, 1990). These absorptive capabilities depend on exogenous and endogenous factors. Economic stability, development, the nature of competition and the interactions between firms and research institutes are important exogenous factors; endogenous factors include organizational cultures (especially, an appreciation of the need for organizational change), incentives for learning, investment in the search for and adaptation of information and mechanisms to socialize knowledge.

Usually, organizations find it difficult to learn and innovate. Since managers and employees are absorbed by routine activities, they lack the time, resources and incentives to innovate beyond their narrow work assignments; also, successful operational routines hamper testing potentially better approaches to problem solving because there is no immediate need to replace something that is working; waiting for the evidence that the routines are not working, however, has meant disaster for many organizations (Dosi *et al.,* 2000). This difficulty has affected the CGIAR and most centers at different stages of their development. To overcome organizational inertia, the specialized literature recommends the creation of teams specialized in fostering organizational learning and change, and to introduce incentives that foster experimentation (Christensen, 2003; Skarzynski and Gibson, 2008).

Learning can occur through several mechanisms. For the CGIAR, the most important mechanisms have been learning by doing, hiring key individuals, interacting with partners and professional networks, and information searches. Surprisingly, learning from past experiences does not seem to have been extensively used, especially at the level of the CGIAR (see Horton *et al.* [2009 and 2010]).

Governance structures

Governance is the process of decision-making in an organization and the process by which decisions are implemented. Decision-making includes formal and informal processes. In an organization such as the CGIAR, with loose governance and diffuse leadership, the informal processes are particularly relevant (see Appendix 3).

While governance involves all of an organization's stakeholders, each stakeholder has a particular influence on the organization's evolution; in other words, some stakeholders have more influence than others, and therefore have a greater say in the decisions that shape the organization. It should be noted, however, that all stakeholders have some degree of power, including, at the very least, the power to boycott decisions taken by others (Ekboir *et al.,* 2009). In the CGIAR, this means that although certain donors have a lot of clout, smaller donors, NAROs, DGs and researchers also influence the system's evolution. It also means that whereas the less influential donors cannot sway major decisions, they can influence the system by funding special projects of their interest.

An analysis of governance should focus on three dimensions:

- strategic axis (mission, shared vision, strategic lines and plans of action)
- structure (distribution of functions and coordination)

- process (communication / coordination / harmonization, leadership, learning policies and operative processes)

The strategic axis defines the objectives and action plans; the structure defines authority, jobs, functions, responsibilities and nexuses of communication between the organization's parts; and the processes are recurrent activities that use organizational resources. Although structure has been discussed at length in the CGIAR change process documents, the strategic axis and processes have received less attention.[8]

Research and innovation partnerships and networks

Because of the exploding volume of information and the increasing complexity of innovations, no organization (including firms, ARIs and NGOs) has all the resources it needs to innovate at a rate that enables it to remain relevant to its mission. In order to access those resources, actors join partnerships and networks that facilitate the exchange of information, abilities and resources (Powell and Grodal, 2005). This trend is particularly relevant for the CGIAR because:

- the technical, social and economic environment in which agricultural research organizations operate is increasingly complex
- science is increasingly a multi-disciplinary, multi-institutional effort
- some essential research inputs are progressively being held by private companies (Ekboir, 2009).

Research and innovation partnerships and networks are groups of various agents (e.g., farmers, private firms, researchers and farmer organizations) who voluntarily contribute knowledge and other resources to jointly develop or improve social or economic processes or products. The membership of innovation networks changes often in response to new challenges or opportunities, whereas that of research partnerships tends to be more stable. Innovation networks are a special form of organization with a non-hierarchical structure, a collaboration-based culture, consensus-based coordination (members are free to leave the network at any time) and, usually, no legal personality (Ekboir, 2011). Research networks often have more formal arrangements, although this is not always the case (see, for example, Skarzynski and Gibson, 2008; and Rycroft and Kash, 1999).

The dynamics of research and innovation partnerships and networks depend on the changing relationships between agents, technologies, markets, the formal and informal rules governing members' behavior, and network complexity and maturity. For simple innovations or mature markets, the organizational arrangements are loose and members interact mostly formally or through markets because each actor understands the needs of other actors. In the case of new or complex innovations, however, members interact often and informally to overcome unforeseen obstacles and build confidence. The need for intense interaction arises because uncertainty about the new technologies and their market potential prevents effective contracting (Christensen *et al.*, 2004). Also, the characterization of a market or innovation as simple and formal or complex and informal can change reflecting on new technologies or commercial opportunities (e.g., the international market for shrimps was complex in the 1980s, but has now been commoditized [simplified], whereas the market for gourmet coffees, including the fair trade movement, has moved from simple to complex). As markets and

[8] Although four working groups were formed to discuss the CGIAR's operations, their conclusions on what the CGIAR should do and how it should do it were not prominently discussed in the documents that set the basis for the creation of the Consortium.

innovations evolve, a network's membership changes, reflecting changes in the partners' objectives and emerging challenges and opportunities (Rycroft and Kash, 1999).

The emergence of a research or innovation partnership or network requires collaboration between two types of partners: a catalytic agent and a funder. Committed and innovative catalytic agents are vital for the emergence of innovation networks, because only they can induce other partners to invest time and resources in the network; they also seek partners to contribute the resources needed by the group (Ekboir *et al*., 2009). Funders provide the resources that allow the catalytic agent to operate. Fostering the emergence of innovation partnerships and networks and, especially, supporting them financially, has been a major challenge because these processes need adaptive management over several years, but most donors have tended to require strict adherence to project protocols and evidence of project impact within a specific period of time.[9]

Since its inception, the CGIAR has participated in research and innovation partnerships that have had important impacts on agricultural productivity and poverty, including breeding networks, the development and diffusion of no-till farming, and the development of value chains to facilitate market access for small farmers. An understanding of the changing dynamics of research and innovation partnerships and networks is critical for the future of the CGIAR, because it helps to define the system's niche and the type of research it should conduct (see Ekboir, 2009).

Inducing change in complex organizations

Two of ILAC's lines of work are contributing to i) the experimentation of new models of partnerships and ii) the design and implementation of a learning strategy for the CGIAR. Here, the focus is on the dynamics of complex organizational change and an intervention that could be used in this endeavor – the manipulation of variation and selection; the application of this intervention in the context of the CGIAR is discussed in Section 5.

Several studies have reported that organizations are inherently conservative (Christensen, 2003; Davila *et al.*, 2006). For example, although most firms are born from an innovative business plan, very few can consistently generate profits that exceed the average of their industry; in other words, after an initial advantage, most firms are unable to develop new business plans that are more innovative than those used by their competitors. The most important reason for organizational inertia is the effective working routines that enabled the initial success; once these routines have proved themselves effective, there is little incentive to change them until the competitive advantages the firm once enjoyed are visibly eroded. By this time, more efficient competitors have captured a substantial portion of the market and the original leader often cannot regain its leadership (Christensen and Raynor, 2003). Similar organizational inertia has been documented in NGOs and civil society organizations (Ekboir *et al*., 2009). The CGIAR has also experienced this phenomenon, derived from the impact of the Green Revolution and the subsequent focus on developing technologies that could have a comparable success (see Appendix 3).

To overcome inertias, organizations have to create the appropriate mechanisms to build up their capabilities for change and innovation. As explained earlier, however, this is a difficult,

[9] For example, the Papa Andina project managed by CIP started in 1998. In 2000, the researchers started to experiment with participatory methods; market chain building and research to develop new potato-based products were initiated in 2002, and the first sales of new products started in 2004. In 2007, the Peruvian component of the project received a United Nations award for 'Supporting Entrepreneurs for Environment and Development' (Devaux *et al*., 2010).

protracted process that requires visionary leadership, sufficient resources, flexible implementation and a clear understanding of complex organizational dynamics (Skarzynski and Gibson, 2008). Due to the participation of many actors, organizations can be seen as complex organisms whose evolution depends on the interaction between motivation and capability, conditioned by the enabling environment. Although organizations operate on both motivation and capability, the latter also responds to internal and external forces (e.g., employees' resistance to change and new technologies); therefore, they can be only partially controlled by senior management. Given these multiple forces operating simultaneously, the dynamics of organizational change can be explained by the properties of Complex Adaptive Systems (CAS) (Gunderson and Holling, 2002; Axelrod and Cohen, 1999; Kauffman, 1995).

CAS evolve through the interactions among a large number of actors of various types, conditioned by the process history, the socioeconomic environment in which they operate and random events (Gunderson and Holling, 2002; Axelrod and Cohen, 1999). Examples of CAS are markets, ecosystems and the human body. From the actions and interactions among the various actors, the system develops properties at larger scales that do not exist at smaller scales – that is, CAS self-organize (Crutchfield and Schuster 2003; Axelrod and Cohen 1999). For example, life results from an infinite number of chemical reactions, but each reaction is not alive. Because of its many independent decision-makers (i.e., donors, researchers, DGs and stakeholders), the GCIAR has many of the features of a self-organizing system; therefore, explicitly taking its complex nature into consideration could improve the design and implementation of interventions to induce organizational change.

Inducing institutional change in the CGIAR requires approaches that recognize the complexity of the system's mandate and structure. Designing such strategies has been a major challenge (see, for example, Ekboir *et al*., 2009; Skarzynski and Gibson, 2008; Christensen, Anthony and Roth, 2004; Gunderson and Holling, 2002; Axelrod and Cohen, 1999). In fact, the relatively few organizations that have been able to develop effective change strategies have based them on strong learning mechanisms (Skarzynski and Gibson, 2008; Davila *et al*., 2006). Learning and feedback loops are essential for the effectiveness of interventions because the number of options that can be tried is limited by coordination problems within an organization, by the resources available for exploration of alternatives and by organizational capabilities (Dosi *et al*., 2000).

The interaction between self-organization and random events is the main reason why CAS are uncertain, often unpredictable, and can be steered but not controlled. Also, due to the many actions and interactions that characterize the system, it is often impossible to predict the outcomes of an intervention; also, the same outcome can often be achieved with different interventions. For example, transportation losses of fresh fruits can be reduced with sturdier varieties, better packaging, better trucks or better roads. In other cases, the solution to a problem can be found without a clear understanding of how the outcome emerges, as exemplified by traditional plant breeding, medicine side effects and management of large ecosystems (Gunderson and Holling, 2002; Kauffman, 1995).[10]

Given the uncertainties that characterize a CAS, interventions should not be seen as working through a mechanical apparatus that consistently delivers the same output, but as operating on an organism

[10] Although breeders can have an idea of the genes involved in conferring certain traits to a plant, they cannot yet design a crossing between parents that will be certain to possess the trait. Therefore, they have to make thousands of crosses until a combination of genes that has the desired combination of genes is found by a guided exploration. While marker-assisted breeding has reduced the uncertainty of the process, the result of each crossing is still uncertain because thousands of genes are involved. Similar directed search processes are now being used to develop chemical molecules, a process known as 'molecular breeding' (Kauffman, 1995).

that has a life of its own and responds to external influences. It is also important that interventions do not seek to achieve precise results, but to increase the odds of obtaining positive results and reduce the probability of negative outcomes.

Exploitation reaps the greatest benefits of a known intervention, but as the system reacts, it loses effectiveness and eventually has to be discarded. For example, after a variety with strong resistance to certain diseases is found, breeders use it to develop new varieties with additional traits (e.g., higher yields). If the variety is adopted by farmers, the disease eventually evolves and erodes the resistance. Breeders do not wait until the disease has broken the resistance to start looking for new sources of immunity, because that could prevent cultivation of the crop for several years. The balance between exploitation and exploration is how natural systems evolve (Crutchfield and Schuster, 2003), and it has been shown in several scientific disciplines to be the optimal policy in uncertain processes (Barabasi, 2010).

When trying to influence a CAS, decision-makers have to choose between using interventions that are known to have a high probability of yielding the desired results, or searching for new instruments that may be more effective. This trade-off is known in the specialized literature as '**exploitation versus exploration**'.

While there are no recipes for operating on a CAS, some guidelines based on experimentation, search and learning have been proposed in the literature (Crutchfield and Schuster 2003; Gunderson and Holling, 2002; Axelrod and Cohen, 1999). Two of the most relevant ones in terms of the CGIAR change process are: manipulation of variation and selection; and easing of restrictions. Section 5 discusses the use of these guidelines in the CGIAR.

Manipulation of variation and selection

The manipulation of variation combined with effective selection has been used to improve agriculture for many centuries, but the reasons for its effectiveness have been understood only in recent years. In natural systems, variation is random and selection is based on reproductive efficiency; in social systems, variation results from the interaction among different actors and selection results from the relative effectiveness of each actor in advancing his or her agenda. Human interventions operate on both mechanisms, modifying them in a directed fashion, as exemplified by plant breeding (see Box 3). The effectiveness of this method depends crucially on having appropriate selection mechanisms. Because of self-organization, however, there are no optimal selection mechanisms; appropriate solutions can be found only with a directed trial-and-error approach based on strong learning capabilities (Barabasi, 2010; Crutchfield and Schuster, 2003).

Box 3. Manipulating variety and selection

Wild plants evolve through the random variations that occur every time a flower is pollinated. Plants in a specific location have relatively similar germplasm and therefore, although a large number of variations occur continuously, they introduce relatively similar genetic novelties (also known as 'local exploration'). However, a plant breeder knows the characteristics of the parents that are available to her/him and selects those s/he hopes will pass some desired trait to their progeny (e.g., resistance to a given disease). In the early stages of developing a new variety, the breeder usually makes thousands of non-naturally occurring crosses, choosing varieties that are relatively different (or distant exploration). In other words, the breeder *increases variety* by a) making crosses s/he hopes will raise the probability of obtaining the desired result (as opposed to the totally random crosses that occur in nature) and b) choosing plants from different environments. With *artificial* selection, the breeder overrides the natural process of selection via reproductive efficiency by selecting the progeny that displays the desired properties (e.g., disease resistance), without taking into account its reproductive

efficiency.

Random selection and retention is an ineffective way of introducing innovations and works only when a very large number of trials can be conducted, which is not the case in social and organizational processes. Guided variation and artificial selection are already successfully being used to develop complex computer programs, synthesize new chemical and medical compounds, operate on large-scale ecosystems and manage innovation processes in private firms (Crutchfield and Schuster, 2003). Methodologies that apply these principles include adaptive management, discovery-driven planning, appreciative inquiry and the search for positive deviants.

The example in Box 3 illustrates a key characteristic of operating on a CAS; contrary to what an engineer (or a researcher working with traditional methods) would do, the 'solutions' to problems are obtained through a process of directed search without designing them intentionally. However, scientists who use a 'rational design' approach start by building a detailed model of the problem, and then design a structure that can serve as a solution. The relative efficiency of each method depends on the complexity and stability of the processes upon which it operates and how much is known about it. If little is known, if it changes rapidly or is complex, rational design is less effective because it limits the exploration of alternative solutions and gambles that the designed solution is the most effective. In these cases, the effectiveness of the rational design approach depends more on luck than the management of variety and selection approach. It has been demonstrated that the latter converges on an optimum at least as quickly as the rational design method (Crutchfield and Schuster, 2003).

In complex organizations, variation emerges in two ways, from the bottom up and from the top down. Top-down variation occurs when an organization's top management recognizes that it has limited knowledge of key organizational processes. In such cases, instead of planning the operations, managers set up a learning strategy by:

- building a conceptual, qualitative model of the process they want to influence
- making explicit the model's assumptions
- identifying some interventions that might have a high probability of yielding the desired results

Next, pilot projects are used to explore the validity of the key assumptions and interventions. After the assumptions and/or interventions have been validated and enough understanding of the process has been achieved, the pilot projects are scaled up. Such an approach is known as discovery-driven planning (Christensen and Raynor, 2003) or adaptive management (Gunderson and Holling, 2002).

Bottom-up variations occur when actors at the base of the organization innovate in any way or when employees seek to do their best given the organization's goals. INTEL's transformation into a producer of microprocessors is a good example of bottom-up variation. In the 1960s, INTEL's main business was the production of RAM chips. The microprocessor was developed by an INTEL engineer working in a small project contracted by a Japanese firm willing to produce electronic calculators; eventually, new uses for the microprocessor were found. INTEL's managers periodically allocated resources based on the relative profitability of all the activities in the company's portfolio. Due to competition from cheap Chinese manufacturers, the profitability of RAMs plummeted in the 1980s; therefore, thanks to its resource allocation routines, INTEL gradually and automatically expanded the production of microprocessors at the expense of RAMs. Eventually, INTEL's top management realized that the company's main business had shifted and it abandoned the production of RAMs (Christensen and Raynor, 2003).

Top-down and bottom-up variation can be combined to search for superior organizational strategies. Organizational strategies are defined through two simultaneous processes – 'deliberate' and 'emergent' (Christensen and Raynor, 2003). Deliberate strategies are those consciously defined by the organization (top-down), whereas emergent strategies are those that result from the day-to-day, decentralized actions of all decision-makers within the organization, such as top and middle managers, sales people and shopfloor workers (bottom-up). These actions tend to be tactical and include, for example, resource allocations within divisions or deciding which clients should be prioritized. The accumulation of these operational decisions results in the organization's actual resource allocation, which may differ from the allocation decided in the deliberate strategies (Christensen *et al.,* 2004). Deliberate strategies are defined by top management through a process of planning. Emergent strategies can be seen as the operation of variation and selection. The change from an emergent strategy to a deliberate one is similar to the change from natural selection to guided selection. No strategy is absolutely better than the other; deliberate strategies are more effective when a process is well understood and relatively stable, whereas emergent strategies should be used when implementation is plagued by uncertainties. How to combine both approaches, and deciding which one should be dominant, is one of the most important decisions for an organization's management.

Without strong leadership and effective learning mechanisms, emergent strategies control the evolution of organizations, even if the latter seek to implement a deliberate strategy. In such cases, organizations cannot operate consciously to take advantage of emergent opportunities. Emergent strategies have dominated most of the time in the CGIAR, even when major changes were implemented (see Appendix 3).

Appendix 3: The evolution of the CGIAR

The CGIAR is a legacy of the Green Revolution. Over the years, a stylized narrative of the Green Revolution emphasized the central role of science, but only marginally acknowledged the policies that made adoption possible. This model guided the actions of several donors and centers. Although new activities have been incorporated and alternative research models have been tried, the initial model remains dominant in the discourse of many stakeholders who often consider alternative models as development and not research (Alston *et al.*, 2006) and therefore outside the CGIAR's mandate. In recent years, however, the need to develop new organizational and research models, including new partnerships, has gained momentum (see, for example, GAT, 2010).

In its early years, the CGIAR had a very clear and narrow goal: to stave off hunger by increasing the productivity of staple crops from small farms (Alston *et al.,* 2006). It therefore gave highest priority to breeding HYVs. In the 1970s, about two-thirds of CGIAR's resources were allocated to research on rice, wheat and maize. High priority was later given to improving the quality of diets through research on food legumes and ruminant livestock (Anderson, 1998). The initial success of the CGIAR resulted from the collective effort of high-quality researchers working on a narrowly focused problem (i.e., improved productivity of three crops) and policy-makers providing the economic incentives to induce adoption (CGIAR, 2008). The prevalent vision among stakeholders was that excellent, highly motivated and committed researchers working with sufficient resources would develop superior technologies that local research organizations could adapt to local conditions, and extension agents would then transfer them to farmers who would adopt them because they were more profitable (Ekboir 2009).

The first CGIAR centers were the central nodes of breeding networks that also included the NAROs selecting locally adapted varieties, extension agents taking the technologies to the farmers and policy-makers subsidizing adopters. In 1971, the donors and centers created the CGIAR and expanded the system's activities under six broad program thrusts: research to increase productivity of food production; management of natural resources; helping countries to design and implement food, agricultural and research policies; capacity building by training and strengthening NARS; germplasm conservation by collecting and classifying genetic resources, and maintaining gene banks and other means of conservation; and building links between NAROs and other components of the international agricultural research system (Anderson, 1998).

The new activities were added with little consideration for what these changes meant for the type of science the CGIAR should conduct or how it should be carried out. Several factors reduced the effectiveness of the expanded mandate. In contrast with the initial focused mission, the new objectives were more diffused and spread the resources over more activities. Second, plant breeding is essentially different from research in other agricultural fields. Breeding relied on international networks that facilitated exchanges of germplasm. The other activities did not form similar global networks and worked with a smaller set of partners because their research was more location-specific, and no agreement emerged on what the best methods to study those topics were. Also, it was not clear what advantage international researchers had in more location-specific research (CGIAR, 2006).

In the 1980s, research policies in many countries underwent a major transformation which included a shift from the 'blind' funding of research institutions to project funding where policy-makers set more specific targets; in other words, policy-makers reduced their support for academic (i.e., curiosity-oriented) research and increased it for research oriented to social and economic needs (Lepori *et al*., 2007). This change was accompanied by a demand for research institutions to demonstrate the impact of their activities, as evidenced by the discussions that followed the 1993 US Government Performance and Results Act (Kraemer, 2006). CGIAR funders also adopted these principles, and in the mid-1990s the centers began to transform themselves into output- and impact-driven organizations (Kassam, 2006); this move increased the system's transaction costs, hampered long-term research programs (CGIAR Independent Review Panel 2008) and forced the centers to commit important resources to demonstrating impact (Bellon *et al.,* 2006).

The conceptual model of research systems in developing countries also underwent major changes. The concept of NAROs was replaced by NARS, which also included universities and other agricultural research institutions; in the 1990s, the NARS concept was replaced by the Agricultural Knowledge and Information System (AKIS), which included research, education and extension (Byerlee et al., 2002). In parallel, private firms and NGOs in developing countries started to develop commercial agriculture, usually importing technical and scientific information. In the early 2000s, the concept of the Agricultural Innovation System (AIS) began to gain acceptance (Hall *et al*., 2006); the main consequence of this transition was that researchers in national or international centers were no longer seen as critical to agricultural growth, but just another source of information or a potential partner in innovation networks. These models showed that the CGIAR had to develop new research capabilities and establish new types of interactions with a more diverse set of partners, many of whom had weak research capabilities (see, for example, Spielman *et al.,* 2008).

Several stakeholders criticized the NARS for their lack of participation in the emergence of high-value markets and the failure of modern technologies to eradicate poverty. This led to a substantial downsizing or closure of public research and extension institutions (Byerlee *et al.*,

2002). The CGIAR centers found that they could no longer rely exclusively on weakened traditional partners, and started to work with private firms, NGOs, farmer organizations and farmers (see, for example, the work done by CIP and the International Center for Tropical Agriculture [CIAT]).

During these years, the CGIAR's mandate expanded still further. The new activities included managing research networks to facilitate research performed by others, some in conjunction with CGIAR centers (Plucknett *et al.*, 1990); rehabilitating seed stocks in natural disaster- or war-ravaged countries; and promoting no-till farming and developing niche markets. Because the expanded mandate had to be implemented with reduced budgets, breeding programs were scaled back even further (Alston *et al.*, 2006). The expansion in the types of interventions carried out by the centers and in the number and types of partners the centers worked with made most of the networks even more diffused. Some of these activities were branded "development less directly related to research" (Alston *et al*., 2006, pp. 324). It should be noted, however, that this statement reflects a mode 1 vision of research; if properly conducted, these activities could involve new approaches in the mode 2 research (e.g., action-research or the manipulation of variation and selection, as explained in Appendix 2).

After realizing the potential of high-value agriculture in poverty alleviation, several centers started to work on the diversification and development of niche markets to the point where high-value agriculture became one of the CGIAR's priorities (CGIAR, 2005). This type of work, however, differs greatly from that done on staples and livestock. Because high-value markets are more complex, newer and fast changing, the development of the business model is at least as important as the agronomic package (Reardon *et al*., 2009). When their mandate committed them to work on low-value products (e.g., maize or rice), some centers explored the use of these crops as inputs in the production of high-value products, but the CGIAR centers did not have the expertise to develop agricultural value chains or to research these topics (Science Council Secretariat, 2007). Over time, a few centers (e.g., CIP and CIAT) developed some of these capabilities, but then they started to resemble NGOs and became increasingly different from the traditional research centers. This does not mean that these activities should not be done, but it is not clear what advantage the CGIAR has in this area relative to specialized NGOs, (such as Practical Action or Technoserve), consulting firms (e.g., Chemonics), or universities with strong international programs, such as Michigan State University or Wageningen University. Defining these differences will help the CGIAR to better focus its activities.

As the CGIAR added activities, it became clear that the centers needed to develop new capabilities. In the 1990s, the Ford Foundation funded a project to support organizational learning, which included workshops and retreats for senior management and research staff on leading organizational change, mobilizing resources and promoting effective teamwork and collaborative partnerships (Horton *et al*., 2007). The project's impact was limited, however, as suggested by the fact that the current change process is meant to solve the same issues.

The main lesson for the current change process is that effective organizational change cannot be accomplished with isolated actions, but requires a sustained effort that includes new incentives, appropriate metrics, innovation architectures, technological platforms, mentoring and strong leadership (Skarzynski and Gibson, 2008). Strong leadership is not synonymous with centralized, top-down decision-making; in a decentralized organization such as the CGIAR, it means providing intellectual direction, facilitating learning and playing a pivotal role representing the concerns of the centers in their dealings with the donors and conveying to the centers the messages from the donors.

In 2003, the CGIAR launched its first Challenge Program, with four main objectives:

- addressing complex issues of great global and/or regional significance
- involving high-impact research relating to CGIAR goals
- working through broad partnerships involving a wide range of institutions
- mobilizing additional funds

The Challenge Programs provided a flexible mechanism for structuring multidisciplinary, inter-institutional teams to address specific issues. If properly managed, they could have been the basis for conducting mode 2 research. Two reviews by the Science Council and the CGIAR Secretariat (Science Council, 2007, 2004) and a recent independent review (CGIAR, 2008), however, showed that the CGIAR still evaluated the Challenge Programs from the traditional perspective of science. Despite these reviews, the CGIAR Research Programs governance structures have a great resemblance to the Challenge Programs.

In 2004, the Science Council was given more power to oversee the work of the centers, especially in terms of setting the system's priorities (CGIAR, 2005). In the following few years it tried to align the centers' activities with these priorities by tying funding to its approval of the centers' activities, as measured by inflexible standards defined by the Science Council itself. This new role, however, alienated the centers and the researchers (The Boston Consulting Group, 2009). A similar strict alignment could have serious consequences for the future CGIAR. As explained in Appendix 2, complex processes are difficult to understand and predict. Therefore, instead of setting clearly defined strategies and priorities, actors operating in such environments should use learning strategies to identify emerging trends and to explore alternative solutions. Fifteen independent but coordinated centers operating a number of research programs designed to address significant issues where research can make an important contribution can be an effective structure for implementing a strategy of decentralized experimentation with centralized learning. Some centers have already implemented innovative projects that explore new partnerships and research approaches in response to identified opportunities (e.g., CIMMYT's work on no-till farming, CIP's development of niche markets for native potatoes and, more recently, the CPWF). What the CGIAR system lacks is an effective and flexible structure that enables it to learn collectively from these projects.

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