CHILE Action Plan 2030

Chile's Agricultural Innovation System: An Action Plan Towards 2030

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TABLE OF CONTENTS

Acronyms

ACHIPIA	Chilean Agency of Food Safety
AgGDP	Agriculture Gross Domestic Production
ASOEX	Chilean Exporters Association
BIOGRAM	Biotechnology Products and Supplies Inc.
CASEN	Chile National Socio-economic Survey
CENMA	National Center for the Environment
ChileGAP	Chilean Good Agricultural Practices Voluntary Standard Certification Process
CIMM	Mining and Metallurgical Research Center
CIREN	Information Center on Natural Resources
CMI	Innovation Ministers' Committee
CNED	National Council for Education
CNIC	National Innovation Council for Competitiveness
CONICYT	National Commission for Science and Technology
CORFO	Corporation for Production Development
CRC	Competitive Research Centers
CTCB	Technological Center for Biological Controls
DROPCO	Green Chemistry Innovation and Development Laboratory Inc.
FDF	Fruit Development Foundation
FDI	Foreign Direct Investment
FEDEFRUTA	Chilean Fruit Producers' Federation
FIA	Foundation for Agricultural Innovation
FIC	Innovation Fund for Competitiveness
FOCAL	Promoting Quality, Subsidy Program under CORFO
FONDECYT	National Fund for Science and Technology Development
FONDEF	Fund for the Advancement of Science and Technology Development
FTE	Full Time Equivalent
GlobalGAP	Global Good Agricultural Practices Voluntary Standard Certification Process
GMO	Genetically Modified Organism
GPS	Global Positioning System
GTT	Technological Transfer Groups
HACCP	Hazard Analysis at Critical Control Points
ICM	Millennium Scientific Initiative
ICT	Information Communication Technologies
IFOP	Institute for Fisheries Development
IFPRI	International Food Policy Research Institute
IPR	Intellectual Property Rights
IMF	International Monetary Fund
INDAP	Agricultural Development Agency
INFOR	National Forestry Institute
INIA	National Institute of Agricultural Research
INNOVA-Chile	Public Innovation Program within CORFO
ISO	International Organization for Standardization
ITP	Industrial Technologies Program
MINAGRI	Ministry of Agriculture
MIS	Management Information System
OECD	Organization for Economic Cooperation and Development

PDP	Supplier Development Program
PDT	Technology Diffusion Program
PTI	Public Technological Institute
R&D	Research and Development
SAG	Plant and Livestock Health Service
SENCE	National Service of Training and Employment
SNA	National Society of Farmers
UC PUC	Pontifical Catholic University of Chile
UPOV	Union for the Protection of New Plant Varieties

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This report was prepared by a core team made up of Willem Janssen (Lead Agricultural Specialist and Team Leader) and Matthew McMahon (Consultant). The report builds on the "Towards a Vision for Agricultural Innovation in Chile in 2030" report and is further based on a series of background papers and a consultation process that took place between December 2010 and May 2011. An earlier draft was discussed within Chile with MINAGRI, FIA and other interested parties. The final draft was produced based on the feedback received in Chile and during the World Bank's Quality Enhancement Review process.

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Preface

After a long period of slowly falling agricultural prices in global markets, the agricultural outlook over the last five years has been volatile, to say the least. Lately global agricultural markets have experienced very significant price spikes for many key commodities. These developments can be traced to at least three key factors: (i) climate change is starting to affect the productive potential of agricultural systems; (ii) the push towards agriculture based biofuels (ethanol, biodiesel) creates upward pressures on agricultural prices; and (iii) the quickly growing average incomes in Asia (China, India) push up long-term demand. The welfare implications, especially for poor consumers, may be significant. Agricultural innovation is a central part of the responses to the opportunities and threats that these new settings bring.

The World Bank commends the Ministry of Agriculture of Chile (MINAGRI) and its Foundation for Agricultural Innovation (FIA) for their efforts to understand Chile's position in the global agricultural developments and for the central role they are seeing for agricultural innovation. Chile's authorities are keenly aware of the continued need for the improved profitability of the sector and expressed concerns when productivity growth started to level off. They know that the country needs new technologies, new organizational and institutional arrangements and enhanced farmer skills to successfully confront the future.

We have appreciated the productive and pleasant collaboration with MINAGRI and FIA in trying to understand how Chile can energize its agricultural productivity growth in a quickly evolving global setting. We are happy to have been part of the mutual learning process behind the development of the Vision and the Action Plan towards 2030. We wish the Chilean government success in the implementation of the recommendations and stand ready for further support.

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Manager, Agriculture and Rural Development
Latin America and the Caribbean Region
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Executive Summary

The current study is the third in a series of three that were agreed between the Government of Chile and the World Bank to support the development of a long-term agricultural innovation strategy. The first paper reviewed the functioning of the three main public technological institutes and recommended how their performance can be improved. The second study explored the future of Chile's agriculture towards 2030, using scenario planning and developing a Vision for the future of its agricultural innovation system. This paper is based on the results of the former two studies, as well as a set of background documents and further consultations, and will outline the Action Plan required to achieve the aforementioned Vision.

It is no surprise that the Government of Chile perceives the country as a food and forest power – *"Chile: Potencia Alimentaria y Forestal"*. Chile has set as a national goal to become an important actor in global agro-food markets; there is a widely shared agreement in the country that this is a realistic and desirable objective. There are, however, a series of challenges that need to be addressed. In the last decade, the sector has shown a decline in dynamism. By the end of 2007, Chile's total factor productivity growth was lower than ten years earlier[1] (IMF, 2009).[2] The annual growth rate of agricultural value added was 11% in 2004 and only 2% in 2008.[3] Access to technology will become increasingly difficult and more expensive in the future as evidenced by the increased protection of intellectual property rights. Climate change may constrain agricultural development and international trade opportunities may change due to increased consumer demands and hidden protection measures.

A Vision for the Sector. To understand how the sector should respond to these challenges, scenario planning was used to develop a Vision for the agricultural sector for 2030, using a consultative process with a large number of people drawn from both outside and within the agricultural sector. While the scenarios are plausible based on present day trends and available information, the Vision itself is aspirational and is based on a range of assumptions and desires that are widely shared, not only in the agricultural sector, but across Chilean society. The Vision has been phrased as follows:

In 2030 Chile is a quality producer of a range of food and fiber products. Its international image is marked by the diversity that its geography allows it to produce. The sector has an emphasis on environmental sustainability and wholesomeness, valued by both domestic and international consumers. Through the application of ICT, investments in agricultural technology and the training of its labor force, Chile has been able to develop profitable value chains, well integrated from production to final markets, and able to remunerate its participants at comparable levels to the rest of the rural economy.

Based on the background studies and the consultative process, the following topics were identified as key elements for Action to realize the Vision:

- A. Further strengthening Chile's agricultural innovation system in comparison to other OECD countries
- B. Strengthening the availability of new information and knowledge to agricultural producers
- C. Improving the technological control over production systems
  - C1. Pursuing genetic improvement and biotechnology for developing eco-efficient agricultural production systems
  - C2. Improving farm management

1 Total factor productivity growth decreased from 2,8 between 1984-1997, to only 0,9 between 1998-2005.

2 Di Bella, G. and M. Cerisola. Investment-Specific Productivity Growth: Chile in a Global Perspective. IMF Working Paper. 2009. At: **http://www.imf.org/external/pubs/ft/wp/2009/wp09264.pdf**

3 World Development Report 2010, World Bank.

C3. Strengthening value chain management systems, through expert and market information systems

D. Enhancing quality compliance and certification systems

E. Improving the human resource base, especially within the value chains

The objective of this Action Plan is to enhance the capacity of Chile's agricultural innovation system in order to achieve the goals as laid out in the Vision for the sector for the year 2030. It builds on the current strengths of the agricultural innovation system and elaborates on the main actions needed to address the priority topics. Five principles serve as the foundation of the Plan: recognizing national and regional responsibilities; distinguishing public and private roles; diversity; excellence; and institutional integration. Most of the proposes actions can be implemented between 2011 and 2015 and consolidated in the next five years. After 2020, plans and activities can be revised in the light of the progress obtained up to that moment.

Main Recommendations

Leadership and Facilitation

1. MINAGRI should enhance its capacity to manage the issues related to agricultural innovation. It is recommended that a Directorate for Innovation be established within the newly structured MINAGRI whose main responsibility would be to ensure the participation of the sector in the National Innovation System and facilitate the implementation of its own agenda within the sector.
2. The first responsibility of this Directorate is to develop a strategy to articulate the positions of the agriculture sector within the National Innovation System, thereby contributing to the strengthening of that same System in general.
3. MINAGRI should invite the private sector to strengthen its organization, at the sector and key subsectoral levels. MINAGRI might make funds available to support the establishment of these national producer and agro-industry associations for the first two years.

Getting Value for Money

1. To increase the efficiency of funding in the short term, the Ministry of Agriculture has to work with the funding agencies and use its own budget to support multidisciplinary teams with a critical mass of scientists in its priority areas of interest.
2. A better mix of instruments should be put in place to strike a balance between core funding, competitive funding, performance contracts, development of human resources, support to private sector, infrastructure, equipment, etc.
3. To benchmark with the OECD countries in the year 2020, MINAGRI needs to pursue a tripling of total public resources.
4. Regional governments should be more explicitly included as partners in the system with an emphasis on developing and financing regional agendas.
5. Instruments should be put in place to encourage private sector participation such as development of consortia, tax breaks, IPR legislation and enforcement.

Integrating Institutions

1. A framework needs to be established to create viable and attractive linkages among the various institutions of the system. The integration should take place within the priority research areas identified for the future and through the Regional Agricultural Research and Development Centers proposed in this study's section on Translating Results. Integrated teams need to have stable funding and need to pool resources where necessary. This will require programmatic funding on the basis of performance contracts; joint teaching appointments; the secondment of researchers from the PTIs to bolster research teams in the universities; collaboration in doctoral and master's level programs; and the integration of research facilities, i.e. shared laboratories and equipment.

Translating Results

1. Chile should develop Regional Technology Transfer Centers throughout the country. These centers would be staffed by highly trained technology transfer specialists, like the extension specialists that are employed in the US system, and would form a part of multidisciplinary teams to be established. These centers would be located in institutions such as research institutes, university campuses or other institutions that are recognized by the state. The role of the extension specialists would be to organize and work with groups of extension agents from both public and private sector, but not with individual farmers directly. The centers will develop partnerships with both public and private actors, a range of methodologies depending on the message and the clientele, a policy on access to information, the recruitment of professionals across a range of specializations and the use of modern communications technologies in all its modalities.

Thematic Areas and Cross Cutting Issues

Genetic Improvement

1. Chile needs to develop multidisciplinary teams of scientists for various commodities, in order to increase productivity and ensure stable levels of production. Such teams may include breeders, biotechnologists, agronomists, and disease and insect specialists. A strategy paper on genetic improvement may be helpful to define which products and which disciplines should be considered.
2. Chile should manage biotechnology tools so that they form an integral part of a genetic improvement program.
3. Chile should strengthen the legal framework related to intellectual property and patents in order to strengthen the relationship between the scientific community and the commercial sector, and to ensure access to genetic resources worldwide.

Farm Management

1. The Regional Centers should develop mission oriented research programs focused primarily on:
   - The management of natural resources towards clean agriculture
   - Efficient use of water resources at the farm level
   - The integration of ICTs (wireless communication, sensors, MIS, GPS, robots, etc.) across the value chain
   - The use of ecological inputs

Harvest and Post-harvest

1. The proposal is to establish a network of multidisciplinary teams that establishes a strategic agenda of interest to the private sector and incorporates this agenda in the calls for proposals from competitive funds. Both the network and the resulting programs and projects should be funded on a shared basis between government and private sector, with the private sector's share growing over time.

Standards and Quality

1. MINAGRI should support private sector led expansion of ChileGAP to all agricultural production, be it for export or domestic markets; expansion of support programs for certification with public/private financing; and the benchmarking of quality standards with importing countries of Chilean produce.

Qualified Human Resources

1. In collaboration with *Becas Chile,* the agricultural sector should elaborate a plan for the development of qualified human resources based on the sectoral strategy for innovation and strengthen international networks for the exchange of scientific personnel.

Labor Resources

1. MINAGRI should work with the Ministry of Education in the strengthening of basic education in rural areas; strengthen vocational training in agriculture and publicly financed training programs for agricultural workers.

2. The Ministry of Agriculture should manage a monitoring system on training needs in the agricultural sector.

Next Steps

To ensure the successful implementation of the Action Plan the following recommendations are made:

1. The Action Plan and the Vision behind it require further consultation and validation, especially at the regional level. While ample consultations were held in the preparation of the documents, most of those took place in Santiago and at the national level. The resulting "helicopter view" needs to be complemented with the perspectives of stakeholders within each region.
2. The main Action Plan elements may be sequenced over time, in order to learn from experience and to manage the workload. For this purpose, it would be useful to develop a more detailed "Action Plan Operational Manual" that indicates for each of the proposed activities: which organizations are involved; what are their responsibilities; what progress on implementation can be expected; what are the costs of implementing the different activities; when are they supposed to be concluded; when are the first results expected. A Roadmap was developed to outline the possible milestones for the main elements of the Action Plan.
3. A budget proposal needs to be prepared which indicates, over time, the sources that will be used to finance the different initiatives, in order to ensure not only that the funds are available, but that they are in the right lines of the public budget.

Implementation of the Action Plan and the Role of FIA. The implementation of the Action Plan will require considerable capacity and will involve significant institutional change. While the implementation of the Plan will be led by MINAGRI as soon as the function of innovation policy management has been established, the proposal is that, in the meantime, FIA leads the implementation of the Action Plan. FIA would thus obtain a role as a change agent, as the innovation broker in its own system. A further new role for FIA may be in the strengthening of the evaluation capacity, both ex-ante and ex-post, of the agricultural innovation system.

1. Introduction

The current paper is the third in a series of three that were agreed between the Government of Chile and the World Bank to support the development of a long-term agricultural innovation strategy. The first one reviewed the functioning of the three main public technological institutes and made recommendations on how their performance can be improved. The second explored the future of Chile's agriculture towards 2030, using a scenario planning methodology and developing a Vision for the future of its agricultural innovation system. This study is based on the results of the former two studies, as well as a set of background documents and further consultations, and will outline the Action Plan required to achieve the Vision.

Why does Chile need a long-term Agricultural Innovation Strategy? Chile is an important player in world agro-food markets. In terms of production value, the country has established itself as one of the top twenty fruit and vegetable producers in the world.[4] Intensification of agriculture has brought important yield increases, placing agriculture in Chile among the most productive sectors in the region, with notable success in fruit, wine, salmon and forestry products. It is no surprise that the Government of Chile perceives the country as a food and forest power – *"Chile: Potencia Alimentaria y Forestal"*. Everything suggests that Chile's future market presence could increase through improved production, new products and added value. Chile has set as a national goal to become an important actor in global agro-food markets and there is a widely shared agreement in the country that this is a realistic and desirable objective.

There are, however, a series of challenges coming from within and outside the sector, that need to be addressed. In the last decade, the sector has shown a decline in dynamism. By the end of 2007, Chile's total factor productivity growth was lower than ten years earlier[5], a performance that contrasted sharply with the previous decade, when productivity grew by a cumulative 30% (IMF, 2009).[6] The annual growth rate of agricultural value added was 11% in 2004 and only 2% in 2008.[7]

Chile has also been fortunate in that, because of its ecological similarity with California, it has had access to ready-made technology that could be easily adapted to the country's conditions. This has been an important factor in the expansion of the fruit sector. However, access to technology may become increasingly difficult and more expensive in the future as evidenced by the increased protection of intellectual property rights. Since mining is the principal economic sector and the demand for minerals is increasing, the sector must compete in an environment where exchange rate appreciation has been a reality for a number of years.

In Chile's main export markets, quality concerns are stronger every day and more multi-dimensional. Market access is not only based on price and presentation but is increasingly contingent upon proof of environmental sustainability, social justice and nutritional value. But there are also new markets, especially in Asia, with high economic growth and large population sizes, promising massive opportunities.

Under certain climate change scenarios it is possible that there will be a further realignment of production zones and product mix as water scarcity would be felt more severely in the north and center-north of the country and intensive agricultural production would move southwards. The agricultural sector is experiencing a process of consolidation, with many older smallholders selling or renting their land to increasingly commercially oriented farm businesses. Labor costs are increasing because of employment

4 FAOSTAT – http://www.fao.org/corp/statistics/en/ – several years.

5 Total factor productivity growth decreased from 2,8 between 1984-1997, to only 0,9 between 1998-2005.

6 Di Bella, G. and M. Cerisola. Investment-Specific Productivity Growth: Chile in a Global Perspective. IMF Working Paper. 2009. At: http://www.imf.org/external/pubs/ft/wp/2009/wp09264.pdf

7 World Development Report 2010, World Bank.

opportunities in other sectors such as construction and mining. All of these factors could act against the comparative advantages that the agricultural sector has had in the past, and that now require it to have a greater flexibility which can be supported by a strong and effective innovation system. Such an innovation system will not only focus on agricultural production, but will consider the whole production process including post-harvest handling and processing, certification, guarantees of origin, classification or standardization, packaging, means of transportation and storage, and good agricultural and manufacturing practices.

It is possible that the agriculture sector could be substantially more challenging in 2030, because of external factors, i.e. climate change, quality standards, etc., than is presently envisioned and might require a series of major adjustments. In that case an innovation system that can effectively confront production problems in Chile will be important in helping the sector to adapt to, and mitigate any adverse effects of major scenario changes.

Innovation as a National Strategy. In the face of the need to generate a productive transformation in the Chilean economy, the Government has launched a growth strategy which assigns a central role to innovation. Since 2005, with the creation of the *Fondo de Innovación para la Competitividad* (FIC), whose funding was made possible through increased government revenues that resulted from a royalty on mining, the government has dramatically increased its investment in the innovation sector at an annual rate of 24% going from US$240m in 2005 to US$530m in 2009 (2009 US$). Along with increasing resources dedicated to innovation, the government has also carried out a series of institutional initiatives such as the creation of the *Consejo Nacional de Innovación para la Competitividad* (CNIC) which has broad social participation and provides an advisory role to the Executive, being also responsible for the proposal of a national innovation strategy. To ensure the implementation of this strategy, the Government has also created a committee at the ministerial level (*Comité de Ministros para la Innovación* [CMI]).

The challenge of the agriculture sector is to position itself within the National Innovation System and draw on the resources of the system to fulfill its Vision.

A Vision for the Sector. Through scenario building, a Vision for the agricultural sector for 2030 was developed, using a consultative process with a large number of people drawn from both outside and within the agricultural sector. While the scenarios are plausible based on present day trends and available information, the Vision itself is aspirational and is based on a range of assumptions and desires that are widely shared not only in the agricultural sector but across Chilean society. Figure 1 presents the Vision.

Figure 1. A Vision for Chile's agriculture in 2030

In 2030 Chile is a quality producer of a range of food and fiber products. Its international image is marked by the diversity that its geography allows it to produce. The sector has an emphasis on environmental sustainability and wholesomeness, valued by both domestic and international consumers. Through the application of ICT, investments in agricultural technology and the training of its labor force, Chile has been able to develop profitable value chains, well integrated from production to final markets, and able to remunerate its participants at comparable levels to the rest of the rural economy.

In five letters, Chile's agriculture is:

English	Spanish
C Clean	**C** Capacitación continua
H Healthy and wholesome	**H** Honesta y saludable
I Information based and Internationally integrated	**I** Integrada internacionalmente y basada en información
L Learning oriented	**L** Limpia
E Efficient and Equitable	**E** Eficiente y Equitativa

Based on the background studies, the interviews and the focus groups, the following topics were identified as key elements for Action in the next five years in order to move towards the components of the Vision:

A. Benchmarking and strengthening Chile's agricultural innovation system in comparison to other OECD countries
B. Strengthening the availability of new information and knowledge to agricultural producers
C. Improving the technological control over production systems
  C1. Pursuing genetic improvement and biotechnology for developing eco-efficient agricultural production systems
  C2. Improving farm management, including agronomy and water use efficiency
  C3. Strengthening value chain management systems, through expert and market information systems
D. Enhancing quality compliance and certification systems
E. Improving the human resource base, especially within the value chains

What follows. The remainder of the report has 4 chapters. Chapter 2 will briefly outline the current agricultural innovation system and how it is integrated in the sector and in the National Innovation System. Chapter 3 will outline the objectives of the Action Plan, the principles on which it is built and the way it is structured. Chapter 4 is the most extensive. Based on an analysis of the current innovation system, it will detail the institutional elements of an Action Plan for the next five years, together with the expected results. Chapter 5 then outlines the thematic dimension of the Action Plan: the topics that require special attention if Chile wants to further strengthen its innovation performance. Chapter 6 describes the next steps to implement the Action Plan, and establishes a Roadmap for its implementation.

Besides the background studies for the earlier papers, in-depth studies were commissioned on the thematic areas identified in the Vision report. These studies present the current situation (baseline) in each of the areas and identify specific issues that need to be addressed if the country is to confront the challenges presented by changing markets, societal trends and internal dynamics. The Action Plan draws on these, as well as the earlier studies, and proposes to build on the current strengths of the existing agricultural innovation system.

2. Evolution of Chile's Agricultural Innovation System – a Summary

2.1 Policy Environment

The transformational changes of Chilean agriculture over the past forty years have been adequately documented. Macroeconomic reforms enacted after 1974 played an important role in setting the stage for the changes that occurred throughout the sector. Among these important reforms were the setting of an adequate real exchange rate, removing quantitative import restrictions, reduction of import tariffs and a more competitive rural labor market.[8] These reforms, coupled with a series of natural advantages (i.e. adequate climate, counter seasonal production vis the northern hemisphere, and cheap labor), resulted in a phenomenal increase in fruit exports which continues up to the present. Reliance on the market as a mechanism for resource allocation continues to be a central feature of Chile's macroeconomic policy.

Much of the increase in fruit production occurred in irrigated areas, thereby displacing traditional agriculture, i.e. cereals (with the exception of maize), food legumes, pastures and animal production, to rainfed areas. These agroecological shifts have been pronounced, and continue to adjust, giving Chilean agriculture a strong regional specialization, i.e. fruit production dominating in the north-central, and central areas of the country, while cereal, potato, meat and milk production are concentrated in the rainfed areas of the south.

There have been also been significant changes in what is called traditional agriculture, with increases in productivity in the principal crops and horticulture as well as livestock production.[9] These latter subsectors have great importance on a regional basis, forming the productive agriculture base for local development as well as being the main source of nutritious, healthy food for domestic consumption.

2.2 Three Phases of Change

Modern organized agricultural sector innovation in Chile is a phenomenon of the past fifty years and can be divided into three phases. The initial phase begins in the 1960s with the establishment of the *Instituto Nacional de Investigaciones Agropecuarias* (INIA), and the *Instituto Nacional Forestal* (INFOR). INIA was established to address issues of agricultural productivity in commodities such as cereals, meat and milk, as well as a range of agronomic issues such as crop management, soils, water and chemical inputs.[10] INFOR was founded to address forestry issues ranging from planting to harvesting and utilization of forestry products. These initiatives have given important results, since much of the basic information on the resource base of agriculture was developed during this time. Although little impact evaluation has been done, the work of Irarrázaval et al[11] has shown estimated annual internal rates of return of research and extension on wheat and maize during the period 1949-1978 to range between 21-34%. These results indicate that returns to research and extension in Chile are in line with those from other countries[12] and are socially profitable. This phase supported an agricultural policy that was focused on food self-sufficiency and social equity. The model was almost exclusively state financed and executed.

8 Jarvis, Lowell S., Changing Private and Public Roles in Technological Development: Lessons from the Chilean Fruit Sector. In: Agricultural Technology: Current Policy Issues for the International Community, Wallingford: CAB International,1994.

9 FAOSTAT Op. cit.

10 Faigenbaum Ch. Sergio, *Ciencia, Agricultura y Sociedad: Cuarenta Años del Instituto de Investigaciones Agropecuarias*. Unpublished, 2007.

11 Yrrázaval E., Rafael, Rodrigo Navarrete G., and Victor Valdivia P., *Costos y Beneficios Sociales de los Programas de Mejoramiento Varietal de Trigo y Maiz en Chile*. Seminario sobre los Aspectos Socioeconómicos de la Investigación Agrícola en los Países en Desarrollo, Santiago de Chile, May 7-11, 1979.

12 Evenson R., Economic Impacts of Agricultural Research and Extension; Chapter 11. In: B.Gardner and G.Rausser (eds). Handbook of Agricultural Economics, Vol 1A, North Holland.

A second phase in the history of agricultural innovation begins in the late 1970s with the opening up of the Chilean economy and the start of the fruit boom, and lasted until the mid-1990s. Innovations in the expansion of the fruit sector were mainly the work of the private sector building on the public sector investments of the 1960s in the development of scientific expertise such as the Chile-California program.[13] These innovations were applied across the production/post-harvest spectrum of activities. They included the introduction of new crops and varieties, orchard management, and post-harvest activities. Export firms played a major role in introducing and managing the innovations and were able to capture significant benefits from these activities. Since only a small proportion of such activities were privately captured, it would be logical to assume that the private sector would not invest in innovation to the extent that it did. However, during the early phases of the expansion, the profitability of many of the innovations were so high relative to their cost that the private sector invested freely.[14]

During this period the public sector institutions retained their mandate to support traditional agriculture, albeit with reduced budgets and personnel. Nevertheless, with support from private sector efforts, some notable successes were achieved. For example, wheat productivity increased from 1700kg/ha (1980-82) to 4600kg/ha (2006-08).[15] The formation of the *Grupos de Transferencia Tecnológica* (GTT), which were organized by INIA, was also seen as a major success in the area of technology transfer, being especially important in response to the government's policy of price bands to increase wheat production in the 1980s. At the same time INDAP introduced a new approach to technical assistance. This approach, coupled with lending, combined public support with private delivery. It targeted exclusively small farmers[16] with long-term viability potential. This program, which has undergone several adjustments since it began, remains an important component of the government's strategy to support small farmers.

The third phase of the evolution of the agricultural innovation system began in the mid-1990s with the creation of a number of competitive funds for innovation. These funds have had a profound impact on the agricultural sector by both diversifying funding sources as well as allowing a wider participation of other suppliers of innovation (i.e. universities). Agencies that led this expansion of competitive funding for applied research and innovation are CORFO (*Corporación de Fomento de la Producción*) through its INNOVA-Chile program (previously Fontec and FDI); CONICYT (*Consejo Nacional de Investigación Científica y Tecnológica*); and MIDEPLAN (*Ministerio de Planificación*), through ICM (*Iniciativa Científica Milenio*).[17] FIA (*Fundación para la Innovación Agraria*) is a fund that is specific to the agricultural sector. Initially most of the competitive funding schemes lacked a clear focus, had a wide array of objectives and responded mostly to project supply. Over time, however, the calls for proposals have become more specific.

These competitive funds (with the exception of FIA), along with other institutional innovations such as the establishment of consortia, Regional Centers and centers of excellence, have taken place outside of MINAGRI with the result that, in practice, priorities are being set by the funding agencies rather than by the sector. The strategy adopted by the sector and its institutions is to accommodate to these priorities. The present financing of the system is dealt with in another section below.

13 This program was based on an agreement between the University of Chile and the University of California which provided access to Chilean students to get Masters and Ph.D. degrees at the latter institution.

14 Jarvis op.cit.

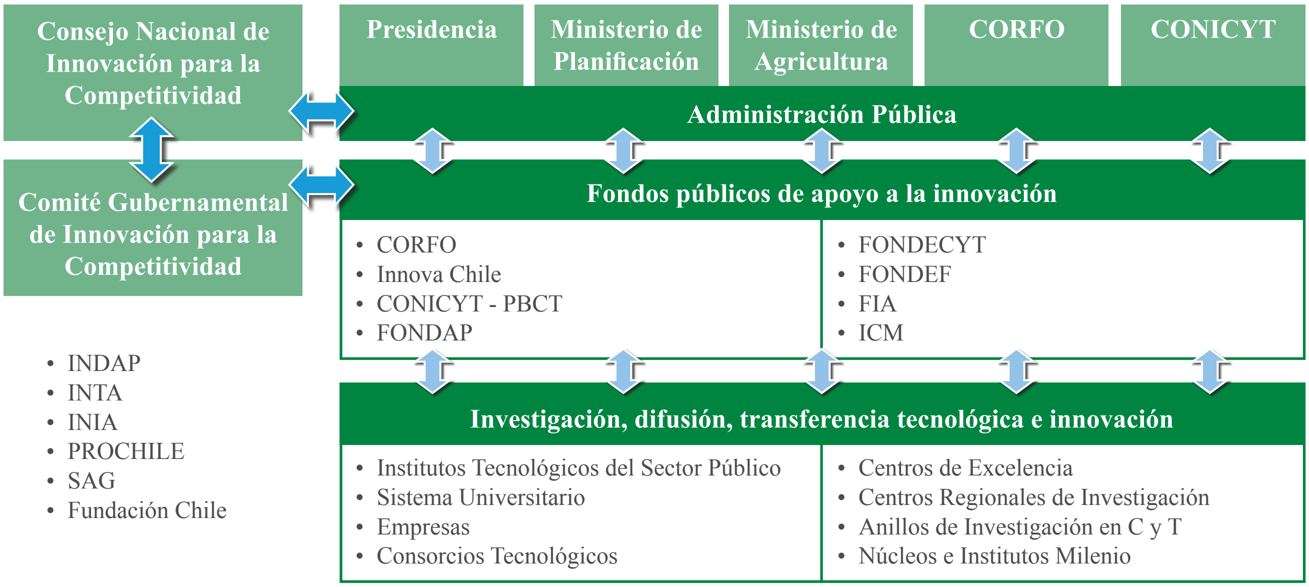
15 FAOSTAT – http://www.fao.org/corp/statistics/en/

16 The definition of small farms is written in the law, and has remained unchanged since 1962 – a maximum farm size of 12 irrigated hectares or its equivalent, based on the area's soil productive capacity categories (plus whether irrigated vs. rain fed, distance to markets, etc.) and a limit on owned capital.

17 Now under *Ministerio de Economía*.

The following Figure gives an overall view of the public institutions that are relevant to the agricultural innovation system today.

Figure 2. Public institutional framework in which the Agricultural Innovation System is embedded



2.3 Present and Future Challenges

The panorama presented above shows an agricultural innovation system that has undergone a series of major changes over the past several years and that has evolved into a system that is characterized by a diverse range of implementing and financing agencies, a large reliance on competitive funding, a strategy that is mostly set by the financing agencies from outside the sector, and a possibly large but undocumented input from the private sector in both research and technology transfer.

This system, in its different stages, has had many successes. Public sector research and extension were focused on traditional agriculture management of natural resources and issues related to small farmers. There have been large productivity increases in staple crops, such as wheat, and livestock production. Successes in the fruit sector came about from the import, adaptation and adoption of technology and know-how. This was mostly financed and implemented by the private sector over the past thirty years when profitability levels were high. The private sector continues to invest in innovation, especially in the high profit sectors such as wine and higher-end crops, but margins have been reduced in many subsectors and production problems are becoming more complex and costly. Besides profitability, limitations have been placed on the availability of technology, especially in the area of varieties, through the enforcement of intellectual property rights that require the payment of royalties. Moreover, markets are demanding products that combine quality, as well as environmental and social standards[18], which require solutions adapted to Chilean conditions.

As a result, the export sector is faced with a number of new issues on which it has to be competitive, confronted at the same time by the lose of competitiveness in the traditional areas of counter-seasonal production and cheap labor. Innovation needs are moving towards more basic and more costly solutions with higher levels of socially profitable activities that justify increased public intervention.

18 Giovannucci, Daniele, How New Agrifood Standards Are Affecting Trade. International Trade Centre World Export Development Forum, October 2008. Online at: http://mpra.ub.uni-muenchen.de/17203/

3. Objective, Principles and Timeline of the Action Plan

3.1 Objective

The objective of the Action Plan is to enhance the capacity of Chile's agricultural innovation system in order to achieve the goals as laid out in the agreed upon Vision for the sector for the year 2030. The Plan focuses on national and regional capacities, rather than on specific institutions, and identifies the major needed adjustments. It is proposed with the knowledge that the Government has assigned a central role to innovation in its growth strategy, and that the Plan will contribute to the effective participation of the agricultural sector in that strategy.

3.2 Principles Underlying the Plan

Five principles have been identified for organizing an effective agricultural innovation system for the next twenty years. These principles are outlined as follows:

- ***Subsidiarity – Building National and Regional Capacity.*** The Action Plan will focus on building national and regional capacities by drawing on the strengths of the current system as well as correcting the present weaknesses. Because of the country's unique geography and the increasing agro-ecological specialization in agriculture, regional competitiveness will continue to assume greater importance over time. As a result, capacity building will have to be implemented simultaneously at both the national and regional levels, with regional entities assuming a greater role in planning and financing the agenda for innovation.

- ***Public and Private Responsibilities.*** Both public and private sectors have responsibilities in Chile's agricultural innovation system and those responsibilities have to be distinct and complementary. The private sector will continue to set its own agenda within a regulatory framework (i.e. intellectual properties rights) which is the responsibility of the public sector. The public sector will focus on the public goods agenda using its resources to achieve the greatest possible social returns. Public investment should lay the basis for more private participation over time, with the private sector investing in activities where it can better appropriate the benefits. Since public and private agendas are dynamic and changing in response to internal and external factors, the management of these agendas will become an important determinant of the effectiveness and efficiency of the system.

- ***Diversity.*** An effective innovation system is made up of different actors with a high degree of interaction. These components include producers, processors, transporters and commercial agents in the value chains; and governments, researchers, extensionists, educators, consultants and financiers in the service sector. Each actor has to develop human capital and new knowledge for the improvement of the entire system. All these actors are already present and contributing to the Chilean agricultural innovation system. The Action Plan recognizes the diverse nature of the agricultural innovation agenda and the range of participating actors. It will promote diversity through open competition and through the differentiation of funding and implementation arrangements.

- ***Excellence and Flexibility.*** Since Chile is an open economy and since the Vision for the agriculture sector is to remain competitive in international markets, the country needs an agricultural innovation system that is able to collaborate with other innovation systems both in trading-partner and competitor countries. In other words, Chile needs a world class system that can gain access to, and partner with other innovation systems worldwide, allowing it to participate in the exchange of ideas, and that can change its orientation if conditions require it. This vision of excellence will lead Chile to assume a greater role in the discovery of new knowledge and to develop a stronger capacity for translating this new knowledge into practical applications. This will require benchmarking with other countries in aspects such as financing, administration, recruitment and personnel policies in the public domain, as well as the fostering of private sector capacity to absorb and apply new knowledge.

- ***Institutional Integration.*** The Action Plan recognizes that the agricultural innovation system should be an active participant in the national system and that there should also be more integration within the sector in order to increase critical mass and facilitate knowledge flows. An important reason is that many agricultural innovations are starting to originate in other sectors. For example in biotechnology, medical and agricultural applications may be linked. New fields such as precision agriculture are based on ICT applications such as Geographic Positioning Systems that were developed for more generic purposes. This will require emphasis on long-term programming and financing to link knowledge generation with knowledge application.

3.3 A Vision for 20 Years and Actions for 5 to 10 Years

While the Action Plan is designed to realize a Vision for 20 years from now, most of the proposals should be implemented in the next five years. Between 2011 and 2015, the institutional mechanisms and the main thematic actions will be implemented and put to work. Between 2015 and 2020, these changes can then be consolidated and, by 2020 major progress towards realizing the Vision can be measured. After 2020, the system will need to be adjusted and further consolidated as both external and internal changes occur. At this moment, however, it is hard to say what these changes will be.

4. A Plan for 2030 – Institutional issues

The Action Plan builds on the topics that were identified in the Vision 2030 document, but provides more attention to some than to others. Chapter 4 will elaborate on the main institutional issues related with the two first topics identified in the Vision.

The topic of **benchmarking and strengthening the system** will be elaborated through three themes:

- Leadership and Facilitation
- Getting Value for Money
- Institutional Integration

The topic on **strengthening the availability of new information and knowledge to producers** will be elaborated in:

- Translating Results

4.1 Leadership and Facilitation

After a period of rapid progress in which Chile had comparative advantages in counter-seasonal production, cheap labor costs, and free access to technology worldwide, the sector is faced with challenges in all of these areas along with increasing demands from retailers and consumers for standards that encompass quality as well as environmental and social standards. This requires a paradigm shift for the agricultural innovation system, moving from an ad-hoc "trial and error approach" based on available technology, much of it imported, to a more long-term view focused on productivity, quality, better resource management and the establishment of a knowledge base and mission-oriented institutions that support the sector's competitive advantage. Only with a long-term view, it will be possible to progress toward turning the Vision 2030 into reality.

Juxtaposed to these challenges, innovation is clearly prioritized at the national level and is seen as an engine for growth in the sector. The increased funding towards the sector from the different public funding sources is an evidence of this. The agricultural innovation system today is characterized as diverse, with many actors in the public and private sector, many sources of funding, a wide research agenda across the production spectrum, and a competitive funding system. The system has many of the key attributes that characterize a modern innovation system. However, there are also some key aspects missing, especially in terms of leadership, strategy and facilitation, that, if in place, should lend much greater synergy to the overall system.

Public leadership. MINAGRI has the responsibility to lead the public sector in this endeavor recognizing that innovation is a cross-cutting theme in its agenda (i.e. plant and animal health, support to smallholder agriculture, conservation of natural resources, biodiversity and forest resources). These issues have been dealt with in the first report of this work[19] and are reiterated here.

To participate actively in the National Innovation System, MINAGRI needs to formulate an innovation strategy that is in line with the overall national strategy and develop an agenda for its implementation. Up until now, most of the new initiatives that characterize the Innovation System have taken place outside of MINAGRI and priorities have been established by the funding agencies. MINAGRI and its agencies have accommodated themselves to these priorities without developing a proposal for a more complete, integrated agricultural and forestry agenda. The result is an unbalanced innovation agenda where it is difficult to ensure sufficient attention to priority subsectors or topics. Moreover, since it is so fragmented among different funding and executing agencies, it is difficult to evaluate the overall impact of this agenda in the sector. Rather than merely adapting to

19 Chile: Review of Public Technological Institutes in the Agriculture Sector. World Bank, 2009.

the objectives of the competitive funds, the suggestion is not only to use these funds to nurture new initiatives, but to additionally develop a leadership role within the agricultural sector in order to identify and support sector priorities.

MINAGRI now needs to position itself in a leadership position to maximize its policy impact. To do this effectively, MINAGRI should enhance its capacity to manage the issues related to agricultural innovation. **It is recommended that a Directorate for Innovation be established within the newly structured MINAGRI** whose main responsibility would be to ensure the participation of the sector in the National Innovation System and facilitate the implementation of its own agenda within the sector.

The first responsibility of this Directorate is to develop a strategy to articulate the positions of the agriculture sector within the National Innovation System, thereby contributing to the strengthening of that same System in general. Besides providing leadership, the Directorate would facilitate the implementation of the innovation agenda in the sector and be responsible for the quality of the outcomes. This would include the recommendations proposed in the first report[20] in regard to the management and strategic orientation of the PTIs in the sector. Its responsibilities would include: orientation of the flow of resources from the funding agencies to the priority strategic areas; setting quality standards and the implementation of a quality control system; ensuring permanent monitoring and evaluation; facilitating both private and public inter-institutional collaboration; promoting technology transfer; and monitoring developments in reference countries.

Private leadership. Strengthening Chile's agricultural innovation system is a joint responsibility of the public and private sectors, and will bring benefits to the country as a whole as well as to the individual enterprises of the agriculture sector. The public sector needs to have counterpart organizations in the private sector that can speak and decide on behalf of the latter, for example on priority programs, funding modalities and co-financing, and educational requirements. Currently, Chile has a large number of associations (*gremios*), but many of these represent only small groups of farmers and have a short-term perspective. This increases the system's transaction costs as well as the confusion, and is also leading, as shown in several consortia, to the use of public funding for private benefits (or to benefit a "small club").

The proposal is to invite the private sector to strengthen its organization, at the sector and key subsectors levels. MINAGRI might make funds available to support the establishment of these national producer and agro-industry associations for the first two years, after which they would need to have established their own funding base, for example through a voluntary contribution or a levy system. These associations should be actively engaged in the management of innovation activities in their domain, for example by suggesting priority areas to the competitive funds, and by participating in the governance of long-term multi-disciplinary programs. They should also provide co-funding for those innovation activities that exclusively benefit their particular subsector.

4.2 Getting Value for Money

Funding sources. Financing for the Chilean public agricultural innovation system comes from the following four sources:

- A transfer from MINAGRI to the sectoral PTIs under a Transfer Agreement, as referred to above. In practice this transfer mostly covers personnel and administrative costs
- Publicly funded competitive funding schemes with different objectives and priorities that are referred to above
- Specific research contracts with both public and private agencies
- Self-financing generated by the sales of goods and services

20 Chile: Review of Public Technological Institutes in the Agriculture Sector. World Bank, November 2009.

The Government of Chile has committed itself to significantly increase the funding for innovation activities. Between 2005 and 2011, it projected to almost quadruple its innovation budget in real terms (from $88.8bn pesos to $336bn pesos). This increase in budget has been financed through a levy on the mining industry. FIC (*Fondo de Innovación para la Competividad*) is in charge of allocating the resources across the innovation system. The following Table shows the evolution of financing in the main funding schemes since 2004.

Table 1. Evolution of the funding across agencies

Development of the budgets of the principal funding schemes in Chile (millions of pesos)								
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
CONICYT	45,482	50,618	63,769	90,317	80,277	140,527	196,986	213,975
INNOVA	na	10,679	31,201	38,074	52,371	63,977	68,565	72,458
FIA	4,035	4,771	4,223	6,497	6,985	7,206	7,667	8,053
ICM	na	4,157	3,975	5,977	6,178	6,560	7,543	8,061
FIP	2,211	2,193	2,170	2,246	2,340	1,280	2,704	2,476
FIC regional					20,227	25,555	28,626	31,324
TOTAL	**51,728**	**72,418**	**105,338**	**143,111**	**168,378**	**245,105**	**312,091**	**336,347**
TOTAL - 2011 prices	**65,283**	**88,812**	**124,656**	**163,708**	**177,154**	**250,778**	**316,835**	**336,347**

Until now, most of FIC's administered resources have been channeled to three institutions which are the major sources of funding for innovation. These are as follows:

- ***CONICYT***, which manages instruments such as FONDECYT, FONDEF, FONDAP (centers of excellence), and a scholarship fund (*Becas Chile*). These finance competitive funds in various sectors along with support for contracting human resources in industry and universities, core funding for research programs, workshops, technological consortia, and international cooperation.

- ***CORFO****,* through InnovaChile, supports by way of competitive a wide range of programs such as precompetitive innovation, capacity strengthening at the national and regional levels, business innovation, business incubators, technology consortia, contracting human resources in the private sector, seed capital, technological missions, scholarships (*pasantías*), and technology diffusion.

- ***FIA*** finances agricultural innovation projects, studies, regional innovation projects, and other areas such as technology missions, consultancies, and technical meetings.

This presents a broad portfolio of funding instruments for the innovation system and most of the institutions in the agriculture sector have conformed in one form or another to these instruments. As a result, a majority of the institutional innovations that have occurred in the agricultural innovation system over the past fifteen years have been driven by these funding instruments. Their competitive nature has had positive results by strengthening the capacity of the institutions to be innovative and creative in the preparation of quality proposals.

Fragmentation and duplication. There are also some disadvantages to the over-reliance on competitive funding such as the predominance of short-term projects, in contrast with research strategies that need to be financed on a long-term basis with implications for core funding and research infrastructure. Financial stability and a focus on long-term objectives are essential for research programs. Because of the fragmentation of financing for projects, these are spread among a broad range of institutions, or very often individuals, leading to a lack of coordination and lack of focus on strategic areas that are needed for a programmatic approach.

The objectives and rationale behind the funding instruments are not well differentiated, leading to overlap and duplication in the overall funding. Across many areas of research, it is noticeable that the funds often finance similar projects even though they manage a number of different instruments that could be used differentially and that could lead to more comprehensive outcomes. This is especially true in the agriculture sector, which has its own fund, FIA, that does not differentiate itself from other sources of funding.

The predominance of these instruments and the absence of an overall strategy at the sector level have meant that priorities are being defined by the funding agencies. This has led to a dispersed agenda, developed separately by each agency, permeating down to the research organizations, i.e. institutes, universities, etc., which, lacking their own strategies, have also been driven by the supply of financing.

Funding levels. Total public spending as a percentage of AgGDP in Chile reached 1.22% in 2006, the last year for which a general survey has been completed. This was higher than the average of 1.14% for the Latin American and Caribbean region and lower than the 2000 figure (2.35%) for developed (OECD) countries.[21] According to the same report, Chile had close to some 700 FTE researchers working in public (i.e., government, nonprofit and higher education) agricultural research in 2006. Of this capacity, some 49% pertains to the three institutes falling directly under MINAGRI (INIA, INFOR, and CIREN), 17.1% to institutes under other ministries (i.e., IFOP, CIMM, and CENMA – covering fisheries and some natural resources research), 5.2% to autonomous, nonprofit agencies (FDF and *Fundación Chile*), and 28.7% to 14 universities. The corresponding expenditures in public agricultural research have been estimated at some $36,547m pesos (or US$58.4m, at 2005 prices) in 2006.

Not included in these statistics are the research activities by private companies within the agricultural sector (like fruit exporters, seed companies and some of the bigger agricultural, forestry and fisheries enterprises).[22] According to the latest survey[23] on the private sector's R&D investments, the agricultural sector (including fisheries) spent some $10,056m pesos in 2006 on its own R&D and as well as R&D contracts, of which an estimated $2000m pesos flowed to the PTIs (based on INIA reporting some $1,152m pesos in terms of private sector R&D contracts for 2006). Total public and private expenditures for 2006 would then be around $45,000m pesos or US$71m.

The average budget per agricultural researcher in Chile was about US$84,600 in 2006. Compared to other Latin American countries, this is substantially lower than the Brazilian figure of US$126,300 per researcher, about the same as the Mexican figure of US$83,200, but higher than Colombia (US$71,200) and Argentina (US$49,700).[24]

Funding issues. In terms of financing, the agriculture sector faces two challenges: to increase the efficiency of available funding in the short term; and to increase and diversify funding over the long term. Since Chile is now a member of the OECD, it is assumed that it will benchmark its institutional innovations and levels of financing with those countries.

21 Stads, G. J., and C. Covarrubias Zúñiga. Chile. ASTI Country Brief No. 42. Rome: IFPRI, December 2008.

22 The "agricultural sector" definition used in this context follows the international classification of economic activities. Hence research investments by the agricultural machinery, agro-chemical industry and food processing industry are not included.

23 Análisis de la Quinta Encuesta de Innovación en Chile. Informe Final. SCL Econometrics. Santiago de Chile, September 2008.

24 Agricultural Science and Technology Indicators (ASTI): www.asti.cgiar.org/

Efficiency. To increase the efficiency of funding in the short term, t**he Ministry of Agriculture has to work with the funding agencies and to use its own budget to support multidisciplinary teams with a critical mass of scientists in its priority areas of interest**, and to put mechanisms in place that will bring financial stability to the system. Most of the project funding that flows to institutions is going to small teams, generally of one or two senior scientists with their assistants. Not only are these projects of short-term duration but they are not backed by sufficient scientific capacity. Such critical mass is necessary to develop the multidisciplinary research required to solve the problems facing Chilean agriculture. The issue of financial stability will require providing core financing to adequately cover all recurrent costs of these teams. A modern and improved research system would have reasonable funding security at a viable level and this should be enunciated as policy for the system. Core funding would be complemented by access to funding from other sources such as competitive funds.

The sector also has to work with the funding agencies to facilitate the allocation of their resources in a more differentiated way so that the needs of the sector are adequately covered. While the objectives of the funds are not sufficiently differentiated, this is further compounded at the project level, as allocations are driven by researchers' demands, resulting in serious overlap in terms of the types of funded activities. As these funding agencies have a wide array of instruments, the sector needs to provide guidance as to how these instruments can be used in order to achieve a more balanced research agenda, better aligned with sector priorities. **A better mix of instruments should strike a balance between core funding, competitive funding, performance contracts, development of human resources, support to private sector, infrastructure, equipment, etc.** An appropriate place to start would be with the sector's own fund, FIA, which should be used strategically to complement the other funds. In the early stages of the Plan, until 2014, the funds of FIA could be used to finance the institutional reforms that will be needed to meet the objectives of the later stages.

These goals should be achieved by 2014 using the financing instruments and the present levels of funding that are available.

Funding growth. Looking at the long term, the main issue facing the sector is to secure an adequate level of financing. If the goal is to benchmark with the OECD countries, a tripling of resources by the year 2020 will be needed. How this will be achieved and who will participate are key issues that need to be addressed in order to reach the proposed goal.

All of the public sector funding comes from a central source, e.g. Ministry of Agriculture, CORFO, and CONICYT. Because, by its nature, agriculture is a decentralized activity, and research and technology transfer agendas have to be developed locally, **there is a strong argument to be made that regional governments should be partners in the system with an emphasis on developing and financing local agendas**. Financing from national funds, i.e. MINAGRI, etc. would focus on strategic national programs not covered by the regions. The regional governments should focus on the technology transfer agenda, taking it over by 2020, when it should constitute at least 25% of the global innovation agenda. Another source of funding is **the private sector** and instruments such as development of consortia, tax breaks, IPR legislation and enforcement, should be put in place to encourage its participation. There could also be an important component from international companies through **foreign direct investment**.

All three sources of financing, national level government, regional governments and the private sector will have to contribute to the goal of reaching OECD levels by 2020. In an effective system, public and private sector research complement each other, because each one is involved in different types of activities along the research spectrum. Historically, in developed countries public investment has laid the foundation for private involvement in research.

This mix of national, regional and private sector investment in innovation will be the basis for Chile reaching the OECD benchmark for funding in 2020. A good management should allow for a 50/50 split between public and private investement, with a further 50/50 split between national and regional public funds.

4.3 Integrating Institutions

An effective innovation system is made up of different components with a high degree of interaction. Because of the public sector's reliance on competitive funds, a large diversity of institutions participate in the innovation system. However these institutions are largely disconnected from one another and do not benefit from each other's progress. To address this problem, there have been some initiatives in recent years such as the formation of consortia.

The Technology Consortia (*Consorcios Tecnológicos*). They are designed to strengthen collaboration between the private sector and the research agencies. The initial idea was based on the Australian cooperative research centers (CRCs). Unlike the Australian CRCs, however, the Chilean technology consortia have been set up as private entities with private companies, sector organizations, and PTIs and universities as shareholders. The funding agencies (CONICYT, CORFO/INNOVA-Chile, and FIA) finance about two-thirds of the original investment, mostly for feasibility studies and the development of the consortia, but do not hold any shares. The capital invested by the partners is mostly used to finance R&D and technology transfer projects, so the research output is widely considered to be a "club good for the benefit of the shareholders". Consortia can also formulate and mobilize resources for new, additional projects by accessing the funding agencies. The subsidy usually expires after five years and the members of each consortia are expected to finance its full costs from that point forward. To date, 24 technology consortia have been created of which 15 pertain to the agricultural sector: seven funded by INNOVA, five by FIA and three by CONICYT. Recent experience has shown that many of these consortia are not self-financed after five years[25] and will need further subsidies to continue. The focus on "club good for the shareholders" raises the question of whether public resources are being used efficiently or whether the subsidies are essentially being directed to obtain private goods with few positive externalities. A more equitable approach to consortia would be to focus these efforts on small farmers where the investment would more easily transfom into public goods.

The need for critical mass. The reduced level of collaboration among institutions has resulted in research teams that lack critical mass. This is apparent in many of the priority areas such as plant breeding, post-harvest research, farm management, etc. The institutions that are financed by the competitive funds often employ small teams that work on specific areas and lack the multidisciplinary approach that is needed. This is true even in large universities that have a research tradition and in the PTIs. These small teams also lack the capacity to interact with other actors in the system especially with the industrial sector, i.e. input suppliers, packaging, and food processing. This dispersed talent pool, spread over several institutions, needs to be integrated so that research teams have the critical mass to provide solutions to problems faced by both producers and industry.

On the public agricultural research side, there are two institutional entities that account for most of the capacity (INIA and INFOR) and the university system, which is very diverse both in terms of geographical distribution and human resources. The challenge lies in how to integrate these institutions in a meaningful way so that they provide the sustainable support that the sector needs over the long term.

Developing synergies between PTIs and Universities. The PTIs have a strong regional presence, being widely spread throughout the country and, in most cases, in close proximity to universities. They also have a good infrastructure for research and, in the case of INIA, a critical mass of scientists in some areas of priority

25 *Consorcios Tecnológicos en aprietos*. Revista de Campo, El Mercurio. May 9, 2011.

research. Universities have been playing an increasingly important role in agricultural research over the past fifteen years. It is expected for this trend to continue as universities keep expanding their doctorate and master's programs. This is especially true of the major agricultural faculties. There are many advantages to an agricultural research system that links university education closely with research. The quality of education, particularly at the graduate level, is directly related to students participating in research projects. As the professional degree program (*ingeniero agrónomo*) requires a student thesis, there exists a statutory blend between teaching and research, but universities usually provide very little operational budgets for research. Thus, the faculties depend on external project funding to sustain their research. This has led to professors being dependent on short-term projects without the capability of building interdisciplinary teams.

Research is an intimate part of the educational process and should receive the corresponding basic budget support and research appointments. The faculties of agriculture could contribute more than they currently do to solving problems in the agri-food sector through research if they have a clear mandate and stable funding for this purpose.

The integration of research and university programs could thus create critical mass, especially if the Regional Centers for technology transfer that will be discussed in the next section are located in the same place. The resulting critical mass might also help to create the environment in which spin-off companies flourish and where MSc or PhD post-graduates pursue the commercial developments of their earlier research work findings.

This enormous joint capacity to do research and technology transfer needs to have **a framework to establish viable and attractive linkage mechanisms among the various institutions of the system**. The integration should take place **within the priority research areas** identified for the future and **through the Regional Agricultural Research and Development Centers** that will be proposed in the next section. Integrated teams need to have stable funding and need to pool resources where and when necessary. This will require **programmatic funding** on the basis of performance contracts; **joint teaching appointments**; the **secondment of researchers** from the PTIs to bolster research teams in the universities; **collaboration in doctoral and master's level programs**; and the **integration of research facilities,** i.e. shared laboratories and equipment.

4.4 Translating Results

Many resources have been poured into research projects over the past fifteen years but little effort has been made to bring results to application. There are two reasons for this: while the projects themselves cover transfer costs, these are atomized because of their very nature; and the institutions that execute these projects dedicate very little or no resources of their own to technology transfer. The transfer of technology that does occur out of these research projects is often through contracting of the researchers by producers and businesses who can afford to pay for such support.

Chile's success in export markets would not have been possible without technology transfer, mostly achieved through innovative firms that financed and adapted imported technologies and paid for "know-how". These technologies diffused through a "trial and error" system. Input and machinery suppliers are also playing an important role, especially for producers who cannot afford to contract private advice. The small farm sector (*agricultura familiar campesina*) is supported by INDAP programs executed by private contractors. These programs are oriented towards farms with long-term viability – to initiate a sustainable path to higher incomes. INDAP's main current challenges are (a) to incorporate small farmers to the most dynamic value chains, particularly those linked to export oriented products, and (b) to support the development of medium sized farms (more than 12 has of irrigated land) that are too small for commercial credits and are not linked with exporters and processors.

Technology transfer is the weak link in the system. At the national level, INNOVA-Chile has identified that technology transfer to the private sector is one of the weak links in the innovation system. It launched a series of initiatives in this area such as the establishment of Technology Focal Points (*nodos tecnológicos*) and, more recently, Extension Centers (*Centros de Extensionismo*) to support the diffusion of technology to small and medium sized businesses.[26] The latter did not prosper because of the lack of good proposals. CORFO also supports a Technology Diffusion Program (*Programa de Difusion Tecnologica – PDT*) which finances centers based on production systems, and a Program for the Development of Providers (*Programa de Desarrollo de Proveedores – PDP*). These programs suffer from being of short duration, usually three years, and also from a lack of evaluation. Other programs financed by CORFO in the agricultural sector are generally thought to have positive impacts such as technology tours (*misiones tecnológicas*) outside the country, and international consultancies (*consultorías especializadas*) where foreign consultants are financed in Chile.

International experience. Drawing from international experience in technology transfer, the following trends are identified: centralized systems are being replaced by decentralized systems that are cofinanced by various levels of government and clients where possible.[27] [28] Farmer participation is increasing either by paying for the service to some degree or farmer organizations or local committees taking control of administration. The focus of technology transfer is shifting from classic, green revolution messages to more complex subjects such as sustainable resource management, quality compliance and emerging technologies and markets.

As a result, priority setting has shifted to the local level. Capacity in the developed countries is characterized by a high level of education of the extensionists coupled with a strong technical backstopping from extension specialists which in turn guarantees strong research-extension linkages. At the national level, overall strategy development, quality and impact assessment are important roles, while the local levels have a comparative advantage in assessing needs, identifying beneficiaries and designing and implementing programs at the ground level.

A revamped technology transfer system should bring efficiency to the overall innovation system by transferring knowledge and facilitating its flow through the innovation chain, both backwards and forwards among the various actors.

The target population needs to be organized. It is necessary to identify the target population of a revamped technology transfer system. The large commercial farmers are already linked into both external and internal markets and are producing high value crops. These farmers no longer rely on public extension systems as they are already accustomed to getting information from many sources. They are using modern ICT tools such as the Internet and mobile phone for up to the minute technical and marketing information. However, public programs in plant and animal health and food safety remain of major relevance for such farmers. Public support to technology transfer should focus on small and medium farmers that have the potential to incorporate themselves into productive chains. Most of these farmers will produce export crops or staples such as wheat, potatoes, beef, milk, etc. for the domestic market.

The level of organization of farmers in Chile is relatively low compared to other countries in the Latin American region, i.e. Colombia and Mexico. In recent years, there has been an increased awareness of the need for joint action on the part of some growers and new organizations have been formed such the Avocado Growers Committee (*Comité de Paltas Hass*) and ChileNut. It is in the public's interest that farmers are better organized

26 INNOVA-Chile/CORFO. Programa Centros de Extensionismo. Santiago de Chile, 2009.

27 http://www.extension.iastate.edu/communications/Extension2009/Extension2009.pdf

28 http://extension.oregonstate.edu/extadmin/sites/default/files/documents/2005-2007budget.pdf

and a certain level of association is vital for the efficient functioning of the innovation system. The government would be justified in supporting the organization of farmers.

The technology transfer system should be organized and paid for at the regional level; focused on organized farmers with emphasis on working with lead farmers; and graduation of farmers from the system as they become more integrated into the productive chains and acquire skills to manage their own technology and information needs. Since medium to small-scale farmers are becoming more dependent for their information on input and machinery suppliers and other value chain actors, and technology transfer becomes increasingly privatized, public extension will have to focus more on public goods such as risk reduction in terms of plant and animal health as well as food safety, product quality, and environmental management. Training will be a major element of the technology transfer system, focusing for example on the managing of logistics at the farm level (harvesting and packaging).

A new technology transfer system. The proposed structure for a new technology transfer system is **to develop Regional Technology Transfer Centers** throughout the country. These centers would be staffed by highly trained technology transfer specialists, like the extension specialists that are employed in the US system, and would form a part of the multidisciplinary teams for agronomy that have been proposed above. These centers would be located in research institutes, university campuses or other accredited institutions. They could also be co-sponsored by one or more of these institutions as the conditions demand. They can be organized around production systems or regional or commodities themes. They would develop their agendas in concert with regional and producer priorities. **The role of the extension specialists would be to organize and work with groups of extensionists from both public and private sector,** i.e. input suppliers, etc., and lead farmers both in the transfer of knowledge and facilitating the feedback to the research system to help make research more relevant. All technology transfer mechanisms should be integrated under such a program including the present INDAP program. The regional INDAP specialists should be incorporated into these multidisciplinary teams. Joint INDAP/technology-transfer-center appointments should facilitate these activities.

This increased emphasis on technology transfer will require a substantial investment to support its establishment and it is recommended that the financing of this new effort be sourced from the regional governments. These centers should have core funding that will allow the fulfillment of their role. Their development should be undertaken immediately and, by building on the infrastructure that is already present, at least 4 adequately staffed centers should be in place by 2013. Resources dedicated to technology transfer should reach 25% of the public budget dedicated to agricultural innovation by the end of 2015.

The centers will not support technology transfer to individual farmers, but will develop **partnerships with both public and private actors**, **a range of methodologies** depending on the message and the clientele, **a policy on access to information**, the recruitment of **professionals across a range of specializations** and the use of **modern communications technology** in all its aspects. Box 1 provides a summary of some of the ICT options that such Regional Centers may explore. The clientele of such a center would range from farmers groups, field extensionists (both public and private), and all actors in the production chain. In terms of the organization of farmers, Chile has had a very positive experience with the organization of the *Grupos de Transferencia Tecnológica* (GTT) during the 1980s.[29] This proven methodology should be revived at the local level as it not only allows strengthening contacts between the client and the research system but also facilitates

29 Faigenbaum Ch. Sergio, *Ciencia, Agricultura y Sociedad: Cuarenta Años del Instituto de Investigaciones Agropecuarias*. Unpublished, 2007.

farmer to farmer diffusion of technology.[30] Such a program should be focused on leader farmers who have the capacity to innovate.

Box 1. How ICT can improve Agricultural Services along the Supply Chain

Information and Communication Technology is a very rapidly developing field. New ideas come up almost by the hour, often not in response to a need or a demand but to an opportunity that nobody realized before. In agriculture, ICT can have many roles and this box summarizes some of them:

- **Acquiring and retaining endowments.** Traditional land tenure, lack of banking facilities, and deficient infrastructure create barriers to smallholder involvement in profitable markets. Mobile financial services and digital land administration create new opportunities for farmers to increase their collateral.
- **Improving farm practices.** Digital soil maps and advanced monitoring systems identify soil fertility at low cost and help farmers deciding what to plan and how to fertilize. Wireless sensor networks prevent pesticide overuse, allow irrigation fine-tuning. Livestock tagging systems may greatly improve sanitary management at farm and country level.
- **Information for better decisions.** Government web portals allow farmers to access regulatory information and licensing services. Local alert systems may change planting or crop protection decisions. Farmers may upload information to extension offices for improved feedback on their problems.
- **Risk management.** Early warnings systems about weather or market conditions reduce price and climate risk. Parameter based weather insurance reduces transaction costs; damage can be assessed remotely.
- **Improving market information and value chain management.** ICT allows to shortcut traditionally long value chains with many intermediaries, improves traceability, helps to manage storage conditions and helps farmers to sell at the right time in the right place.
- **Farmer to farmer exchanges.** Social media such as Facebook allow farmers to share their practices among their friends, and to learn from their experiences.
- **E-learning.** Farmers and farm groups may learn about new production practices through web-based distance learning tools

Source: World Bank. ICT for Agriculture Sourcebook. 2011, in preparation.

30 Soza, R., 1985. *Causas de articulación de la generación y transferencia de tecnología: los Grupos de Transferencia Tecnológica (GTT) de Chile.* In: Horacio Stagno y Mario Allegri (eds). Seminario sobre Organización y Administración de la Generación y Transferencia de Tecnología Agropecuaria. Montevideo, Uruguay, October 1985 – cited by Faigenbaum.

5. Thematic Areas and Cross Cutting Issues

Chapter 5 explains with more detail the three main thematic areas that were identified in the Vision.

A. “Improving technological control over production systems” will be elaborated in three sections:
- Genetic Improvement
- Farm Management
- Harvest and Post-harvest

B. “Enhancing quality compliance and certification systems” will be elaborated in:
- Standards and Quality

C. “Improving the human resource base” will be elaborated in:
- Qualified Human Resources
- Labor Resources

5.1 Genetic Improvement[31]

Chile has had a long history of genetic improvement in crops, having programs in such traditional staples as wheat, potatoes and rice. These programs, which have made important contributions both at the national and international levels, have incorporated international sourced germplasm and have developed varieties that form the basis of national production.

The large diversification in the number of crops grown over the past thirty years has been done on the basis of the introduction of varieties from other countries, and it has been only in recent years that programs in genetic improvement of fruit have been initiated. To supply expanding markets in the emerging economies, new species and varieties will be demanded with different attributes (taste, ripeness, antioxidant content, etc.) than are available at the moment. Varieties with a better adaptation to Chile’s local conditions are needed. On imported apple varieties, for example, a 30% of production is unfit for export, because of sunburn damage.

Plant breeding capacity. Agricultural production systems will largely benefit, especially in the long run, with the development and management of genetic resources. Chilean agriculture is no exception, as evidenced in the area of its traditional crops where genetic improvement programs have allowed for both productivity increases as well as stability in production over the past fifty years.[32] If the country is to maintain its status as an important player in world food markets, it will have to do so on a dynamic and diverse genetic basis. Since 1997, there has been a strong move in Chile towards supporting plant breeding in general, with a special emphasis on fruit species. This has been sponsored mostly by CONICYT and CORFO, which together account for 79% of the projects financed, and by FIA. Of the 239 financed projects, 52 percent have been in the areas of fruit species, mostly in table grapes and stone fruits. The rest has been in traditional crops such as wheat, potatoes, and beans.

Genetic improvement encompasses many scientific areas and requires a series of inputs for its proper development. Among these are human resources, access to genetic resources, agronomic management, support technologies such as biotechnology, investment capital, and a legal framework. Of the 239 projects financed since 1997 (Table 2), support has centered on biotechnology, followed by plant breeding and genetic resources. There has been very little support for agronomic management and for linking to the private sector to allow dissemination on a commercial basis. For a program to be successful there has to be a balanced

31 This section builds on the Consultant’s Report: *Mejoramiento Genético en Chile: Línea de Base 2010 y Prospectiva 2030*, Aquavita Ltda. Santiago de Chile, April 2011.

32 FAOSTAT.

programmatic support across all of these areas and an integration of these capacities in multidisciplinary teams. The present situation in each of these areas is dealt with below.

Table 2. Chile: Publicly funded genetics-related R&D projects, 1997-2010

	Livestock	Annual Crops	Plant studies	Fruit	Vegetables	Sheep	Total
Agronomy	1		1	8	3		**13**
Genetic improvement	1	9		36	10	4	**60**
Genetic resources	3	4	2	24	1	6	**40**
Support technologies	13		12	47	9	3	**102**
Development & transfer	4	4		11		5	**24**
Total	**22**	**35**	**15**	**126**	**23**	**18**	**239**

In terms of human resources Chile has a small but well qualified group of people working as plant breeders many of which are found in the traditional centers of plant breeding, INIA and the universities such as the University of Chile, Catholic University and the University of Talca. A total of 60 institutions have participated In the genetic improvement projects financed since 1997, of which 74% were executed by public institutions and 10% by private ones. Of the public projects, 32% were executed by INIA, with the UC, PUC and Universidad de Talca making up the most of the rest -25%- (Table 3). A total of ten institutions account for 73% of the plant breeding projects. Three consortia have crop improvement in their agenda, *Biofrutales*, *Consorcio Tecnológico Hortifrutícola* and the *Consorcio de la Papa*. Up to now, most of the projects have had a three year duration. However, since 2010, CONICYT is financing projects with a ten year duration. In the area of wheat, one private company, *Semillas Baer,* is an important player but does not receive public funds.

In the area of support technologies, new tools such as molecular markers have been developed and are making plant breeding more efficient. These and other tools are now important part of any breeding program. Over the past fifteen years, biotechnology has received a very high level of support from funding agencies in Chile coupled with scholarship assistance. Future support for biotechnology in the agricultural sector needs to recognize that it has to be an integral part of genetic improvement programs and not implemented in isolation.

Table 3. Chile: Number of publicly funded genetics-related projects by executing agency, 1997-2010

	Livestock	Annual crops	Plant studies	Fruit	Vegs.	Sheep	Total
Instituto de Investigaciones Agropecuarias	6	20		35	12	4	**77**
Universidad de Chile (UC)	2	1	2	16	2	1	**24**
Pontificia Universidad Católica de Chile (PUC)		1	6	11	1	1	**20**
Universidad de Talca		1	2	9	2		**14**
Consorcio Hortifrutícola				7			**7**
Universidad Austral de Chile		3	1		1	2	**7**
Universidad de Concepción	3			4			**7**
Andes Nursery Association (ANA)				6			**6**
Universidad Técnica Federico Santa María			1	5			**6**

	Livestock	Annual crops	Plant studies	Fruit	Vegs.	Sheep	Total
Fundación Chile			1	3	1		**5**
Pontificia Universidad Católica de Valparaíso				3	1		**4**
Biofrutales, S.A.				3			**3**
Universidad Nacional Andrés Bello				3			**3**
Centro de Estudios en Zonas Áridas (CEAZA)				2			**2**
Otras Instituciones	9	5	2	18	3	10	**47**
TOTAL	**22**	**35**	**15**	**125**	**23**	**18**	**238**

Restrictions to germplasm access. A key ingredient for any plant breeding program is access to a broad range of genetics resources. International exchange of germplasm is a common feature in traditional crops, especially through international centers, and Chile actively participates in these networks. In the case of fruit crops, access has become more restricted and it is assumed that this tendency will continue. Most of the new fruit varieties are protected, either under plant protection laws or patents, and royalties are charged for their use. A key decision for a country such as Chile, which has long depended on importing new varieties, is whether it should develop its own breeding programs or buy its access to these new varieties.

Chilean fruit production depends almost exclusively on imported germplasm. The country exports a wide selection of fruit species totaling 36 in 2010. However, five crops account for 77% of exports, i.e. table grapes (40%) red apples (15%) kiwi (8%), avocado (7%) and blueberries (7%). The varieties used in production are almost exclusively imported and are in the public domain – Chile is not paying for their use. It is estimated that about 800 varieties of fruit are sown in the country. The widest variability is found in stone fruits but narrow in other species such as kiwi and avocado. For example, 40 varieties of grapes are sown but only four varieties account for 90% of the export volume.

The new fruit varieties that are coming on the market are mostly protected. At the moment, there are 387 varieties registered as protected in Chile under SAG - 50% percent of those come from the US with New Zealand, Italy and Spain being other important providers. This protection has meant an increase in private investment, although public investment continues to be important in all of these countries. Protection has been an increasing trend over the past decade. For the period 1995-97 there were 17 protected varieties and this number has risen to 158 for the period 2008-2009. More than 70% are fruit varieties.

In crops and vegetables, there are 142 varieties registered as protected of which potatoes, wheat and beans make up 50% of the total. About 40% of these varieties are of national origin and the majority of the rest come from Holland, US and France. This level of national participation is an indication of the strength of the national programs in these crops.

Although there are a lot of varieties being introduced, production is still reliant on a limited number of varieties. Most fruit production in the world still comes from the old varieties and there has been little replacement. There is a very narrow genetic base in the export sector which means that there is little genetic variability for Chile to expand its supply of new varieties more attuned to Chilean conditions. This calls for better access to genetic resources.

Regulatory issues. The development of genetically modified varieties (GMOs) is also within the reach of the research community and a law governing the use of GMOs is being legislated in Congress. The release of GMOs will need to be done under a legal regime and risk management process that has credibility in the consumer community. Because of the strong export component of the agricultural sector, the acceptance of GMOs will be determined by their acceptance in the export markets.

Commercialization of varieties is usually in the hands of the private sector. In Chile, this is being done by both international and national companies. These companies require an adequate legal framework that allows them to recuperate their investments, which requires patenting or varietal protection. Chile is a signatory to the International Union for the Protection of New Varieties of Plants (UPOV) (*Unión de Protección de Obtenciones Vegetales*) which allows the protection of plants as an intellectual property right. Although there has been a lot of progress in terms of intellectual property rights, their enforcement is still a matter of concern in Chile.

In summary, the Chilean export sector is inserted in a dynamic market where consumer preferences, trade restrictions, or environmental safeguards are constantly changing. Such challenges require well established programs that have the capacity to plan for the long term and to respond to the demands, both seen and unseen. Such well established programs bring several advantages. They allow for more anticipation and quicker responses to change, Furthermore it is well known that advanced capacity also allows for quicker adoption of innovations developed abroad and better learning. Innovation in the field of genetic improvement has to be managed as a long-term process. Breeding a new fruit tree variety requires between 12 to 20 years. For traditional crops such as wheat the time required is 6-10 years. Because of changing market demands and evolving growing conditions, Chile should develop its own genetic improvement capacity in the fruit sector. This is also true for horticultural crops and vegetables.

Strengthening genetic improvement. Chile has the basis for a good program in genetic improvement in various areas. This base needs to be built on, and to do so it will need:

- To develop multidisciplinary teams of scientists in various commodities and regions to continue to increase productivity and to ensure stable levels of production. Such teams may include breeders, biotechnologists, agronomists, and disease and insect specialists. A strategy paper on genetic improvement may be helpful to define which products and which disciplines should be considered.

- To manage the biotechnology tools so that they form an integral part of a genetic improvement program.

- To develop a legal framework concerning intellectual property and patents in order to strengthen the relationship between the scientific community and the commercial sector, and to ensure access to genetic resources worldwide.

5.2 Farm Management[33]

Agronomy. Chile has a very diverse agricultural resource base. This presents the country with many possibilities in terms of supplying both domestic and export markets with a variety of products. But it also requires a capacity to address a wide set of problems which have to be resolved at a local level. With the intensification of agriculture, especially the use of agrochemicals, there is a need to research the impact on soils, water, pathogens and insects.

This diversity, along with greater quality and certification demands, places the sector at a "tipping point" where it has to move on to a new stage of innovation that will require a broader agenda. Relying solely on technology acquisition from other sources will not be sufficient as many of the new problems relating to competitiveness

33 This section draws on the Consultants' Reports: Stanley Best, *Desarrollo Tecnológico para la Gestión y Manejo Predial (Tecnologías Emergentes)*; Fitonova, *Desarrollo Tecnológico y Adopción de Insumos Tecnológicos*. Santiago de Chile, March 2011.

will require local solutions. Looking towards the future, the competitiveness of the sector will depend not only on increased productivity, but also on meeting standards on food safety, quality, and traceability, environmental externalities, and soil and water quality. This requires research at the local level because the demands are different for different crops and regions.

Multidisciplinary teams should be put in place that can provide solutions at the local level. These teams would have the following roles:

- Development of mission oriented research programs defined as the solution of practical problems, i.e. increase the efficiency of water use, reduce the level of chemical residues, increase efficiency of fertilizer use, etc.

- Monitoring of cropping systems for early detection of problems and providing solutions in a timely manner.

Use of ICT. The use of ICT provides many opportunities to improve the quality and timeliness of decision-making (see also Box 1). This may lead to lower costs and environmentally friendly production systems that enhance sustainability and will help meet the environmental and social standards of the export markets.

The use of ICT in agriculture in Chile has been increasing over the last ten years. Recently there has been an initiative to extend wireless coverage to the rural areas which would further help incorporating ICT in the productive process. The new ICT areas include the use of GPS (i.e. for precision agriculture), GIS, remote sensors, biosensors, and smart machinery. Many of these smart systems are still relatively new in the country and only used in profitable sectors such as the vineyards-wine value chain. For their use to expand they need to be supported with detailed and well interpreted data. The use of ICT in getting extension messages out in a timely manner will also be an important component of technology transfer programs.

As the use of ICT is increasing, a major challenge is to ensure their maximum efficiency. **The public and private sectors may work together to ensure that ICT applications are backed up with adequate data** which may require field research across a range of disciplines. There is also a need to incorporate ICT in the curricula of the universities.

Ecological Inputs. Another opportunity for the sector is the new demand for clean production. This requires the development of environment-friendly farming based on ecological inputs. This type of inputs was previously used only by organic agriculture but is now entering into mainstream agriculture. Such farming will be based on biological control agents, integrated pest management and organic fertilizers, and should lead to a reduction in the level of residues and water contamination, and a smaller carbon footprint.

Organic agriculture avoids or excludes chemical inputs, and relies on rotations, incorporation of organic matter, green fertilizers, biological control, and recycling of nutrients. There is an increasing area of organic agriculture being certified in Chile although this is still comparatively small. However, export markets are demanding more organic products and this segment will continue to increase.

Supermarket chains are driving the demand for ecological inputs at the national level - using the GlobalGAP protocol or the Codex Alimentarius and the SAG guidelines on residues. Importing countries such as the EU and the US are introducing their own controls for domestic production both in food safety and the environment and will increasingly impose these standards on their imports.

Of the 1020 pesticides registered in the SAG, only 117 can be considered “ecological inputs”. The use of pesticides, mainly in horticulture and fruit crops, is a major issue for Chile, as residues that are above the guidelines issued by SAG are being found, especially in vegetables for domestic consumption.

Chile is well positioned to manage the demands for ecologically friendly agriculture. It is a signatory to the international conventions and protocols in the area of food production and environmental safeguards, i.e. Codex Alimentarius , Stockholm Convention and Montreal Protocol. It also has its own standards such as the *Programa de Monitoreo de Residuos de Plaguicidas* of SAG. There are also several institutions in Chile working in R&D in the area of biological control, both public and commercial. The establishment of the Technology Center for Biological Control (*Centro Tecnológico de Control Biológico –CTCB*) in INIA Quilamapu is a big step forward. Research is also being done at the Universidad Austral, Universidad de Chile, Universidad Católica, Universidad Católica de Valparaíso, Universidad de Concepción, Universidad de Talca and an increasing number of small commercial firms, such as Bioinsumos Nativa, Productos e Insumos Biotecnológicos, S.A. (BIOGRAM), Controlbest, and DROPCO.

For ecologically friendly agriculture to become more feasible at the farm level, the earlier discussed **mission oriented programs should include research and development of ecological inputs.**

Water Management. A large portion of Chile’s agriculture, and especially its export crops, are highly dependent on irrigation. With the agricultural frontier expanding into drier areas with the advent of drip irrigation, water consumption for irrigation has grown from around 16 million cubic meter in 1995 to 20 million cubic meters in 2010. Climate change is starting to reduce rainfall in many of the drier areas of the country, creating a push on agricultural production towards the South. Combined with greater rainfall variability this will require a focus on increasing water use efficiency and possibly a realignment in production areas and product mix. Drawing on the agricultural census of 2007, Table 4 shows the distribution of irrigation and the efficiency achieved under each method.

Table 4. Distribution of irrigation by type[34]

Type of Irrigation	Area under Irrigation		Efficiency
	Ha	%	
Gravity	789.840	72%	0.3850
Mechanical	56.498	5%	0.7500
Drip Irrigation	247.475	23%	0.8750
Total	**1.093.813**	**100%**	**0.510**

Source: Agricultural Census 2006-2007

Most irrigation (72%) is by gravity with little modernization and with low levels of efficiency. However, major increases in efficiency are achieved when irrigation is technified. When comparing with California (Table 5), the extent of Chile’s challenge in increasing water use efficiency is demonstrated. With changing climatic scenarios this is a priority area for Chile to maintain its competitive advantage.

34 Agricultural Census, 2007.

Table 5. Irrigation efficiency measured in California and Chile grouped by efficiency ranges[35]

	CALIFORNIA	CHILE
Efficiency Range	**% irrigation in each range**	**% irrigation in each range**
0-10	0	36
10.1-20	0	18
20.1-30	2	9
30.1-40	7	12
40.1-50	11	13
50.1-60	25	3
60.1-70	24	6
70.1-80	18	3
80.1-90	12	0
90.1-100	1	0
Average including reutilization	**71.0**	**36.7**

In summary, the main actions proposed on Farm Management are:

- **The development of multidisciplinary teams in the Regional Centers that are focused primarily on:**
  - **The management of natural resources towards clean agriculture**
  - **Efficient use of water resources at the farm level**
  - **The adoption of ICTs (wireless communication, sensors, MIS, GPS, robots, etc.)**
  - **The use of ecological inputs**

5.3 Harvest and Post-harvest[36]

Solving the problems associated with harvest and post-harvest management has been one of the major challenges for the fruit export sector since the beginning. Chile is far away from the consumer markets which means that most of the post-harvest period is spent in transport and that value chain management becomes key to competitiveness. Specific ecological conditions give rise to diseases like Botrytis spp. in table grapes, as well as certain physiological anomalies such as scald in peaches. These problems were mostly resolved by importing and adapting technology, with the risks borne by the exporters and producers involved. There are several examples of the adoption of imported technology such as the efficient use of sulfur dioxide (SO^2) to control disease during shipping; the use of more appropriate packing to accompany this innovation; and the calibration of cold storage for long shipping times. These innovations among others, allowed Chile to place quality fruit in the markets of the Northern Hemisphere in a timely manner.

While the acquisition of these technologies supported the development of the industry in its previous stages, there is further demand for the continuous development of product quality technology. These demands cover a range of issues from orchard management to transportation. Consumer markets around the world not only

35 Valenzuela A., Comparative study of irrigation efficiency: California and Chilean Central Valley. Universidad de Concepción, Departamento de Riego y Drenaje, Facultad de Ingeniería Agrícola, 1997.

36 This section is based on the Consultants' Report: Juan Pablo Zoffoli, Javier Jauregui, and Domiqued'Hainaut, *Tecnologías de Cosecha y Post-cosecha, Línea de Base 2010 y Prospectiva 2030*. Pontificia Universidad Católica de Chile, February 2011.

require different products but also different types of quality. The markets are dynamic and the fruit sector has been exploring them continuously, the latest example being the expansion of the Chinese market with its own quality requirements.

Since 2000, CORFO, CONICYT, and FIA have been financing competitive research projects on post-harvest issues. These projects require private sector participation and most of their support comes in the form of in-kind contributions. The projects analyzed can be characterized as follows:

- There is a similarity across funding sources regarding the types of projects financed with the result that there is a possibility of repetition and lack of efficiency.
- Most funding is short-term, covering the project life.
- Funding sources are not developing long-term strategic programs, which results in little synergy across the financed projects.
- Projects are often developed without taking into account results from previous efforts. They are not necessarily showing incremental progress.

These competitive funds have also helped identify and establish research teams across a range of institutions, from public research centers to private sector laboratories to universities which would form the basis for further efforts in this priority area. Four institutions have important capacities in place even though as many as thirty institutions may have participated in the funds. Research teams may be characterized as follows:

- Small nuclei of excellence in a reduced number of institutions.
- Teams are mostly dependent on project funding with little possibility for long-term development.
- Strengthening of teams especially in universities depends on factors other than research, i.e. teaching appointments.

At present, most of the attention is focused on specific problems such as physiological disorders and packaging. Post-harvest research requires work across many disciplines such as plant physiology, plant breeding, biochemistry, molecular biology, etc. In the area of packaging there is a need for the incorporation of other disciplines such as engineering and the linking of institutions with the industrial sector. Smart transportation and distribution systems need to be developed that combine low cost with optimal presentation and high market penetration. To deal with this agenda, multidisciplinary teams need to be integrated around the concept of value chain management. These teams should have the capacity to develop programs along the value chain and should interact intensely with the private sector in the development of solutions.

The proposal is **to establish a network of multidisciplinary teams** (from biological sciences as well as engineering, logistics, management and consumer sciences). A key responsibility for the network would be **to establish a strategic agenda** of interest to the private sector and to incorporate this agenda in the calls for proposals of the competitive funds. Both the network and the following programs and projects should be **funded on a shared basis between government and private sector**, with the private sector's share growing over time.

5.4 Standards and Quality[37]

Certification schemes. Standards have become an important competitive factor and are now an important component of international trade. Standards are driven by consumers, businesses (retailers), and a new

37 This section draws on the Consultant's Report: *Gestión de Calidad: Linea de Base 2010 y Prospectiva 2010*. Fundación Chile, March 2011.

regulatory environment. Major drivers in this trend are brand-sensitive retailers such as Sainsbury's, McDonalds, and Wal-Mart. There are currently more than 400 private standards schemes and among the best known are the International Organization for Standardization (ISO), HACCP (Hazard Analysis at Critical Control Points), Fair Trade, Good Agricultural Practices (GAP). The number is growing, with an increasing dependence on certifiers. It is a challenge for agricultural producers to keep up with, and understand these standards.

Within Chile, at least 15 different certification schemes are being implemented of which four, GlobalGAP, ISO 9001, USGAP cover about 90% of the total. Chile is the leading country in terms of the number of certifications in Latin America, representing 34% of all the region, but there still remains a large challenge in that only 30% of Chilean producers are certified under GlobalGAP. Today the tendency is towards standardization - especially towards GlobalGAP.

Several entities have responsibilities and competencies in the implementation of quality standards - the Ministry of Agriculture, the Agriculture and Livestock Service (SAG), the National Commission of GAP (*Comisión Nacional de Buenas Prácticas Agrícolas*) - a public private initiative, CODEX Alimentarius Chile, Chilean Agency of Food Safety (ACHIPIA), and the Ministry of Health. Chile also has a number of laws that regulate quality and food safety such as the Meat Law No. 19.162 (*Ley de Carnes*), the Wine Law (*Ley Vitivinícola*), and the National System for the Certification of Organic Products.

There have been many government initiatives to promote Good Agricultural Practices during the last ten years, which makes Chile a leader in the Latin American region. One of the major initiatives has been the establishment of ChileGAP for the fruit and horticulture sector, a public-private initiative promoted by ASOEX (*Asociación de Exportadores de Chile*) and FEDEFRUTA (*Federación de Productores de Fruta de Chile*) and implemented by the FDF (*Fundación para el Desarrollo Frutícola*) which has helped Chile resolve issues related to multiple certifications. Since 2008, ChileGAP is recognized officially as part of GlobalGAP, therefore simplifying the certification process. ChileGAP has the added advantage of incorporating food safety. 143 companies are now certified. This number will need to expand in the future.

Cost of certification. The cost involved in meeting standards (see Table 6) is putting pressure on producers, especially those with limited resources. Nevertheless, it is clear that standards are increasingly critical in global trade and especially for higher value and perishable crops which make up the bulk of Chilean agricultural exports. Quality standards may be necessary for market access but do not ensure remuneration – often seen by producers and exporters as a necessary evil. These quality and standards demands are handed down through the exporters to the producers and the largest adjustments and costs have to be absorbed at the producer level. The challenge is that, like the markets they serve are dynamic, these standards are continuously evolving which requires strong information linkages and knowledge transfer to the producer so as to maintain the competitiveness of the sector.

Table 6. Cost of a certificate under different standards

Standard	Cost (US$)
GLOBALGAP	300-650
BRC	1.400-1.600
Tesco Nature's Choice	640-700
ISO 9001 (LATU systems)	2.200-12.900
ISO 9001 (LS, ÖQS, IQNET)	2.950-113.700
CHILEGAP	700-800

The costs involved in certification and implementation of standards is a barrier to their adoption in Chile and these costs will only increase if there is further proliferation of standards. There are two worlds here - the top tier export sector who can afford to meet these standards and has the capacity to apply them; and those smaller producers who are squeezed because of the extra costs and who produce for the internal market. CORFO created a subsidy program, FOCAL, for the implementation of quality and food safety systems. Promotion and training programs for small farmers have been implemented through INDAP. These programs have not reached their goals due to the high costs of certification and implementation.

More and higher standards and new opportunities. There is a continuing increase in the export of organic products; apples, raspberries and organic wine being the main products. About 55% of organic products go to Europe and the rest to the US. According to Law 20.089, which governs organic production in Chile, organic products are certified by entities registered by SAG. The existence of this Law has resulted in a major increase in the number of hectares registered for organic production.

Standards are not only increasing in number but also in their rigor and requirements. In addition to quality standards, there are new requirements that cover areas such sustainability and social concerns. New standards such as carbon footprint and water footprints are being demanded by some of the big retailers, i.e. Tesco in Europe. Norms covering traceability will increase costs further. It still remains to be seen if the producers can adapt to the new standards as they have to the past ones.

The previous stage of the fruit industry was characterized by expansion into new areas and the introduction of new crops and varieties - the next phase will be meeting increasing standards and quality demands from the markets. This poses a number of challenges for the agricultural innovation system across its components, in areas such as regulation, knowledge management, training, and technology transfer. In this respect,quality management has two public dimensions: at the national level, efforts can be undertaken to establish Chile as a brand name, allowing the country to bring its standards to the markets rather than the other way around; secondly, support has to be provided to the small to medium exporter and to small producers for the internal market, also to make sure that national (brand) standards are not compromised. These producers need to be the target of integrated training and extension programs that should result in a large proportion of national production being managed under practices that are acceptable under international standards such as GlobalGAP, whether for export or domestic markets.

The following actions are proposed in the short to medium term in the area of quality standards:

- **Private sector led expansion of ChileGAP or more stringent standards for all agricultural production, be it for export or domestic markets**
- **Expansion of support programs for certification with public/private financing**
- **Benchmarking of quality standards with importing countries for Chilean produce**

5.5 Qualified Human Resources[38]

Chile's science pool. According to CONICYT (2004), the country has 8507 researchers of which 6476 work in universities, 964 in business, 506 in the state sector, 413 in non-profits, and 148 in other sectors. This diversity is the result of the use of the financing instruments that have been implemented in the last fifteen years to take advantage of the best capacity regardless of where it is.

38 This section draws on the Consultant's Report: *Recursos humanos de alta calificación en ciencia y tecnología del sector agroalimentario y forestal*. Ideaconsultora Ltda. Santiago de Chile, March 2011.

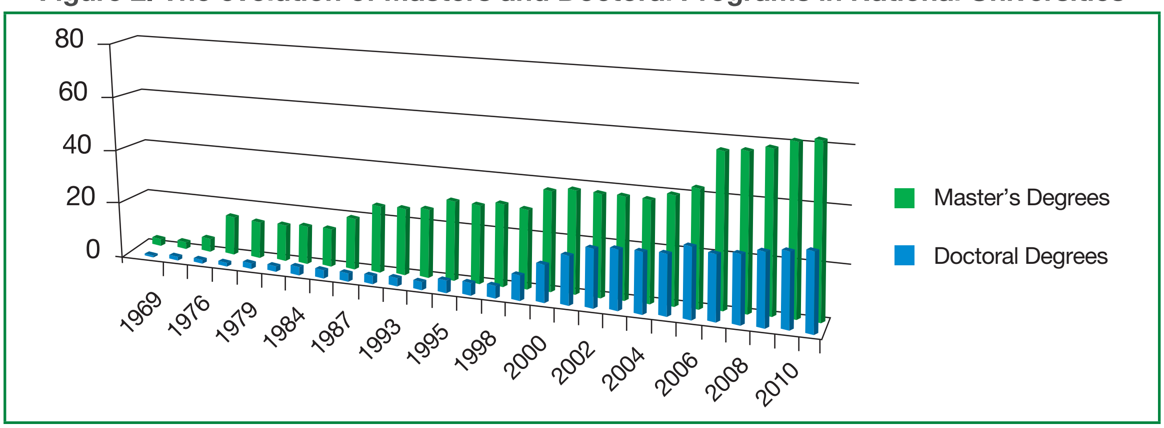
This effort has been accompanied by a series of policies and instruments to increase the number of highly qualified scientists in various areas of science, so as to ensure the implementation of the national innovation strategy. Most of the resources available in the country for advanced degrees come from public funds and from international agreements such the Plan Chile-California which has been important for the agricultural sector.

Productivity, as measured in scientific publications, shows Chile to be leading Latin America but still well behind the other OECD countries - 143 publications per 1 million of population as compared to Argentina (114), Brazil (72.5), Mexico (58), Australia (588), New Zealand (1083). The number of researchers per 1000 people is low (2.03) compared to other countries such New Zealand (10.48) Spain (5.39) and other OECD countries.

Strengthening the science base. CNIC has recognized the need for the formation of human resources for innovation both in national and foreign universities. According to the *Consejo Nacional de Educación* (CNED) the Chilean university system is made up of 57 universities whose main objective is teaching; only 10% do significant research. In the last decade there has been a major effort in national universities to increase the number of doctoral and master's programs, 170 programs giving doctorates and 900 master's degrees. Of these, 93 have relevance for the agricultural sector - 31 at doctoral and 62 at master's level, being delivered in 16 universities. Of a total of 395 doctorates given in 2008, 40 were in agricultural sciences.

Agricultural doctoral degrees are strongly inclined towards biotechnology which accounts for about 50% of the degrees awarded, while some key areas such as post-harvest and oenology receive little attention. At the master's level there is a strong emphasis on agricultural production as well as on other areas and the programs seem to be more congruent with the requirements of the national production system. Still some key areas such as water resources and post-harvest management are being left out.

Figure 2. The evolution of Masters and Doctoral Programs in National Universities



The most important initiative of the past years has been the creation of the scholarship fund, *Becas Chile*, which aims to increase the formation of professionals in foreign institutions and promote cooperation and linkages with international entities as well as modernizing the national scholarship system. *Becas Chile* is overseen by a Committee of Ministers which is responsible for its policies. It finances postgraduate studies, master's, specific medical studies and teaching scholarships among others. It has managed several calls for scholarships since 2006 and during the years 2008-2009 it has financed 1645 master's in foreign universities of which 12.4% were in agricultural sciences. Since 2006, *Becas Chile* has financed 1729 scholarships at the doctoral level of which agricultural sciences accounted for 3.6% of the total.

There are 1249 researchers working in the areas related to the thematic areas identified in the Vision. These were distributed among the various disciplines as shown in Table 7.

Table 7. Distribution of researchers by area

Areas	No. of Researchers	Percent
Biotechnology	288	23.1
Plant Breeding	112	9.0
Production Agriculture	233	18.7
Water Resources	91	7.3
Post-harvest	29	2.3
Food Safety	16	1.3
Agroindustry & Processed Foods	181	14.5
Economics & Policy	67	5.4
Bioenergy	23	1.8
Climate Change	17	1.4
Forestry	192	15.4

In terms of teams, the quality is quite heterogeneous with some strong groups, but many of these researchers work in small groups that do not have the critical mass to deal with programmatic issues. There is a strong need to put together stronger inter-institutional multidisciplinary teams, possibly with an international flavor.

The development of a program for advanced human resources needs to be done in collaboration with *Becas Chile*. The data above should be a starting point for developing a program to build a scientific talent pool that responds to the needs of the sector, both private and public, across a range of disciplines.

In summary, the agricultural sector should:

- **In collaboration with *Becas Chile,* elaborate a plan for the development of qualified human resources based on the sectoral strategy for innovation**
- **Strengthen international networks for the exchange of scientific personnel**

5.6 Labor Resources[39]

Qualifications, wages and innovation dynamics. Agriculture is an important source of employment: it accounted for about 800,000 jobs in the first quarter of 2010 or about 12% of the national workforce. The agricultural labor force has remained constant since 1996 even though employment in the overall economy has increased by about 31%. Labor intensive agriculture is based in the center and center-south parts of the country accounting for about 40% of sector employment. Table 8 gives a snapshot of the labor force and its evolution from 1992 to 2006. It shows that agricultural wage levels are considerably below the rest of the economy.

39 This section draws on the Consultant's Report: *Diagnóstico: Capacitation Trabajador Agricola*. FUCOA. Santiago de Chile, March 2011.

Table 8. Comparison of agricultural and non-agricultural labor forces, 1992-2006

	Agriculture		Non-Agriculture	
	1992	2006	1992	2006
Medium income (in 2008 pesos)	$ 155.312	$ 206.910	$ 308.616	$ 409.831
Rate of literacy (%)	90,4	93,0	98,7	99,2
Average years of schooling	6,9	8,2	10.9	12,0
% with medium level education	14,7	27,1	54,7	70,1
% with training in the last year	N/D	9,2	N/D	19,5
% with Access to cellular telephone	N/D	57,5	N/D	75,4
% with Access to computer	N/D	12,1	N/D	48,7
% with Access to Internet	N/D	9,1	N/D	42,5

Source: Modrego, et al (2009c). *Características de la fuerza de trabajo agrícola en Chile: tendencias y prospecciones relevantes para la innovación en el sector silvoagropecuario*. Report ellaborated by Rimisp for FIA.

Well trained labor is central to any dynamic innovation system. Evidence shows that the adoption of new knowledge, methods and technologies is strongly correlated with education.[40] This presents a special challenge for Chile since the level of education of its agricultural labor force is low and training programs are of mixed quality, although the recent initiative of *ChileValora* to set skills standards and certify training courses is a step in the right direction.

The low level of agricultural education starts with the low quality of basic and secondary education in the rural areas, characterized by irregular attendance, and fragmented coverage of subject areas. In secondary education the lack of attendance in rural areas is nearly three times as high as in urban areas. There is also the problem of small multi-grade schools, where it is difficult to maintain teaching standards. The negative and accumulative effects of this system are brought to bear on the agriculture sector for the lifetime of its workers.

In January 2010 there were 10,193 agricultural enterprises enrolled in formal schemes with 324,890 wage earners. The rest of the workers do not have formal employment contracts. According to the 2007 Census, agricultural enterprises are cataloged as Micro, Small, Medium and Large depending on the number of wage earners as shown in Table 9.

Table 9. Distribution of agricultural employees among different sized enterprises

Size of Enterprise	Nº of Agricultural Employees	% of Enterprises	% Employment
Micro	0	84	
Small	1-9	15	48
Medium	10-49	1	33
Large	>50	0.1	19

Small enterprise workers usually have primary or incomplete primary education and medium enterprise workers are classified as having primary (50%) and secondary (50%). This latter situation is repeated in the big

40 Huffman, W., and R. Evenson, Science for Agriculture. Iowa State University Press. 1993.

enterprises. Overall, 45% of those trained in the agriculture sector have only primary or incomplete primary compared to 13% in the economy overall. In agriculture, 9% have diplomas from professional technical colleges. 11% of workers have a superior technical diploma (*técnico superior*) compared to 24% in the overall economy.

The education level of the owners is characterized as follows: 59% have primary or incomplete primary education (*básica, básica incompleta*) 16% secondary (*enseñanza media*) and 7% university education. The basic level predominates in the micro and small subsectors, while university degrees are found in the medium to big enterprises. While the farm is usually managed by the owner in the micro and small enterprises, administrators are contracted in 73% of the medium and 83% of the large farmers. The skill set and training of this cadre of employees is crucial to the innovation system.

Training efforts. According to the CASEN data of 2006 and 2009, only 7% of agricultural firms use the tax rebate under SENCE (*Franquicia SENCE*) to finance training. Using the same data for 2009, only 7% of salaried workers received training. In 2009 there were a total of 57,000 salaried workers who received training out of a total of 517,000. Salaried workers receive the bulk of the training.

The amount of money invested in training in recent years is stagnant, on average this has been about $5000m pesos for the past five years of which 77% comes from the public purse and 23% from private sources.

In August 2008 the National System for Certification of Labor Skills (*Sistema Nacional de Certificación de Competencias Laborales*) was created. A Commission (*ChileValora*) was established to oversee the implementation of the system, reporting to the President through the Labor Ministry. The mission of this commission is to improve the labor skills in the economy through evaluation and certification as well as proposing policies and establish standards.

There is a major challenge for the agriculture sector to increase labor skills and productivity in the face of the rising costs of that labor. Productivity increases will have to be met through raising labor productivity and a special effort will be required in the small and medium enterprises where education levels are low and where training is reaching a small percentage of the labor pool.

In the area of the labor force the following actions are proposed:

- **Work with the Ministry of Education in the strengthening of basic education in rural areas**
- **Strengthen vocational training in agriculture and publicly financed training programs for agricultural workers**
- **The Ministry of Agriculture should manage a monitoring system on training needs**

6. Next Steps

The proposed Action Plan implies initiatives at various levels of the agricultural innovation system. The Ministry of Agriculture will strengthen its capacity to oversee and guide the future direction of the agricultural innovation system. The Action Plan implies working with the organized and unorganized stakeholders of the sector (farmers, traders, processors, exporters, input suppliers and so on) to establish organizations that are representative of complete subsectors and can contribute to funding the innovation system; with the Ministry of Education to address skills and human capacity issues in the countryside; with the regional governments to establish the Regional Centers for Technology Transfer; with the funding agencies to develop long-term funding mechanisms that complement competitive grants; with PTIs, universities and other stakeholders to integrate their activities into stronger teams with more impact.

To ensure the successful implementation of the Action Plan the following recommendations are made:

1. The Action Plan and the Vision behind it require further consultation and validation, especially in the regions. While ample consultations were held in the preparation of the documents, most of those took place in Santiago and at the national level. The resulting "helicopter view" needs to be complemented with the perspectives of stakeholders within each region. Such consultation/validation will have at least three important benefits: first, the existing recommendation can be confirmed or modified, thereby improving the chance of success of the refined Action Plan; secondly, the process may yield further actionable ideas that could be incorporated in the plan; thirdly, the discussions about the future of the sector may encourage the participants to develop their own ideas and proposals, thereby contributing to the vigor in the agricultural innovation system.

   For the consultation and validation process, MINAGRI may consider a series of regional workshops and a set of consultations with partners at the national level such as the Ministry of Economics, CORFO, CONICYT, the Ministry of Education, the National Society of Farmers (SNA), the major value chain and export associations. These consultations may be followed by a national seminar to present the major conclusions and resulting proposals.

2. The main Action Plan elements may be sequenced over time in order to learn from experience and to manage the workload. For this purpose it would be useful to develop a more detailed "Action Plan Operational Manual" that indicates, for each of the proposed activities, which organizations are involved; what are their responsibilities; what implementation progress can be expected; what are the costs of implementing the different activities; when are they supposed to be concluded; when would the first results be expected. Such sequencing also allows elaborating on the details on some of these steps, such as the specific architecture of the Regional Centers, the multidisciplinary teams, or the post-harvest network. Table 10 presents a Roadmap which outlines possible milestones for the main elements of the Action Plan.

Table 10. Roadmap for the implementation of the Action Plan

Year	Milestone
2011	• Validation and consultation of action has been completed • Operational manual in place; budget assignments agreed • FIA's strategy has been modified to incorporate its role as key implementer of the Action Plan

2012	• MINAGRI has established the function of innovation policy management and has put in place the required capacity • MINAGRI publishes its agricultural innovation strategy • Agreement reached with the Ministry of Finance on the growth of public financing to attain the OECD average in 2020 • First long-term multidisciplinary R&D program has been started • Agreement reached with *Becas Chile* on special call for the agricultural sector • Agreement reached with the Ministry of Education on the Rural Education Plan
2013	• Seven research programs in place that integrate PTI and University staff: 4x with INIA; 2x with INFOR; 1x with CIREN • 4 Regional Centers for Technology Transfer are operating • 8 long-term multidisciplinary R&D programs have been started • R&D support network to the packaging industry is operating • National Genetic Improvement strategy has been published
2015	• ChileGAP operates in all significant subsectors • First external review of the long-term multidisciplinary R&D programs
2020	• Public investment in agricultural innovation reaches the OECD average (as a % of AgGDP) • Two subsectors have established and are financing their own national R&D center

3. Many of the proposals presented here would not need more money, but would require a relocation of funds, for example from competitive sources to long-term assignments. With the operational manual discussed above, a budget proposal needs to be prepared which indicates, over time, the sources that will be used to finance the different initiatives, in order to ensure not only that the funds are available, but that they are in the right lines of the public budget.

Implementation of the Action Plan and the role of FIA. The implementation of the Action Plan will require considerable capacity and will involve significant institutional change. While the implementation of the Plan will be led by MINAGRI as soon as the function of innovation policy management has been established, the proposal is that, in the meantime, FIA leads the implementation of the Action Plan. Once MINAGRI has established the innovation policy management function, it may take over more responsibility. If, however, MINAGRI continues to operate as it does at the moment (a lean ministry directing a series of Services, Institutes and Foundations), it may decide to maintain the responsibility for implementation of the plan with FIA. **FIA would thus obtain a role as a change agent, as the innovation broker in its own system.**

A further new role for FIA may be in the strengthening of the evaluation capacity of the agricultural innovation system, both ex-ante and ex-post. While evaluation is important for short-term and long-term initiatives, ex-post evaluation capacity is central to the implementation of long-term multidisciplinary programs with core funding, to ensure that they stay on track, remain in tune with their clientele, and deliver state of the art results. Strengthened evaluation capacity will also help the system to enhance its learning ability, one of the attributes highlighted in the Vision for Chile's agriculture in 2030.

How could the future of the agricultural innovation system look? Chile's agricultural sector has made remarkable progress in the last 20 years. Chile's government recognizes the role of the innovation system in this success. It is willing to invest in the further growth of the agricultural innovation system and the agricultural sector in order to achieve the Vision of a clean, healthy and wholesome, information-based and internationally integrated, learning oriented, efficient and equitable sector. How such a future agricultural innovation system could look is outlined in Box 2. To achieve this Vision, the agricultural innovation system will require leadership; the establishment of more specialized human capacity (in R&D) as well as more human capacity on farms; long-term funding instruments that will complement the highly successful competitive schemes that Chile's government operates; and bigger roles, responsibilities and contributions from the private sector and regional governments. The implementation of the Action Plan will put in place the building blocks that will allow Chile to realize its ambition.

Box 2. A possible outlook on Chile's Agricultural Innovation System in 2030

Chile's farmers and farm businesses are known around the world for the quality of their production and supply chains. They use small amounts of inputs, applied on a "where needed when needed" basis. They are the global leader in sensor based crop and livestock management systems. Four key developments allowed them to leap to the front. By developing varieties with a special fit to Chile's ecology, the basic planting material came in place. Management parameters for these varieties were established by extensive agronomy and physiology research. Multi-sensor technology was developed, which monitors weather as well as pathological and physiological processes, allowing precise diagnosis of location and intensity of production problems. Chile's farmers and farm workers were trained to combine the elements of success: they manage the information technology and crop management parameters of their production systems and understand the markets that they are supplying.

While Chile is not only present in high value markets, its production is known for its intrinsic quality and its excellent storage life. Its fruits maintain maturity on the shelf, its seeds are guaranteed to germinate after a year or more of storage, and its animal protein products (fish, dairy, meat) are lean and functional to a healthy life. When "Michelin" selects two and three star restaurants, the wine card must contain at least four Chilean estates.

By combining production and post-harvest excellence, Chile has developed a niche in the global agricultural system for its own trademark. A trademark institute, funded by voluntary contributions from different value chain associations, maintains and certifies quality and food safety standards and promotes the trademark in Chile and abroad.

Chile's agricultural performance is based on a network of regional innovation hubs. In these hubs, usually located on or close to a university, one can find a regional center for technology transfer, integrated long-term research programs and a node of the post-harvest research network. With venture capital support of CORFO, agricultural technology businesses have sprouted around these hubs, and several of these are now exporting their sensor technologies, storage systems and packaging methods to other countries. Farmer groups visit these clusters, physically and virtually, for training on new technologies. Such training may be supplied by the universities or by the technology businesses themselves that rent classrooms or e-learning equipment. The most southwards cluster was the one that took off most quickly, but through exchanging experiences the others have caught up.

Every five years external evaluations are commissioned of the major elements of the innovation hubs. These evaluations are not only used to assess quality and relevance of past work, but also to define future plans and financial contributions of the concerned producer associations, as well as the regional and national government.