



CHILE

Vision

2030

Towards a Vision for Agricultural
Innovation in Chile in 2030

May 31, 2011

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Acronyms

AgGDP	Gross Domestic Product in the Agriculture Sector
BAU	Business as Usual
CIAT	International Center for Tropical Agriculture
CNIC	National Innovation Council for Competitiveness
CORFO	Corporation for Production Development
DNA	Deoxyribonucleic Acid
FAO	Food and Agriculture Organization
FIA	Foundation for Agricultural Innovation
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
ICT	Information and Communication Technologies
IMF	International Monetary Fund
INFOR	National Forestry Institute
INIA	National Institute of Agricultural Research
ISO	International Organization for Standardization
MINAGRI	Ministry of Agriculture
ODEPA	Office of Agricultural Studies and Policies
OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
RIMISP	Latin American Center for Rural Development
SPS	Sanitary and Phytosanitary (Standards)
WDI	World Development Indicator

Acknowledgements

The “Towards a Vision for Agricultural Innovation in Chile in 2030” report is the product of a collaborative effort between the Agriculture and Rural Development Unit in the Latin America and Caribbean Region of the World Bank (LCSAR), the Ministry of Agriculture (MINAGRI) and the Foundation of Agricultural Innovation (FIA) of the Government of Chile. The study was funded through a Fee Based Service agreement between MINAGRI, FIA and the World Bank.

This report was prepared by a core team led by Willem Janssen (Lead Agricultural Specialist) and comprising Riikka Rajalahti (Senior Agricultural Specialist), Svetlana Edmeades (Senior Agricultural Economist) and Beatriz Nussbaumer (Economist). The report is based on a series of background papers prepared in support of the study and an extensive consultation process that took place between December 2009 and November 2010. The report has benefited from very significant contributions by Mr. Fernando Rodríguez, the lead counterpart at FIA. An earlier draft of the report has been available for consultation and feedback since February 2011 on FIA's website and was shared widely within the sector. The final draft was produced based on the feedback received both from within Chile and the World Bank (through a comprehensive Quality Enhancement Review).

The team would like to thank the following persons in Chile who gave plenty of their time and provided valuable input to the report: Mr. José Antonio Galilea, Minister of Agriculture; Mr. Álvaro Cruzat, Subsecretary of Agriculture; Ms. Marigen Hornkohl, previous Minister of Agriculture; Mr. Reinaldo Ruiz, previous Subsecretary of Agriculture; Ms. Eugenia Muchnik, Director of FIA; Mr. Fernando Bas, Deputy Director of FIA; Mr. Rodrigo Vega, previous Director of FIA; Ms. Francisca Silva, Advisor, MINAGRI; Mr. Francisco Obrequé and Ms. Soledad Hidalgo and other staff of FIA; and the more than 100 experts that participated in the drafting of the background papers, the development of the scenarios and the drawing of the implications for the agricultural innovation system.

The team is also thankful to the following World Bank staff members for their support to this study: Ethel Sennhauser, Franz Drees-Gross, Michel Kerf, Ousmane Dione, Carlos Silva Jaúregui, Felipe Saez, Verónica Salatino, John Nash, Eija Pehu, Marie-Helene Collion, Aparajita Goyal, Matthew McMahon, Beatriz Franco, Ketty Morales, Ana Francisca Ramírez, and Ariani Wartenberg.



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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Executive Summary

Background. The current paper is the second one 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 agricultural¹ innovation strategy. The reason behind the study is that Chile's agricultural growth performance has leveled off in the last decade. Also, the sector might need to prepare itself for challenges to which it has not given sufficient attention or to which it is hardly aware of. The first paper reported on the analysis of the three main public technological institutes and made recommendations on how their performance can be improved. This second paper explores the future of Chile's agriculture towards 2030. Using a scenario planning methodology, the paper identifies the main opportunities and main challenges that will require attention if Chile wishes to resume its agricultural growth pathway of before the last decade, and proposes a vision to direct Chile's agricultural innovation system towards 2030. The third study will outline actions in order to address these main issues in the coming five years.

Proposed Vision. In 2030 Chile is a renowned quality producer of a range of fresh and processed food and fiber products. Its international image is marked by the diversity that its geography allows it to produce. The agricultural sector emphasizes 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 will be: **C**: Clean; **H**: Healthy and wholesome; **I**: Information based and Internationally integrated; **L**: Learning oriented; **E**: Efficient and Equitable.*

Methodology. A scenario planning approach was employed to explore the future of Chile's agricultural sector and the implications for its innovation system. Scenario planning aims at breaking away from the mindset that the future will be a continuation of the past. It provides useful insights about an uncertain future and helps improve perceptions and judgments in decision making to adapt to and shape the future. Based on alternative scenarios and the associated challenges or opportunities, the actors participating in the process can develop an approximation to future events, contributing to decision-making (within a country) that would most benefit any future conditions.

Process. The vision and its implications were developed through an iterative, highly consultative process. A series of background studies on major developments in Chilean agriculture were prepared; interviews were held with 11 persons of major significance to the sector in Chile. Based on this information a workshop was organized to start designing alternative scenarios for Chilean agriculture. Two major scenarios emerged: a scenario with strong climate change impacts and a strengthened regulatory environment (Terra Calida); a scenario with modest climate change impacts and a regulatory environment similar to the current one (Business as Usual). These scenarios were then presented to 7 focus groups made up of representatives of major subsectors, who were asked to draw the implications for the activities in their subsector if these scenarios would materialize. Three further focus groups were held to draw implications for major cross-cutting themes. The outcomes of the focus groups represent the desired and required actions to the alternative futures presented in the scenarios. These actions were then consolidated and used as inputs into the development of the vision statement.

From vision to reality. While the scenarios represent plausible futures that may happen, the vision represents a desirable future. It is about what Chile wishes its agricultural sector and its innovation system to look like.

¹ "Agriculture" and "agricultural" refer in this document to crop production, livestock systems, horticultural activities (fruit, vegetables) and forestry, and the related value chains. It includes annual as well as perennial production systems. Fisheries are not included. Occasionally, separate reference will be made to sub-sectors such as forestry, fruit, dairy or others.

The next step is to identify the key actions required to move towards such a vision. Based on the background studies, the interviews and the focus groups, the following topics were identified as key elements of an action plan for the next five years:

- 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, 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

Elaborating an Action Plan on these topics will be done in the third study.

A. Building the Vision – Background and Methodology

I. Background

Chile is undoubtedly one of the leading agricultural² producers in Latin America and an important player in world agro-alimentary markets. In terms of value of production, the country has established itself as one of the top twenty fruit and vegetable producers in the world (FAO, 2010). 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. There is a widely shared agreement in the country that this is a realistic and desirable objective.

Despite these marked developments in the agricultural and forestry sectors, there are implicit challenges that need to be addressed today in order to maintain, and potentially increase, Chile’s future international market presence. These challenges come from within and out. In the last decade, the sector has shown a decline in dynamism, which is partly a reflection of a stagnant productivity growth of the overall economy. By the end of 2007, Chile’s total factor productivity growth was lower than ten years earlier³, a performance that contrasted sharply with the previous decade, when productivity grew by a cumulative 30% (IMF, 2009)⁴. The annual growth rate of agricultural value added was 11% in 2004 and only 2% in 2008 (WDI, 2010). Although efficiency gains have been made in the sector, in terms of lowering costs within the area of traditional exports and increasing productivity and value added, these have not yet reached their potential. Also because of the importance of mineral exports, food exports in Chile (as percent of total merchandise exports) are much lower than in its agricultural neighbors – 16% compared to Brazil (28%), Uruguay (59%), Argentina (53%), and agriculture must compete in an environment where exchange rate appreciation is more likely to be expected than depreciation.

International market dynamics also impose challenges to agricultural production at home. Recent price surges of important commodities have made many governments rethink their trade based food security policies in favor of increased emphasis on self-sufficiency. Consumers are becoming more quality sensitive, demanding healthier and environmentally and socially responsible products; they are also making important shifts in their food baskets towards greater consumption of meat and higher end products (such as wine). New markets are quickly opening up especially in Asia, where high economic growth and large population sizes translate into massive increase in demand. Climate change is starting to play a role in the redistribution of comparative advantages for traditional commodities (towards higher latitudes) and will also affect the location for the production of high-value products.

The reduction in the annual growth rate of the agricultural sector would suggest Chile’s innovation system has served the country better in the past than it is doing at the moment and that, without further changes, negative

2 “Agriculture” and “agricultural” refer in this document to crop production, livestock systems, horticultural activities (fruit, vegetables) and forestry, and the related value chains. It includes annual as well as perennial production systems. Fisheries are not included. Occasionally, separate reference will be made to sub-sectors such as forestry, fruit, dairy or others.

3 Total factor productivity growth decreased from 2,8 between 1984-1997, to only 0,9 between 1998-2005. Total factor productivity growth is often used as a proxy for technological change or changes in the quality of the labor force.

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

growth rates might come about soon. Future changes, however, should not only address the challenges that are already clear. Innovation is usually a slow process that may take many years from a first idea or a first finding to the application of a new tool, technology or arrangement on a large scale. This means that changes in the innovation system should try to anticipate the challenges of the future in addition to those of the present. Such threats can be related to domestic and international market factors, climatic and production conditions, competitions with other sectors within and outside Chile, social unrest, access to information and technology, logistics and trade agreements, to mention just a few. It might be better to overestimate these threats and be overly prepared than to underestimate them and be marginalized.

In order to return to earlier growth rates, Chile needs to reassess the suitability and effectiveness of its agricultural innovation system. Investing in innovation is one of the key ingredients for the future competitiveness of the agricultural and forestry sector. Enhanced innovation capacity is not only necessary for the sector to achieve greater participation and a more competitive position in global markets, but also to ensure an adequate supply response to the increasingly sophisticated domestic demand for agricultural products.

Chile's governments recognize innovation as a key source of future development. In 2005 the government created the National Innovation Council for Competitiveness (*Consejo Nacional de Innovación para la Competitividad*; CNIC) as an advisory body to the Presidency in the area of innovation strategies and policies, with a Ministerial Committee in charge of its implementation. It launched a National Innovation Strategy aimed at focusing and coordinating public and private efforts for sectors selected for their competitive and innovative potential.⁵ CNIC (2007) also argued that spending in research, development and innovation in Chile needs to increase from a 0.68% of GDP (in 2004) to a figure close to 2.5% by 2020, with the private sector adopting a greater role (55% of investment). The Pineda Government that took power in early 2010 is considering changes to the strategies and policies of the earlier government but is equally committed to innovation as a motor of development.

To enhance the effectiveness of Chile's agro-food and forestry innovation system, considerable adjustments to Chile's strategy of the last decade may need to be implemented. These adjustments may involve issues such as the redefinition of the roles of the various actors and institutions, the introduction of new actors to the system, making adjustments to its governance structure, introducing new instruments, opening other financing sources as well as making considerable investments in developing human capital.

The complexity of these adjustments implies that this process will stretch over many years and will require the cooperation and coordination among many different actors. If implemented haphazardly, without consultation and with limited support in the sector, the transition process itself could threaten the functioning of the existing system. A poorly managed transition process might do more harm than good. Consequently, the process needs to be conceived and implemented with great care, first in strategic terms and vision and afterwards within the framework of more detailed plans that carefully outline a process of change.

This paper aims to develop a vision statement for the agricultural sector that may then guide the future investments in Chile's agricultural innovation system. A joint and shared perspective on how the sector might look and what role agricultural innovation should play in getting there is a prerequisite for any effective strategy. But developing such a vision is not only a function of what the country wants: it also depends on the context in which Chile's agricultural sector will find itself. This paper therefore reports on a participatory process to explore the many uncertainties that surround Chile's agriculture and to derive possible implications and answers. This will then lead to a vision for the sector that should be realistic both in terms of Chile's agricultural ambitions and

⁵ Priority sectors are: Aquaculture, Off-shoring, Tourism, Porcine and Poultry farming, Fruit culture, Copper Mining, Processed Foods, Financial Services, Logistics and Transport, Communications and Construction.

its surrounding uncertainties. Based on the vision, a series of topics that need to be explored in the agricultural Innovation system if Chile wishes to make its vision come true, will be identified and briefly described.

The current paper is the second one 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 made recommendations on how their performance can be improved. This second study explores 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. The third study will then outline a concrete action plan to make progress on the main topics that need to be addressed in order to achieve the vision.

II. Methodology

Several approaches are commonly used to assess and understand the future. Two such approaches are *trend analysis* and *scenario planning*. *Trend analysis* is based on the assumption that the factors that drove change in the past will continue to drive change in the future. For several factors that are important for understanding the future, such trends can be predicted with reasonable precision (e.g., population growth). *Scenario planning* recognizes that the future is uncertain and that disruptive events are probable. The methodology combines the major uncertainties with safer trends of major importance in “story lines” about the future, i.e., scenarios. Scenarios themselves are not predictions or strategies, but plausible narratives that describe alternative future conditions in which a country or organization may have to operate.

Scenario planning is aimed at breaking away from the idea that the future will be a continuation of the past. It can provide useful insights about an uncertain future and improve perceptions and judgments in decision making to adapt and shape the future. By developing, reviewing and comparing alternative scenarios and their associated challenges and opportunities, decision makers can identify those strategic issues that would most benefit any future condition and can form ideas about what could be achieved. Scenario planning is useful to provide a neutral space for discussion, to build a strategic vision and to derive implications that are widely agreed upon.

The Scenario Development and Vision Building Process

The outcome of any scenario development and vision building process is as robust as the information and input that it is built on. A process was designed that combines analysis (e.g., on markets, rural development, environment and technology trends, and on the main subsectors), multi-disciplinary consultation at different phases (among people with different expertise, experience and view points), and synthesis. The process followed for this report on agriculture and agricultural innovation in Chile is summarized in Table 1.

Table 1. Activities, outputs and contributions towards the scenario development and vision building process

Activity	Output	Contribution toward
Phase 1: Information collection and analysis (October 2009 – December 2009)		
Four analytical driver studies - Science and technology - Markets and consumer demand - The rural context - Environment and climate change	Driver studies (Annexes 1, 2, 3 and 4)	Scenario building workshop Scenario consolidation Vision building for 2030
Information collection on subsectors (clusters)	Cluster sheets (see Annex 2)	Scenario building workshop Scenario implications work days

Phase 2: Consultation and participation (December 2009 – September 2010)		
Interviews with remarkable people and opinion leaders	Interview report (Annex 5)	Scenario building workshop Scenario consolidation Validation of scenario implications Vision building for 2030
Scenario building workshop	Workshop report	Scenario consolidation Scenario implications work days
Scenario consolidation	Scenario story lines (Annexes 6 and 7 and Boxes 1 and 2)	Scenario implications work days Synthesis of scenario implications Vision building for 2030
Scenario implications work days	Implications by cluster and cross-cutting theme (Annex 8)	Synthesis of scenario implications Vision building for 2030
Phase 3: Synthesis (October 2010 – February 2011)		
Synthesis of implications from the analytical studies, the interviews and the scenario planning	Final Report	
Vision building for 2030	Final Report	

Driver Studies. Four driver studies were commissioned to provide past and future context on markets & trade, rural policies and rural development, natural resource management and climate change, and science & technology. The objective of the studies was to identify key trends and driving forces of change that could be to be used for defining and building the scenarios. Based on each study, a short summary was produced and shared during the first workshop.

Cluster information. Information on seven clusters (fresh fruit, processed food, wine, native forestry, dairy, red meats, and cereals) was used during the scenario building process and in the discussions on scenario implications.

Interviews. Further inputs and out-of-the-box ideas on future changes were identified by interviewing ‘remarkable’ people and opinion leaders. Eleven people were interviewed, representing a wide range of views from the public and private sector, as well as academia and civil society. Their views contributed to drawing implications and identifying important elements of the vision for 2030.

Scenario building workshop. The workshop was held in Santiago on December 2 and 3, 2010. A group of 24 experts from public and private sector, academia and civil society participated. The workshop was facilitated by staff from the World Bank, FIA and a consultant group, Poloc. Four scenarios were developed in a series of plenary sessions and smaller working groups.

Scenario consolidation. A comprehensive description of how the future would look in 2030 under the four scenarios was developed by the core team based on the inputs from the workshop participants. The scenario story lines were then submitted for validation to the original workshop participants, the scenario team, other experts in Chile (more than 72 people), and five external peer reviewers. One scenario was considered implausible and did not receive further attention. The team incorporated the feedback and finalized the scenarios, emphasizing scenario 2 (called “Terra Calida”) and consolidating scenarios 1 and 3 in a “Business as Usual” scenario.⁶ A summary of the “Terra Calida” and “Business as Usual” scenarios is provided in part B of this report.

⁶ By consolidating scenarios 1 and 3 in the “Business as Usual” scenario, participants in the scenario implication workdays could more easily contrast and compare implications of the two remaining scenarios.

Scenario implications workdays. Workdays were held in Santiago in July 2010. The focus of the work days was on sharing the two main scenarios and drawing the implications for seven clusters (fresh fruit, processed food, wine, forestry, dairy, red meat, and cereals) and three cross-cutting themes (natural resource management, human resource development, and quality management). Each workday comprised a discussion between a group of experts on each cluster and cross-cutting theme. The derived implications are presented in section B of the report.

Synthesis and vision building. The core team from FIA and the World Bank then drew the implications, focusing on the common challenges across clusters and scenarios. The final step was to formulate a vision. The vision is based on the previously derived implications, but goes one step further: It represents not only an analysis of future challenges and opportunities but also an ambition.

B. Findings and Implications

I. Findings on Future Drivers of Change⁷

Four themes were identified as key drivers of change: trends in natural resources management and specifically the consequences of climate change; the development of both domestic and international markets for Chilean agricultural products; the development in the rural areas; and the developments in the field of science and technology.

A. Natural Resource Management and Climate Change⁸

Current trends. Chile is a large country with many different ecosystems from North to South and East to West. It is hard to do justice to the internal variability within a few pages, so what follows are some abbreviated outstanding findings.

While Chile has a substantial land mass, the arable area per inhabitant is only 0.38 ha. The low availability of land per capita is driving agricultural production into fragile hillside areas and as a consequence a large part of the agricultural area is susceptible to erosion. At this moment almost 46% of Chile's continental surface is considered to be eroded.

Chile's agriculture is very dependent on irrigation sources, certainly north of Santiago, where water is already scarce. Overall water consumption for irrigation has grown from around 16 million cubic meters in 1995 to about 20 million cubic meters in 2010. During the last decade, there has been an observed reduction of rainfall in Chile, as well as changes in the regime of rains (greater variability, lower annual number of rains, longer summer drought). Combined with the existing high levels of water use in the North it is safe to conclude that agricultural expansion North of Santiago will be strongly water constrained. Towards the South the opportunities are better because of the excess of water availability.

Over the last decades temperatures have been rising with an estimated total increase of 0.8 degrees Celsius since the 1960s. Within the country however there have been markedly diverse patterns. In many areas minimum temperatures increased, but in the coastal areas maximum temperatures have been falling.

Because of its location west of the Andes and south of the Atacama desert, Chile maintains substantial endemic biodiversity and has been able to protect itself from several diseases and pests. Chile's isolated geography provides a large comparative advantage in international agricultural trade because it is easy to control and manage pests and diseases.

Future trends. While there is little doubt that climate change will take place over the coming 20 years, there is great uncertainty over the extent of climate change. Temperatures are generally expected to rise (in the range of 0.3 degrees Celsius average by decade), also along the Coast, pushing up the isothermal elevation by 200m. The minimum and maximum predictions for the average increase in temperature however are several degrees Celsius away from each other. The lower climate change predictions would require only marginal adjustments, whereas the higher ones will require major re-engineering of agricultural production systems.

Rainfall dynamics point to less rain, with higher variability and some increases in precipitation to be expected in high altitude areas and in the Southern parts of the country. In the next 20 years certain areas may face rainfall

⁷ This section presents summaries of the background studies available as Annexes to this report.

⁸ Based on Annex 1.

reduction in the order of 12 %, while other areas in the cooler areas and at higher altitudes may see rainfall increase by 17%.

Other environmental tendencies will also continue. Soil degradation and urban expansion will continue to be important factors in the reduction of arable land in Chile. Better soils will increasingly be used by high-value agricultural production systems (horticulture and fruits), while less profitable commodities (cereals) will be pushed towards marginal lands. More water will be required to supply expanding agricultural systems that will cover larger areas.

Agriculture is a considerable consumer of fossil energy, in the form of fertilizers and fuel to enable mechanization. Most of those fossil energy requirements are imported. With a falling labor force and an intensification of the agricultural systems, the fossil energy requirements of the agricultural sector will increase, requiring more foreign exchange to stay in business.



Implications. For Chilean agriculture to maintain its important role in the economy and to increase its competitiveness, it will have to adjust to a series of natural resource management challenges and will have to explore the opportunities of climate change:

i. Shifts and diversification of production. The future trends in water availability and temperatures will have important effects on the suitability of areas for agricultural production. Whereas the climate trend is uncertain, the water availability patterns tend to favor agricultural growth in the Southern part of the country and tend to discourage growth in the Central and Northern parts, maybe with the exception of some extensive production systems such as ranching and forestry. Soil conservation measures will be essential as land use intensity will increase.

ii. Territorial strategies. Chile's agricultural resource base is fragile and will require advanced integrated management systems in order to maintain its productivity. Such management systems need to combine soils, plants, water and animals at the level of the plot, the farm and the watershed. Territorial strategies would have to take into account the effect of changing agricultural suitability on the location of production and on regional comparative advantages. Areas towards the South may prepare themselves for absorbing, slowly and over time, production systems from lower latitudes.

iii. Re-thinking technological interventions. Investments in precision technology and related infrastructure will be required, in particular for water management (water harvesting, distribution, water use efficiency), to confront future increased variability and shortfalls of rainfall. This can improve the arable potential of the country and will reduce the shift of production towards the South. Investments in crop improvements and biotechnology (linked with adequate biosafety regulations) may help to increase yields and to widen adaptability in a wider range of production systems. While for some production systems (maize, wheat, pastures) such improvements will often originate in public sector research, for others (fruits, wine, timber, cattle) the private sector will play a leading role. Coordinated public-private efforts will ensure the right focus and synergy thereby increasing effectiveness and sustainability.

iv. Awareness and capacity. Increasing the ability of agricultural producers to manage their natural resources and their capacity to adapt to climate change is key to successfully confront future changes, no matter how big or small they are.

B. Market dynamics⁹

Current trends. Chile has been following a free trade development model and participates in many important trade agreements that have enabled greater integration of Chilean products in international markets. Among the export leaders are fresh fruit (+141% from 2000 to 2008), processed fruits and vegetables (+500% from 2000 to 2008), wine (+100% from 2003 to 2008) and salmon (+145% from 2000 to 2008) value chains, with emergence of also the dairy (+169% from 2004 to 2008) and white meats (+59% from 2004 to 2008) value chains. Exports of timber products are also increasing (+133% from 2000 to 2008). The development of Chile's agricultural exports can be considered highly dynamic: export volumes have increased in general, but for many industries (e.g., wine, processed fruits, salmon, forestry) the value added per unit of exports has also increased.

Domestically, income increases in the 1990s have brought a trend of nutritional transition in the country, with greater consumption of meats and dairy products and of products with high sugar and fat contents, especially in the lower income groups. The consumption of fruits and vegetables and functional foods, in general has remained low, at about 50% of the recommendations of the World Health Organization. There are on-going efforts for increasing consumer awareness of healthy eating in Chile, but up until now their impact has been small, possibly because consumers are not able to understand the messages. Certification of nutritional composition has had more effect and certified foods have high levels of acceptance. A possible trend towards more healthy and wholesome food might have important implications for the demand for quality agricultural products in domestic markets and might increase the congruency between domestic and international developments.

Both domestic and international markets are characterized by a relatively small number of highly integrated corporations. Within Chile, two supermarket chains dominate the retail channel and control large parts of Chile's agricultural production through contracting arrangements.

Future trends. With future global increases in population and per capita income, there will be an increasing demand for food in international markets. Staple food markets may experience more frequent periods of short supply, such as those seen in 2008 and 2010. The demand for healthy and functional foods and for animal proteins and meats in general will also increase. Urbanization will create a higher demand for convenience and there seems to be large potential for food concepts that combine wholesomeness and convenience.

Furthermore the weight of the main trading blocs is changing. While the US and Europe will not reduce their demand for agricultural imports, it is very likely that new markets such as China, India and also Latin America will grow more quickly. These markets have different inherent preferences and will develop from different dietary bases. Beef consumption in India or China, for example, is expected to remain lower than in the US or Europe, fruit or dairy preferences will also be different. To be successful in these markets new product mixes may be required.

The foreseen changes in climate are changing trade dynamics and will redefine comparative advantages in agricultural production. Products with small ecological footprints, in terms of both production and distribution, will be favored. New trade policies and standards are starting to emerge focusing on carbon and water footprints, eco-labeling, and eco-taxing. While such policies may respond to genuine climatic concerns, there is a big chance that they will also be applied for protectionist purposes (in order to promote domestically produced over imported foods).

There will be increasing consumer awareness in favor of fair trade, organic, as well as locally grown products. These consumer trends will be articulated in Chile's exports as well as in its domestic markets, creating an opportunity at home for more wholesome and clean food products. Certification of origin and of production

⁹ Based on Annex 2.

practices will grow in importance. Finally, Chile's competitive potential in internationally accessible agricultural markets may be suffering from a strong Chilean peso.



Implications. The challenge for agriculture in Chile and in general will be to supply growing domestic and international markets in the context of increasing environmental restrictions (trend towards organics, possible climate change implications) and new commercial demands (combining wholesomeness and convenience, new markets). Finding new niches and new ways of positioning itself in global markets will be a challenge and an opportunity for Chile's agricultural exports.

i. Adapting to eco and footprint labeling requirements in international markets.

Environmental safety will be an important new trend in international agricultural trade. Consumers will be increasingly more conscious about the carbon and/or use of water footprint of agricultural produce and products, requiring safety guarantees, such as labeling. This will require adjustments in production approaches (improving the efficiency of input use and machinery) and value chain logistics, but it also provides an opportunity for identifying new market niches and placement of agricultural products in markets where consumers are willing to pay for environmental safety. Sanitary and phyto-sanitary regulations would need to be able to internalize these new market requirements and readily adapt to them. Biodiversity guarantees may also be needed for product placement (e.g. over-exploitation of Chilean sea bass has recently dropped it from the list of sustainable seafood).

ii. Identifying opportunities for small producers in domestic markets. Provision for domestic markets will continue to correspond to smaller agricultural producers in Chile. Efforts should be made to effectively integrate these producers to existent and emerging value chains through different mechanisms. For example, modern markets can be brought to farmers by establishing collection centers and a multipronged collection of service provision arrangements, as well as forming market cooperatives and farmer companies to help small farmers access the increasing number of supermarkets.¹⁰ With view of increased urbanization in Chile, another opportunity for small producers is the development of domestic demand for local foods, focusing on their freshness and convenience (delivered at the door step).

iii. Adopting new post-harvest technologies. The diversification of foreign markets and agricultural products will require improvements in the technologies related to the harvesting, storage, conservation, packaging, logistics and transport, so that product quality is not compromised (e.g. preservation technologies, pasteurizing and sterilizing technologies, refrigeration, packaging technologies, technologies for quality control and identification of origin). This is particularly relevant in Chile, as it is far away from many of its markets and many of its agricultural export products are not processed.

iv. Satisfying increased diversity of demand. With the growth of non-traditional export markets and the changes in domestic consumption, Chile's markets will be more diverse in 20 years time than they are now. Especially within the emerging markets, new players will arise that may start controlling large market share. The dynamic and highly diverse development patterns of Chile agricultural markets may provide opportunities for medium sized enterprises that are able to link up with these new markets and new players.

¹⁰ Thomas Reardon, C. Peter Timmer and Bart Minten. Supermarket revolution in Asia and emerging development strategies to include small farmers (www.pnas.org/cgi/doi/10.1073/pnas.1003160108).

C. The Rural World¹¹

Current trends. Migration towards urban areas is an important demographic trend in Chile. Like in the rest of Latin America, rural population growth in Chile is negative (-1% in 2009). The rural population represents only 11% of the total population of Chile (in 2009), well below the OECD average of 23% or the Latin America average of 21%.¹² Migration is induced by the lower average income levels in the rural areas (and especially in agriculture) and by the lower quality of social services such as education and health.

As in other Latin American countries, there are large disparities among agricultural producers in Chile. On one hand, there is a large number of small holders, usually with low levels of education, producing for subsistence or for local markets. On the other hand, there is a concentrated, export-oriented agri-business, usually well capitalized. In turn, the agri-business relies on daily labor, with very low levels of education. Despite these disparities, during the period 2003-2009, the sector has sustained an average yearly growth rate of 3.3%, although there is a clear downward trend in the growth rate from 7.47% (in 2004) to 2.40% (in 2008).¹³

The transmission of agricultural growth to income growth of rural households has not been direct. Rural livelihoods are increasingly becoming less dependent on earnings from the agricultural sector. Between 1992 and 2006, the participation of agricultural earnings in total rural income has decreased from 41% to 27%. Other sources of income (e.g. non-agricultural earnings, government transfers) represent an increasing share of rural income (RIMISP, 2009).

Future trends. There will be greater integration between the rural and urban worlds. With the improvement of the country's physical and ICT infrastructure, the movement of people, goods and services, productive activities and information will become easier, facilitating this integration. The trend of the rural world depending less on agriculture and diversifying its economic base will continue. The concentration of agricultural production and know-how will probably remain within the small number of large and wealthy producers, limiting the impact on the rural poor of innovation initiatives in the sector. Agricultural growth will be sustained by the export agro-industries. However, labor markets will be a limiting factor for this growth if human capital is not better qualified and strengthened to meet the future challenges. If the innovation policy in agriculture remains as currently designed, focused on a number of prioritized clusters, competitiveness may be improved, but the observed tendencies of poverty and inequality will remain in place.



Implications. The current innovation policy in the agricultural sector has been defined around five strategic clusters (processed foods; pork and chicken; fruits; grapes and wine; beef and lamb). While the prioritization of clusters has clear benefits related to the allocation of scarce resources to high growth opportunities, the challenge is to ensure that this growth also translates into higher welfare for the rural population.

i. Spreading innovation initiatives across the rural space. There is spatial concentration (in peri-urban areas) of the prioritized agricultural clusters, which is not surprising given the diversity of production environments present in Chile and required by each agricultural subsector. Of the 215 communes (*comunas*) in the country, 62% have production linkages with at least one of the 5 agro-food clusters. Agricultural clusters are found to be important pull factors of population, in general, and labor force, in particular. Communes with presence of clusters have experienced between 1992 and 2002 an average population growth of 19%

¹¹ Based on Annex 3.

¹² World Development Indicators 2010 (data.worldbank.org).

¹³ ODEPA (www.odepa.gob.cl).

and those without cluster presence - less than 4%. In the former, more than 44% of the labor force is employed in agriculture, compared to 33% in the latter. Finding means to include the communes without presence of priority cluster in the dynamics of agricultural and rural innovation may strengthen its social impacts. This may be done by considering non-agricultural rural innovation (for example in agro-tourism), or by considering other clusters (for example, forestry).

ii. Strengthening innovation ability independent of priority clusters. The rural space in Chile is greatly heterogeneous, complex, with different levels of articulation between rural and urban areas. There is a wide range of rural areas with opportunities for development that are in the middle of the spectrum between highly integrated and more marginalized agricultural areas, but that are currently not well served by the cluster approach. In these areas, investments in human capital, digital connectivity, phyto-sanitary protection, support infrastructure, organizations systems for management and commercialization are examples of initiatives that will increase the potential for growth, independent of the priority clusters.

iii. Investing in human capital. The ability of both agri-business to develop more sophisticated, higher value production systems and many rural dwellers to earn higher incomes is constrained by low levels of education. Low levels of education make it hard for people to change jobs and to find better remuneration. Low levels of education will also constrain the ability of the agro-industry to cater to specific market and customer demands with tailor-made production and marketing systems.

D. Research and Development Aspects¹⁴

Current trends. ICT (Information and Communication Technology) has been the strongest driver of technological change over the last decade. While not originating in agricultural sciences, ICT still has strongly affected, and will strongly affect the technological base of agriculture. Market information systems of many kinds are being put in place, allowing suppliers to deliver their produce at the right time in the market with the best prices and allowing traders to source their supply from the best possible origin. ICT has facilitated the development of expert systems for agricultural production (for example in integrated pest or water management) and has contributed to robotization (for example in dairy).

In most OECD countries, the role of private investments in agricultural R&D has been growing. This has been caused by several factors: improved property right legislation has made it more attractive for private businesses to invest; the large scale of several agro-food companies and their strong position in certain market segments allows them to invest in company specific R&D; industry associations and public-private partnerships have allowed to form clubs of private sector companies that can jointly benefit from research programs.

Corporate R&D is increasingly footloose. It is located where companies have the best ability to protect their results and where they find the most cost effective labor force. Whereas ten years ago the idea was that R&D activities would remain in the highest income countries, there has been a considerable movement to mid income countries which are able to supply high quality labor at lower costs.

While R&D to improve market access and market position has a strong private dimension, R&D on natural resource management and on production technologies has remained more public. The emphasis is increasingly on environmental sustainability and on reducing the burden of production on the environment.

¹⁴ Based on Annex 5.

Future trends. Molecular biosciences (biotechnology, genomics) will overcome public skepticism and increasingly become key drivers of agricultural change. They will contribute to higher production potential and reduced pest and disease vulnerability. Three factors will contribute to their increased role: the molecular toolkit will be increasingly sophisticated and the risks of different tools will be better understood and managed; better biosafety systems will be in place to effectively separate areas where GMOs are allowed from areas for organic production; the tightening global supply for staple foods will increase the incentives for the application of technologies that can expand production possibilities.

The future of nanotechnology is less clear. Similar to the earlier developments in biotechnology, possible applications of nanotechnology (for example in storage systems) will become available, but their health and environmental risks are still poorly understood.

Along the value chain, smart packaging will be a key factor in marketing agricultural products. More generally, ICTs will provide a fundamental support in the management of the production process and across the value chain for both fresh produce and processed agricultural products.

International technology transfer will continue to be an important factor for improving productivity in the sector vis-a-vis climate constraints and market demands. At the same time there will be less freedom to operate in science, because of an increasing number of foreign patents, resulting from science and technology investments in developed countries. With the high cost and the high levels of specialization in agricultural research, international research networks (or programs) will gain in importance. Early access to new research findings is constrained to those countries and organizations that participated in the research network.



Implications. For Chile's agriculture to remain competitive in the context of globalizing value chains and the increasing reliance on science and technology for improving productivity, several actions may be considered:


i. Investing in science and technology for agriculture. Public investment levels may need to be increased from the current 1.2% of AgGDP (2006) to the 2.5 to 3.0% level more commonly found in high-income countries.¹⁵ Three areas stand out here:

- Pre-competitive research to improve market access and consumer confidence, for example in food safety, biosafety, animal health and welfare, and sustainable value chains.
- Pre-competitive research on product traits such as consistent quality and functional performance, uniqueness and timeliness of delivery.
- Research on productivity issues such as decision making on farm and high yielding plants and animals.¹⁶

ii. Improving the incentives for private participation in agricultural R&D. This may be done by matching grant systems for private research activities, promoting public-private partnership (e.g., the ongoing consortia) and strengthening the enabling environment (IPR legislation, tax regime for research activities). This is on-going for some prioritized clusters (e.g. viti and viticulture) and should be scaled up for other clusters.

¹⁵ Pardey, P.G. and J.M. Alston. U.S. Agricultural Research in a Global Food Security Setting, 2010 (<http://csis.org/multimedia/agricultural-research-and-development-and-food-security>).

¹⁶ In principle, public research should be geared towards public benefits (for example environmental benefits). In agriculture, public funding is also used to correct for the underinvestment caused by the limited capacity of individual farmers to undertake research, and to support the development of non-appropriable technologies.



iii. Improving human capacity for development, transferring and adopting new technologies. For Chile to benefit from international technology transfer, to successfully host private research activities, and to facilitate technical assistance within the sector, it needs to have a critical mass of professionals trained at post-graduate levels.

II. The View of Decision Makers on the Future of Chile's Agriculture

Eleven outstanding personalities¹⁷ in Chile, including an ex-president, ex-ministers of agriculture, business leaders, academic leaders and think-tank leaders were asked their opinions on the key issues for the development of Chile's agricultural innovation system. The common issues that emerged from the interviews are: 1) climate change; 2) market dynamics and quality issues; 3) human resources; 4) public policy and institutional development; and 5) research, development and innovation. Most of these issues have been treated in detail above. What follows is a summary of some of the outstanding observations on the functioning of Chile's agricultural innovation system:¹⁸

1. **Lack of collective action in the agricultural sector.** The perception is that production is very atomized and individualized and that there is a high degree of fragmentation of public services.
2. **The coordination of the innovation system is deficient.** The innovation system does not function as a system. Even though efforts have been made to improve internal coordination, there is no clear leadership or oversight.
3. **Limited involvement of the private sector in R&D.** There is little capacity and apparently little interest in the private sector to invest in research that may increase the value added of the agricultural sector.
4. **Low training levels of agricultural entrepreneurs.** Students are usually not keen on developing entrepreneurial skills, which may become a constraint in the future management of the agricultural innovation system and the growth of the sector.
5. **Many instruments, little clarity.** There is a multitude of funds and other instruments to enable basic research and innovation activities, but they are rigid and bureaucratic, and it is not clear how they relate to each other.
6. **Obsolete regulation.** Certain regulatory systems (e.g., biosafety and sanitary systems) are outdated and not in line with the dynamics and aspirations of the sector.
7. **Limited human resources.** While university education is of sufficient quality, the number of graduates is too low to satisfy the research and development needs of Chile's agricultural and forestry value chains.
8. **Big means success.** Production is increasingly concentrated in the hands of large producers, and small producers are increasingly marginalized.
9. **Forestry limitations.** The productivity and creativity of the forestry sector is limited, the sector is inward looking and has a short-term perspective.
10. **Lack of strategic vision.** The sector needs a strategic vision and a focus on long-term market potential, more than studies on productivity issues.

III. Exploring Alternative Futures

A. Alternative Scenarios for Chile's Agriculture

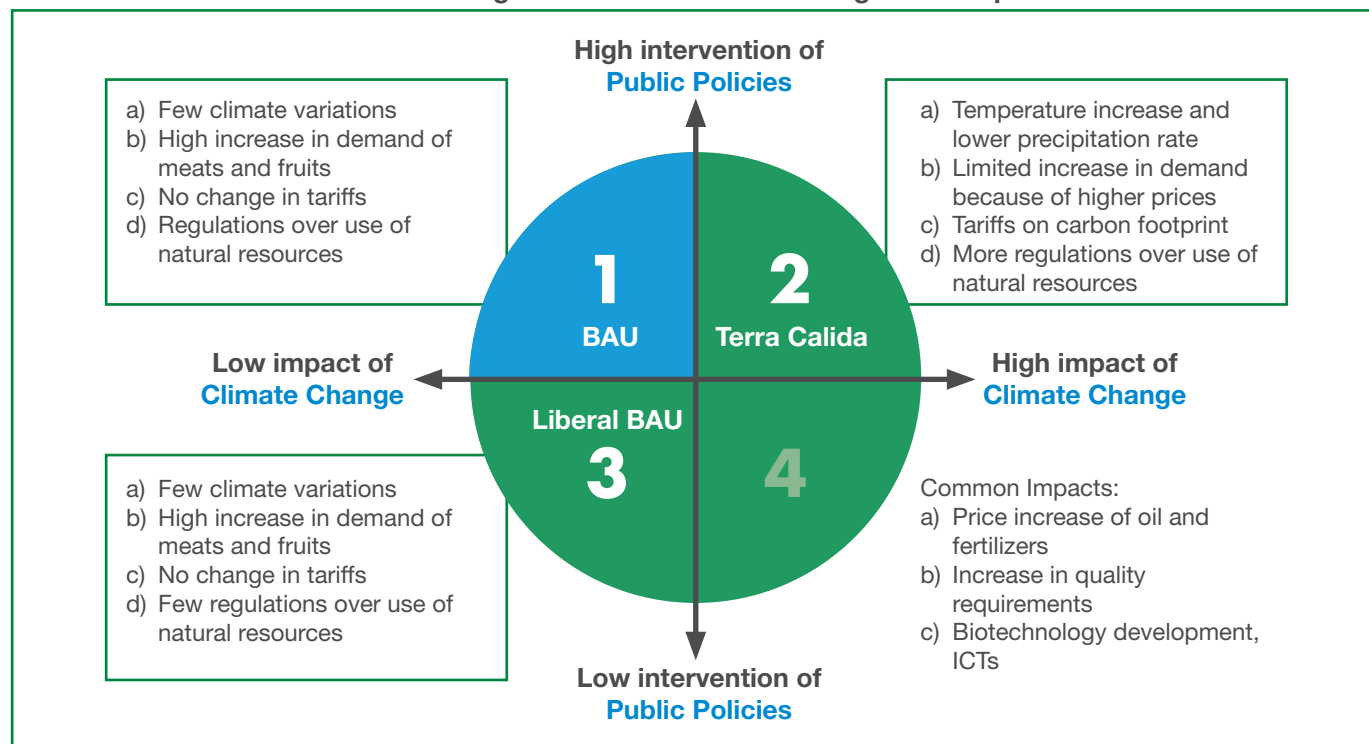
The four scenarios that were initially developed (see part A-II) were built around two axes: whether the incidence of climate change would be low or high; and whether the public policy regime would be free

¹⁷ Oscar Guillermo Garretón, Verónica González, María Olivia Recart, Ricardo Ariztía, Ruperto Concha, Patricio Arce, Marigen Hornkohl, José Miguel Aguilera, Eduardo Bitran, Ricardo Lagos and Jaime Lavados.

¹⁸ For further information see Annex 5.

market based or more interventionist. These two drivers were combined in a two by two scenario framework as shown in Figure 1.¹⁹

Figure 1. Scenario framework for Chile's agricultural innovation system as arising from the scenario-building workshop



To facilitate drawing the implications in the working day sessions, two scenarios were used: a “Business as Usual” (BAU) scenario, where climate change would have limited incidence and where the public policy regime would remain similar to what it is in 2010 (combining scenarios 1 and 3 of Figure 1); and a “Terra Calida” scenario, where climate change would have a strong incidence and where the public policy regime would be more interventionist to manage the impacts of climate change (scenario 2 of Figure 1). Box 1 and 2 provide summaries of the two scenarios.²⁰

Box 1. The Business as Usual (BAU) scenario

Climate Change: Towards 2030 there have only been limited further increases in average temperatures and rainfall regimes have remained the same. Governments and civil society have gradually lost interest in the topic of climate change. Only a few mitigation regulations and laws have been adopted in Chile and the focus of the government and the private sector is on sustainable economic growth.

Natural Resources: While climate change has had limited impact, other factors have had more significant effects. The world economy is significantly disrupted due to oil scarcity and a barrel costs \$150 in 2030. The agriculture and forestry sectors have become important sources of renewable energy. The bio-refinery business is booming in Chile. Biomass is converted into fuel for vehicles and is used for electricity and heating. In 2020 Chile has opened its first bio-refinery that produces biodiesel and other high return products from native forests and seaweed. The world's phosphate rock reserves

¹⁹ Although story lines were produced for each one of the four scenarios (available on the FIA web page), during the validation process Scenario 4 was considered to be implausible and subsequently removed from further consideration. Figure 2 depicts this and it also presents a summary of the key characteristics for each scenario (in the boxes), as well as the emerging common elements across the scenarios.

²⁰ For further information on the two scenarios see Annex 6 (Business as Usual) and Annex 7 (Terra Calida).

are getting exhausted and the agricultural sector faces peaking phosphate prices, also due to the increased use by India and China, as well as for biofuel production.

Science and Technology: Molecular biosciences (biotechnology, genomics and proteomics) have become the main drivers of biological sciences and are increasingly applied to environmental, pharmaceutical and varietal improvement research. DNA profiles for the majority of crops are available globally. These technologies can be used at a limited cost and through simple practices. The wide and effective use of biotechnology has allowed producing crops for food as well as for energy, due to research investments in crops such as *Jatropha*, *Miscanthus* and *Panicum Virgatum*. Food and energy prices have risen however, which has further improved the acceptance of biotechnology applications in the EU and US, resulting also in a gradual reduction of biosafety regulation.

Markets: New packaging and wrapping technologies have lengthened the post-harvest life of perishables, making cold room and storage facilities less necessary. In Chile, the salmon and fresh fruit industries benefit the most from this change.

Information and Communication Technologies: ICTs are widely used in the agro-food and forestry sector and their production chains both at the local and international level. Traceability and precision farming systems are common and have become indispensable for accessing consumers markets that are increasingly concerned with where and how their food has been produced.

Human Resources: Between 2012 and 2020, the scientific knowledge gap between Chile and developed countries in particular has been reduced. Chile's decision to increase investment in R&D to 2.2% of the GDP by 2030 resulted in strong innovation institutions and the development of new technologies.

Food Consumption: By 2030, the global area dedicated to agriculture has been increased with 121 million new hectares. The developing countries' middle class has tripled in size and adopted consumption patterns that favor meat, fruits and vegetables, becoming the most important target group for Chile's export agriculture. Consumers from the EU and the US have opted for a return to locally grown products. In general consumers appreciate to know that their food has been produced in ecologically balanced and sustainable systems.

Government Actions:

- The Chilean government has developed a database for all natural resource use in the country but has not been able to introduce regulatory frameworks to control and protect the use of natural resources.
- The availability of information on the natural resource base and on land use has helped to improve the functioning of the land market. Many small farmers have been able to sell their land and retire in the cities.
- Oil prices have increased, but the government has not started to subsidize energy prices.
- Water use policies are based on the legal framework that was already in place in 2010, but in 2030 the irrigated surface makes up 50% of the total irrigation area. The increase has been largely due to the law that promotes the establishment and improvement of irrigation and drainage works by private agents.
- Forest management is largely unregulated, leading to major forest degradation, especially among small land owners.

Box 2. The Terra Calida scenario

Climate Change: By 2030 average temperatures in Chile have increased between 1.6 and 2.0 degrees Celsius, and rainfall patterns have become more variable, but at lower average levels. The isotherm has moved up between 300 and 400 meters, causing adaptation problems for many crops and changing disease and pest incidence. Chile's agriculture needs more water because of the higher temperatures, but has less. The fruit sector has been seriously affected in its competitiveness, is desperately trying to move its production southwards, but finding heavy competition for land. The planting season of annual crops has shifted towards the winter.

The developments in Chile resemble the rest of the world where average grain yield levels are between 1 and 10% below the levels expected without climate change. Global grain harvests have become more volatile causing price spikes and a trend towards higher price levels. Global cereal and meat consumption per capita has been falling. Areas with similar production systems such as California have yield losses between 0 and 40%.

Agriculture investors directed their investments to the Araucanía region and to Southern Chile. In turn, livestock and cereal products had to be relocated further south, or to marginal areas within their original regions. The forestry industry

began relocating itself to the O'Higgins and Maule regions where it started to establish new exotic forest plantations (pine and eucalyptus). The service infrastructure for the sector slowly has begun to decentralize away from Santiago, which is increasingly outside the margin of the main agricultural production area.

Natural Resources: The global demand-supply balance for oil has changed considerably. Oil extraction levels have been falling and demand, especially from India and China have been rising, leading to price levels in the order of \$200 per barrel. While the world has however been very successful in opening renewable sources of energy (hydro, wind, sun, biofuel), energy prices in general are considerably above the 2010 levels. The high energy prices and the reduced availability of phosphate sources have swept up fertilizer prices.

Science and Technology: Since 2020 Chile has strongly increased its investments in science and technology, which is helping it to tackle climate change issues. Molecular sciences and biotechnology have become key components of those strategies. The availability of improved varieties for vegetable and fruits, adapted to the demands of the emerging markets has increased. Progress has been made on microbiological technologies to allow plants to absorb phosphorus sources available in the soil. Major efforts have been made in fine tuning irrigation systems, using ICT as well as advanced organizational models to distribute water. Chile has adopted site-specific management technologies for agriculture and remote sensing systems for livestock management. The presentation and conservation of products has improved by new packaging products made from fiber foods and green compost. Genetic engineering also helped to improve value added. In 2030, the food cluster has increased the value of its exports per ton by 60%. Green materials for the production of plastic, enzyme, chemicals and other industrial commodities are increasingly exported, as a replacement for petroleum. Forestry has become one of the most dynamic parts of the sector.

Markets: The quality of Chilean products has been recognized internationally as a result of considerable investments in the promotion of the country's image. A few agricultural companies have relocated closer to import centers such as Mexico and Central America. As a response to energy restrictions, the majority of the Chilean industry's exports are made in bulk and packed, processed and prepared in the country of destination. The first lighter-than-air airplane for food exports was inaugurated in 2025. The global food market is increasingly dominated by a small number of multinational retailers that have also been able to penetrate the emerging markets. Several developed countries have implemented border tax adjustment to take into account the ecological (especially greenhouse gas) footprint of the imported products. Labeling has become more stringent and packaging materials derived from fossil oil have been prohibited in most industrialized countries.

Information and Communication Technologies: ICT has become a key response strategy to climate change issues. Irrigation and pest management requirements are defined by sensor-based systems that can measure soil humidity or disease presence. ICT systems have also helped to improve climate sciences and long-term weather predictions, reducing strongly the chances of crop failures and improving the ability to adapt product systems to meteorological conditions. While the export-oriented agri-business may have integrated such weather predictions in its expert systems for crop management, small farmers are able to obtain crop and location specific advice through their smart phones and tablet PCs.

Human Resources: The availability of manual labor for planting, weeding and harvesting has decreased. Mixed harvesting systems were adopted for various fruits: mechanical systems destined for industrial consumption and manual systems for produce destined for fresh consumption. Most manual agricultural labor comes from neighboring countries. The sector depends more strongly on trained personnel to manage production, harvesting and distribution systems, and this has been key to responding to the increasingly diverse demands coming from both exports and domestic markets. The availability of well-trained staff has also helped to manage ecological concerns. Chile counts with a wide range of highly qualified technical experts and has strongly increased its scientific capacity. There is still a deficit of professionals in the field of knowledge management.

Food Consumption: While the ecological quality of food is increasingly appreciated, consumers cannot exercise their preference for organic and sustainably produced food products because of the high overall price levels. What they have been able to express is their preference for nutritious food. The obesity boom of the start of the century has been overcome. Chilean consumers have increased their consumption of fruits and vegetables.

Government Actions: Chile's government has implemented a strict system of ecological and greenhouse gas certification for agricultural production in order to reduce emissions and enhance sustainability. This not only concerns individual plots or value chains: Chile has imposed a farm certification system where the farming system is reviewed on various dimensions such as waste recycling, rotational synergies, pesticide management, water use efficiency and efficiency of mechanization. Farmers have to pass four years of post-primary education in order to be certified and if not, their production will not be certified and is hard to sell. A strict system for regulating land use has been put in place, reducing the flexibility of the land market, and emphasizing the importance of sustainable forestry. The government has aggressively developed its hydro-

energy potential in the south of the country and has been able to keep the CO² emissions for energy production below the agreed post Kyoto levels, thereby passing a first hurdle to market access for Chilean products. However, no framework for Intellectual Property rights has been developed by the government. Subsidy schemes keep the costs of biofuels down.

The key purpose of the developing the scenarios is to move the attention from the present problems to the issues of the future (in this case 2030). This is important for the agricultural innovation system and especially the science based part because the lead time from having an idea to applying a new technology can be very long. The scenarios help in raising awareness on how different the future can be, more than defining how exactly the future will be.

B. Deriving Implications Across Clusters and Cross-cutting Themes

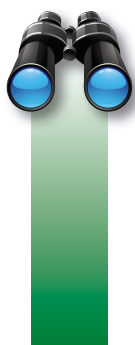
Workdays were held in which representatives of seven clusters (fresh fruits, processed food, wine, dairy, red meats, forestry and cereals) were confronted with these two scenarios and were asked to respond to two main questions: 1. In each of these scenarios, how do you see your cluster developing? 2. What are the implications for the types of investments, especially in agricultural innovation for your cluster? The outcomes of the workdays for each cluster are summarized in Annex 8.

Competitiveness considerations led to the selection of clusters like processed food, fresh fruit, and wine. Sustainable natural resources use led to a particular focus on forestry (in which case there is also potential for productivity growth and further value addition). The attention to productivity led to a focus on traditional agriculture, where productivity of commodities like cereals and dairy can be increased. These are also important clusters for employment of small producers in Chile. Red meats represent a relatively traditional sector but is considered to have substantial opportunities to increase its competitiveness.

Similar to the workdays for the seven clusters, workdays were held for three cross-cutting issues (human resources, natural resource management, quality management). The first cross-cutting theme considered the human resources in the sector. Human resources relate not only to capacity building, but also to labor quality and labor management. It was selected because in most agricultural economies it takes a major part of the costs and the incomes. Natural resources management was selected as the second-cross cutting theme because it strongly defines the physical possibilities of the agricultural sector. This cross-cutting theme addresses a broad range of natural resource management issues (soils, payment for environmental services, use of water resources, biodiversity, etc.). Quality management was selected because it is key to Chile's competitive position in export markets. It touches on issues related to regulatory compliance, certification, value addition and quality monitoring along the value chain.

The implications derived from the clusters were then triangulated with the implications obtained from the three cross-cutting issues. A summary of the main implications is presented next.

C. Synthesis of Implications in the Business as Usual (BAU) Scenario



In the BAU scenario the future opportunities and challenges are perceived to be in the **further integration of Chile in the markets**, internationally but also at home. The consensus is that a strong “Chile brand” needs to be developed, based on excellent compliance with market norms and standards, and supported by a labor force that is able to understand and implement such compliance mechanisms.

Competitive positioning (e.g., through competitive products and niche markets) requires an efficient, integrated sector and value chains. The sector and its production will further consolidate, and become more sophisticated, creating significant pressure on the land

and well-being of rural people. To offset these challenges, the public sector should introduce incentives for adoption of sustainable production practices, strengthened education and health services, and overall connectivity of the rural areas to improve the quality of life.

Product and market differentiation will be increasingly important – requiring market scoping, and correspondent product development to meet the diverse market needs. The private sector must upgrade its ability to comply with market norms and standards such as traceability requirements, animal welfare standards and other social and environmental sustainability criteria, ISO certification, and the increasingly important SPS standards. The public sector has a crucial role in supporting the private sector in addressing these challenges. Information systems on agricultural production, marketing and trade are essential in guiding sector prioritization and development. The public sector can also support the agricultural sector by harmonizing the SPS system to international standards, strengthening currently outdated regulatory systems (e.g., biosafety), and providing incentives (via appropriate instruments) for the private sector to improve their skills and systems to meet quality and compliance requirements.

An innovative sector requires **entrepreneurs and a more sophisticated labor force**. The main clusters will increasingly rely on staff with marketing, product development and value chain management skills, and on more sophisticated production systems. Skills upgrading is important for both the private and the public sector. The private sector must provide appropriate incentives to its skilled labor and opportunities for professional growth via in-service training systems. The public sector efforts should center on strengthening the rural education system. Special attention should be given to integrating formal training and practice (e.g., through internships and rural exposure of students), and to equipping graduates with business understanding and soft skills (problem solving and communication).

Knowledge and technology are being used more efficiently. Innovation is the pillar of several value chains that produce **high value differentiated products**. The sector has made significant efforts, with the leadership of the public sector, to collectively address the challenges with knowledge acquisition and sharing, regulatory compliance, value addition, and innovation. The sector has invested in highly trained scientific staff, such as genetics and biotechnology specialists, working mainly on the development of products with improved market acceptance. The small and medium enterprises – the driving force of value addition in the sector – have developed an appetite for value addition, incentivized by matching grants systems for business development and public-private partnerships. The knowledge and technology transfer system has been strengthened, particularly by ICT-enabled application.

D. Synthesis of Implications in the Terra Calida Scenario



In the Terra Calida scenario, the logic changes. Chile might still wish to be a bigger player in the international and domestic markets but if the agricultural sector is not able to successfully adapt to the changed climatic conditions, success in the markets will be remote. While markets remain important, **managing production conditions is the key challenge**.

In this scenario the number and the significance of the production challenges within Chile increase over the Business as Usual scenario and Chile's competitive advantages might be severely reduced. With the same amount of resources available, and a larger number of production

challenges, **Chile would need to make stronger choices**, focusing on those subsectors that are projected to stay competitive in conditions of strong climate change and dedicating more concentrated efforts towards those subsectors. Alternatively **Chile should further increase its investments in the innovation system**, in order to handle a wider range of issues.

Priority should be given to the production and marketing of environmentally sustainable products, including products with reduced ecological footprints and in meeting the market demand for wholesome products. The private sector needs support and joint action to meet these quality compliance and certification requirements. In response the public sector will need to develop policies and incentives for sustainable natural resource management, a harmonized SPS system, and systems to monitor compliance with regulations to reduce greenhouse gas emissions. ICT-based surveillance systems need to be put in place to support weather and pest management strategies. Chile's large forest area is used as a compensation mechanism for the greenhouse gas emissions linked with its agricultural production – an effort that requires coordination at the sector level.

Designing such new systems requires **highly educated staff with multidisciplinary resource management skills**, and having such professionals will take priority over entrepreneurial and skill improvement. Climate change professionals and climate change researchers are designing and managing, production and marketing systems to reduce Chile's footprints. The skills development strategy relies on both private and public efforts, the public having the main responsibility for training specialists in water and energy management, adapting postgraduate degree programs to climate change issues and retraining the rural labor force in response to the geographic relocation of production. The private sector, on the other hand, focuses on upgrading the skills of its labor force and including footprint requirements as an integral part of the value chains.

Innovation, knowledge and technology are again the pillars of **competitive, resource-efficient value chains** that are able to adjust to changing ecological conditions, confronting the natural resource management issues required for the sector's success. More efficient water and energy use, and stress tolerant species/varieties and breeds, often in new production areas, are the start of the innovation agenda and contribute to footprint reduction of Chilean supply, facilitating compliance, favorable quality/price ratios and access to markets. The public sector improves the scientific skills base particularly in genetics, biotechnology and natural resource management, generating professionals who work in response to climate change adaptation and resource management problems. A strengthened knowledge transfer system, largely relying on ICT and new rural information centers, plays a significant role in equipping rural producers and forest owners for new production practices and processes.

E. Some Conclusions Across the Two Scenarios



The first subject that stands out in both scenarios is that **Chile should focus on being a quality producer**. It does not have the areas and the scale of production to compete in bulk production with countries such as the US, Brazil and Ukraine. On the other hand its remarkable range of ecological niches makes it very well suited to produce a **diversity of high quality, high value products**.

Being a quality producer however has implications for the type of development in the country's agricultural businesses and subsectors. In its existing markets (US, Europe), Chile's future in

wines, fresh fruits and meats is increasingly based on quality more than volume, but in the new markets (China, India) there may be a demand for products with a more favorable price-quality ratio. For cereals and dairy, satisfying domestic markets with high value products may have more potential than exporting, because these export markets are usually of low value (most cereals are commodities, milk is exported as powder). For processed fruits, the success of the strategy will depend on finding the production-processing-marketing combinations that allow adding value in international markets. For forestry, adding value is a continued challenge, also because of the usual low value per unit weight which becomes a more binding constraint with higher energy prices. On the other hand, forestry's ability to contribute to improved environmental management and to mitigating climate change by absorbing greenhouse gasses may open new opportunities.

In both scenarios it is clear that Chile's future competitiveness and total factor productivity growth is limited by **the low quality of most of its agricultural labor**. The sector needs to pursue a strategy in which, simultaneously, the quality of labor is improved (more education), the size of the productive holdings is increased (to allow economies of scale and pay farmers better) and the quality of rural life is improved (to ensure that people stay). A further factor in support of this strategy is the aging of the rural population. Twenty years from now many farmers will have retired.

The need to upgrade the labor base is relatively independent of the amount of climate change or public policy. Some other strategies may be more dependent on the future scenario. In the scenario with little climate change the country may win more with **investing relatively more in institutional innovations** (branding, market and price risk management, enhanced regulatory and certification systems, PPPs for market identification and product differentiation, stronger subsector organizations, etc.) than with investing in technical innovation. In the scenario with climate change, however, **adaptations in production technology and production systems** will be more vital to ensure that Chile's agricultural systems remain productive. Only if agriculture remains productive, the country may profitably invest in better market access, which will now be strongly linked with reducing and certifying the ecological footprint of Chile's agricultural value chains

The different ways in which the two scenarios play out would also suggest that **the agricultural innovation system should maintain a certain amount of flexibility** and ability to address unexpected problems. This conclusion would only grow in strength when realizing that the two scenarios are only some of many possible ways in which the future may present itself: market conditions might change more strongly; the geopolitics of international trade might move away from the trend towards more open markets; competing countries might improve their position more slowly, or more quickly. In order to maintain flexibility, several suggestions can be made. It may be useful to develop strong market information systems to understand long-term consumer trends; to strengthen knowledge and information systems within the sector to channel the right information at the right time; to invest in basic human resources skills before specializing; and to anticipate market trends, for example by establishing Chile's own trademark rather than following the many certification standards that have been introduced in the last decades.

While the difference between the scenarios may appear to be big, they become smaller once we realize that Chile is a net importer of fossil fuels. Reducing the use of fossil fuel per unit

of production will lower costs of production in the “Business as Usual” scenario and will reduce the ecological footprint in the “Terra Calida” scenario. Focusing Chile’s agricultural technology generation on **“eco-efficient agriculture”** (a concept first developed by CIAT, the *Centro Internacional de Agricultura Tropical* in Cali, Colombia, part of the Consultative Group for International Agricultural Research) would be a strategy that could pay off in either future scenario.

C. Towards a Vision for Agricultural Innovation in Chile in 2030

I. Drafting a Vision Statement

Informed by the results of the analytical studies, the considerations of a group of decision makers, the scenario story lines and the implications derived during the workdays, FIA and World Bank staff drafted a vision. The vision tries to bring together those strands of the earlier inputs that show up repeatedly (for example the need for increasing the level of sophistication of the labor force comes back in many inputs), and tries to reconcile opposing or divergent future possibilities (for example, the market versus the resource based orientation in the two scenarios). But a vision is not only a process of adding and averaging. **It also expresses an ambition, an idea about how the future should look.** It is better to say that the vision is inspired on the earlier inputs than that it is derived from it.

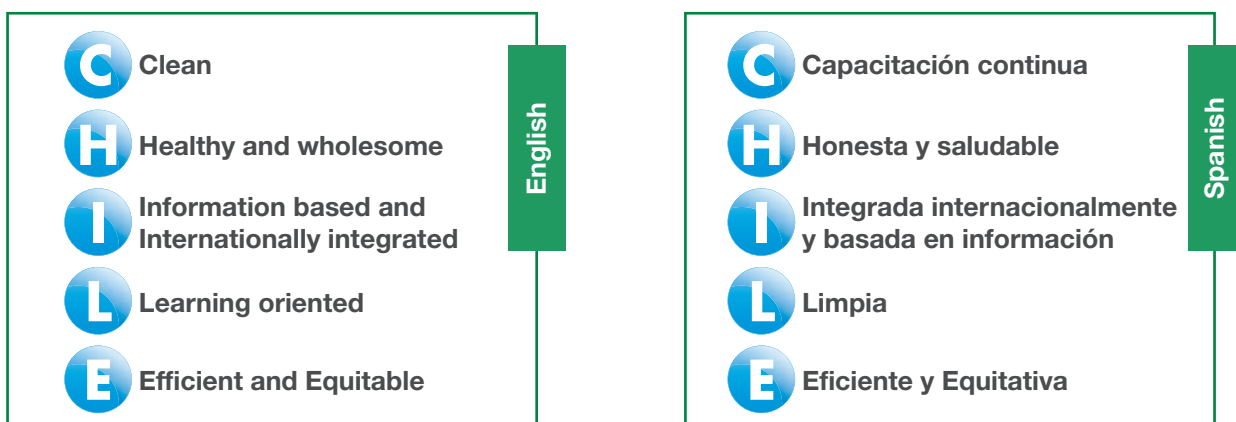
Because the vision reflects future trends but also subjective positions, it cannot be wrong or right and cannot be empirically verified. It should however be attractive and inspiring not only to the authors, but also to the readers. And it should provide ideas for future activities to help achieve the vision. The vision statement will be made available for comments on FIA's web site (<http://www.fia.cl>). Based on these comments the vision statement below can then be further elaborated.

II. A Proposed Vision for Agriculture and Agricultural Innovation in Chile in 2030



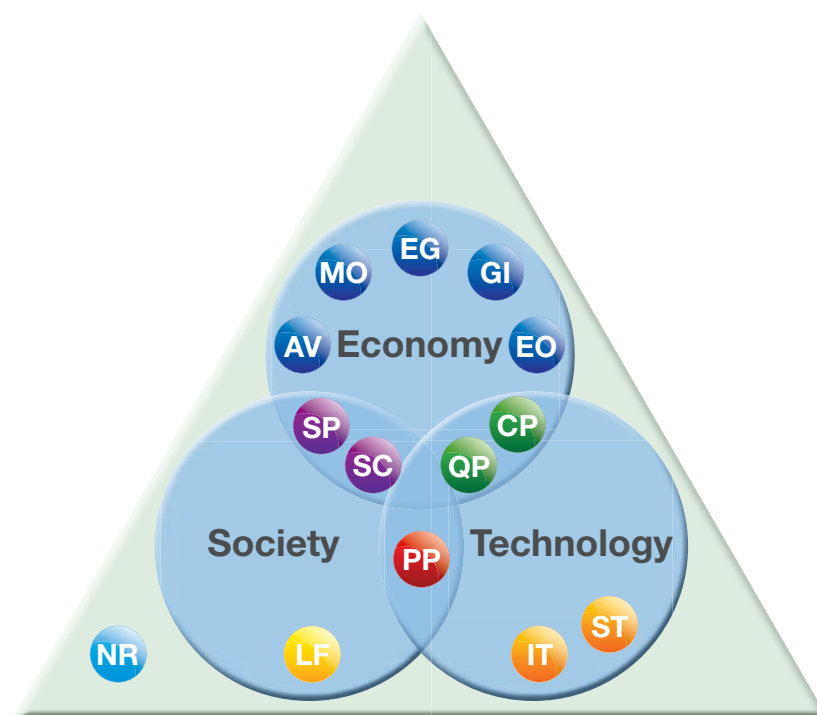
In 2030 Chile is a quality producer of a range of food and fiber products. Its international image is marked by the diversity that its geography allows it to produce. The sector has an emphasis on environmental sustainability and wholesomeness, valued by both domestic and international consumers. Through 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:



To further elaborate the vision statement, the desired characteristics of the sector in 2030 will be discussed. As shown in Figure 2, some of the desired characteristics are mainly of an economic nature, some relate more with the societal dimension and a third group is based in the field of science and technology. There are also some characteristics that relate with more than one field. And finally all these characteristics must be realized within the context of the environment. **By focusing the action agenda of the Government of Chile on these key characteristics, the country will be able to achieve this vision.**

Figure 2. A graphic presentation of a vision with economic, societal, technological and environmental characteristics



Economic characteristics:

EG Economic and sector growth. In 2030 income per capita in Chile has doubled from \$9470 in 2008 to around \$20,000, a level slightly below the average of the OECD countries. The structural change that is usually associated with such development has also taken place. Chile's agricultural sector has grown somewhat less than the rest of the economy and its participation has fallen from 6% to 5%. Labor participation has fallen more quickly, from 13% to 8%, but average wage levels have increased and are similar to those for other jobs in the rural economy. In 2010 Chile's agricultural exports were 20% of total exports, and twenty years later the sector has been able to increase its share to 25%. Chile's agricultural sector is considered a sound investment opportunity. There is no shortage of capital and the sector grows at just 1% below the average of the rest of the economy.

GI Globalization/internationalization. Chile's agricultural sector has developed itself in an increasingly globalized setting, where value chains and corporate engagements cross borders, in function of relative profitability and opportunity. The internationalization trends that were already visible by 2010 have strengthened, with the main difference that China and other parts of Asia have grown in importance. With the global trend towards healthy and wholesome food, Chile's ability to bring freshly harvested produce to the table in a counter seasonal way has again obtained value: Chilean products can be made available fresh and with minimum storage or processing treatment when there is limited supply from other countries.



MO Market orientation and market awareness. Chilean producers understand very well that the market is the final measure of success. Market information systems, both for domestic and international destinations are available to any farmer. Most small and medium farmers for products that require extensive processing (dairy) are part of cooperatives or have long-term contracts with the industry. Cereal and potato growers don't have such long-term commitments but may engage in season-to-season contracts and in virtual markets based on clearly defined quality parameters and ICT based markets. Large, capital-intensive producers have often been able to develop direct contracts with retailers, within or outside Chile.

EO Export versus domestic orientation. Chile's production capacity exceeds its domestic demand for some of its export products, but the country has effectively learned to test new ideas and concepts among its own increasingly sophisticated consumer base. For some other products (e.g., soy beans for animal feed) the country is an importer.

AV Added value and Income levels. Chile's clean and healthy products are being made available through efficiently, domestically and internationally, integrated value chains. Its added value allows the sector to pay salaries comparable to the rest of the rural economy and to yield competitive returns to capital.

Societal characteristics:

LF Labor force. Between 2010 and 2030 Chile has experienced an exodus of aging farmers into retirement, especially in the family farm segment. The replacement ratio has been below 50%, with many farms being sold or rented out to neighbors. The result is that by 2030 there is still some dominance of older farmers but much less than in the past. In the export-oriented subsectors, the labor force has fallen somewhat due to competition from the urban economy and the mining sector.

Success is about working with the right people. Chile's agriculture is aware that it needs to make sure it keeps having the right people. The educational level in the sector has improved, through major efforts by both the Ministry of Agriculture and the Ministry of Education. Besides a strong system for educating agricultural graduates and post graduates, the country has strengthened education at the vocational and farm management level. On line, on demand training systems help in maintaining Chile's agricultural people on top of their game. Certification systems are in place to ensure continuous upgrading of people's skills and knowledge. Most agricultural workers are now able to complete complex assignments and to make minor crop or livestock management decisions based on their own judgment and the availability of ICT enabled information systems.

Technological characteristics:

ST Scientific support and the use of agricultural technologies. Chile's scientific support to the agricultural sector has reached the average investment level (as the share of AgGDP) of the OECD. Chile has invested significantly in agricultural science and has strongly increased the availability of locally developed technologies. This concerns, among others, plant varieties, agronomic systems, integrated crop and pest management systems, livestock breeds and animal health and husbandry systems. Biotechnology is often behind the new



technologies, supporting basic knowledge on plant genetics and facilitating the application of genes in new backgrounds. GMOs are commonly used where the product is further processed such as the case of feed grains or wines, and of course in Chile's export oriented seed production systems. For fresh foods, Chile's agricultural biotechnology has focused on increasing the functional value (and thereby the possible price) over raising productivity. The impact of these new technologies is strongly enhanced by their interaction with:

IT The use of technologies from other sectors (ICT, nano). ICT is changing the face of Chilean agriculture. For example, while the effective water availability has been falling, the agricultural sector is able to irrigate larger areas through the use of ICT based irrigation systems. Web enabled expert systems and precision farming support farmers in their agronomic choices. Even small farmers access technical assistance services, weather forecasts, and market information through their smart phones. ICT is not only improving the efficiency and the quality of agricultural production, it also has started to allow better labor conditions (e.g., milk robots allowing family farmers to stay in bed in the morning, less need for pesticide applications).

Mixed characteristics:

SP Scale of production. Scale of production has been increasing from 2010 to 2030 in the light of the higher labor costs and the reduced labor availability. In the traditional sectors such as cereals and dairy, small farms are still found. Usually they are owned by farmers with little debt that are too old to change their economic activity. When they decide to retire, their land is often absorbed by larger neighbors or by corporate producers (for example from the fruit and wine sector). In the subsectors mainly oriented towards exports, scale of production is large, most labor is hired on formal contracts, capital investments per business are high and obtained from the formal credit system.

SC Sector coordination and concertation. Chile's producers, both in the export and in the domestically oriented subsectors, as well as Chile's government, are all aware that in 2030 the setting is not about producers that compete among each other within national markets, but that the challenge for Chile's agriculture is to compete with other countries. This has led to the strengthening of horizontal organizations (e.g., any type of farmer or wholesaler) and vertical organizations (e.g., all actors in one value chain). These organizations lobby with the government and are consulted in decision making when it affects their interests.

PP Public and private responsibilities. While recognizing the intimate need for public-private collaboration and for concerted strategies in the subsectors, the Chilean government is maintaining a clear and concise regulatory system regarding environmental management, food safety, and sanitary management. The sector recognizes the importance of the regulatory regime for maintaining Chile's reputation as a clean, responsible, quality producer.

CP Collaboration with external partners. The ongoing internationalization has affected the control over some of Chile's most important value chains, such as fruits, wine and processed foods. Chilean businesses have started to invest abroad in order to be close to the final consumer; and foreign businesses have started to invest in Chile to have better control over production systems. Chile has also been recognized as an attractive final market for agricultural products and most multi-nationals active in the global food systems



have strengthened their presence in Chilean food markets. Chile's agricultural innovation system is strongly internationally integrated. It sources its staff from where they are best, and collaborates in many international networks and partnerships. From being a follower, Chile has become a co-pioneer.

QP Quality of production. In 2030, sophisticated restaurants around the world serve Dutch cheese, Swiss chocolates and Chilean fruits and wine. Chile is able to manage the quality of its production in response to the market that it is targeting. It has top of the line products but is also able to supply competitive quality to its own domestic markets and to the large retail markets that have developed in Asia.

Environmental characteristics:

NR Natural resources endowments and climate. Effective water availability has been falling due to competition for water from urban and industrial consumers and because of the reduced reliability of glacier based run-off. Chile has maintained its patchwork of valleys and regions with specialized adapted production systems. Chile's counterseasonal seed Industry has benefited from improved zoning to separate areas of organic production from areas where GMOs are allowed. In function of changing international demands, water availability, as well as climatic changes, the geographical pattern of production has started to shift southward. Careful resource use has contributed to an attractive countryside and the development of agro-tourism.

The vision statement and the further elaboration on the characteristics of the sector in 2030 are not specific to any sub-sector and may be further developed for each of them, taking into account their own particularities. Box 3 provides an example of how a sub-sector specific vision would look for Forestry.

Box 3. A Vision for the Chilean Forestry Sector in the Year 2030

In 2012, Chile's forestry industry and public sector organizations came together to develop a long-term development plan for the area. Three components were key to the plan: First, under the joint governance of Chile's forestry association, MINAGRI and the regional governments, R&D programs were put in place to make the forestry subsector more competitive, by taking a reversed engineering approach. By focusing on consumer demands, for example in construction and furniture, and adapting the value chain (from production to consumption) to meet these demands, Chile started to grow its market size and adding value to its exports.

Secondly, parallel to the R&D efforts, forest management policies were implemented to ensure sustainable resource use, focusing on water and soil conservation. Based on monitoring systems that combine satellite and ground information, Chile registered 95% of its forests in environmental certification systems and obtained carbon credits for them.

Thirdly, major investments were made to upgrade Chile's forest based industries, for paper, packaging materials, construction, furniture, and non-timber products. Forests started to play a role in Chile's "active eco-tourism" sector, which allows its clients to engage and appreciate the environment in an active way, through hiking, biking, rafting, skiing and exploring. Many small and medium enterprises were able to establish themselves in activities such as eco-tourism, furniture manufacturing and non-timber products.

Chile's forestry is now seen as a sector that contributes to a sustainable quality of life with a growing number of renewable products and environmental services. The forestry-based sector increased its contribution to GDP and to employment. It now employs close to 300,000 people, most in postproduction activities. The plantation stock has risen to 3.6 million hectares with an annual supply of 72 million m³ of wood. A million hectares of productive native forest is maintained, supplying another 10 million m³ of wood per year. The value added of the forestry-based sector is US\$ 15 billion per year.

R&D institutions have been successfully reviewed at several times by teams made up of scientists of other OECD members. Its main subjects are plant production, genetics and biotechnology, diversification, native forest recovery, non-timber products, wood production technology, bio-energy, water management, ecosystem services, forest inventory and monitoring. While the sector has done well, it cannot rest. Climate change is putting extreme pressure on forest ecologies. The high price of carbon is increasing the cost of international transportation. The country is now preparing a market segmentation strategy with high-value, high-density products for export markets, and low-density, low-value products for domestic use, while further enhancing the ecological services of the forest.

D. From Vision to Reality – Next Steps

To move towards the vision painted above, (A) the structure of Chile's agricultural innovation system, (B) the information availability to producers, (C) the technological control over production systems, and (D) the ability to extract value from quality, will need to be reviewed. Finally, (E) the human resources base may need to be strengthened. This leads to the suggestion that the strengthening of Chile's agricultural innovation system should focus over the coming five years on the following issues:

A. Further Strengthening Chile's Agricultural Innovation System in Comparison to Other OECD Countries

Chile needs to define the investment level and the type of organization of its agricultural innovation system required to successfully strengthen its position as an agro-food power. As a new OECD member, Chile may wish to compare its investment levels with its peer countries and consider instruments to raise investment. Public sector investment will need to expand, but should be complemented increasingly by private contributions, of individual enterprises or of subsector organizations that may impose levies or demand contributions from their members.

Secondly, the country needs to decide **to what extent it wishes to integrate its agricultural innovation system with the overall national innovation system.** By integrating with the rest of the country, the sector would have access to a wider and deeper pool of knowledge and expertise, certainly interesting in fields like ICT and biotechnology. On the other hand, the agricultural sector is very different from most of the other sectors: it is geographically spread across a major part of the territory; it is made up of a large number of small or medium sized production units, and a fewer number of large enterprises, which strengthens the case for public sector involvement.

Thirdly, **the possibilities for creating synergy should be explored.** Synergy might be achieved by **integrating research and education roles**, as done in the US land grant model since more than a century ago, and in the Netherlands more recently. Synergy may also be achieved by creating an **"agricultural capital"**, like Wageningen in the Netherlands, Davis in California, US or Campinas in São Paulo, Brazil. Such places reduce the transaction costs for collaboration and communication and create an environment where pieces of **the different innovation puzzles can be put together more easily.** In the light of the southward trend of agriculture's point of gravity, such an agricultural capital would have to be located south of Santiago.

A **benchmark review** with recommendations on future funding and funding mechanisms, and with strategies for achieving the right levels of synergy within the sector and with the rest of the economy would be a central piece to strengthening Chile's agricultural innovation system in the coming five years and would help to create the conditions for making progress on the other issues.

B. Strengthening the Availability of Information and Knowledge to Agricultural Producers

The current access of Chilean farmers to information and knowledge is limiting the uptake of new technologies. As concluded in the first study completed by the World Bank, there is a large gap between what is known at the level of INIA or INFOR and what is applied on farms. There are initiatives to overcome the problem, such as the centers of excellence funded through CORFO, but these are time-bounded and tend to focus on specific topics, rather than strengthening knowledge and information availability in general.

ICT is creating transformational change across society. In the agricultural sector it allows for improved market information and market management, new and cost effective knowledge and information sharing

systems, precision planting systems, geographically based pest management, robotized milking and animal feeding, expert based crop management systems, communities of practice for specific activities, and so on.

Using ICT to improve information availability to farmers appears to be a low hanging fruit. ICT should not be seen as a way to replace technical assistance programs. Rather, **ICT should be integrated in enhanced technical assistance models**. In such models, institutional development considerations (strengthening the apparatus to reach out to farmers) should be combined with **strategies to increase the absorption capacity of farmers** (internet access, cell phone use, quality circles). In order to reach out towards small and medium sized farmers, **public-private partnerships could be developed**, with the public sector providing the content and the private sector the delivery modalities. For the commercial large-farm sector, the role of the public sector would be smaller.

C. Improving the Technological Control Over Production Systems

Here attention may be given to the following issues:

C1. Pursuing genetic improvement and biotechnology for developing eco-efficient agricultural production systems

Chile's agricultural genetic resources base has been strongly dependent on imported varieties. The advantage of this strategy has been that in many cases the fit with market requirements was ensured beforehand. The consequence, however, is also that Chile has followed in the markets, and not led, and that in case of stronger property right regimes, Chile may be excluded from the use of new varieties.

Strengthening Chile's domestic capacity for genetic improvement brings several advantages: it allows more rapid adaptation to changes in production conditions such as those caused by climate change; it will enhance Chile's capacity for product development strategies and for establishing its own (high value) niches. It will provide bargaining chips when negotiating access to genetic material developed in other countries.

Genetic improvement strategies may be based on traditional plant breeding or on genetic modification through the application of biotechnology. While both approaches should be used, they should carefully be assessed for environmental impact and consumer acceptance. A safe but possibly overly conservative approach would be to use genetic modification for products that are not meant for direct human consumption.

C2. Improving farm management, including agronomy and water use efficiency

Chile's arable land-base is small compared to the size of the country, and vulnerable to erosion due to its topography. With the intensification of agriculture, especially the use of agrochemicals, there is a need to manage the impacts on soil, water, pathogens and insects. Furthermore, in a market setting where clean production receives premium prices, the development of low input systems that are in ecological balance with their environment, will become a necessary condition for sustained value adding.

Water availability and the competition for water use between agriculture and other sectors (urban, industrial) **will strongly define future production patterns** and may create a shift of production towards the South, even more than possible climate change effects. Improving water use efficiency has many dimensions:

first, the **water storage and supply systems can be further improved** and made more demand-based. Secondly, **water application can be made more efficient** by the development of sensor-based expert systems for irrigation (drip and sprinkler). Thirdly, the **water uptake by different crops may be improved**. **Achieving better water use efficiency requires a mix of approaches**, some based in agricultural science (e.g., crop water uptake), some based in engineering (water supply systems), and some based in operational research (crop irrigation).

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

Chile's agricultural value chains require **in-depth knowledge and understanding of final consumer markets**, in order to produce what is demanded and supply it in the right shape and package, at the right time and in the right place. Because of Chile's distance from many of its export markets, it is not always easy to understand these markets or to respond over night to new demands.

Improved value chain management relies on **strengthened market information systems**, and mechanisms to share this information with the lower levels of the value chain (producers); it will require **improved storage, processing and packaging technologies** to supply products in the shape that consumer prefer (the tendency is towards fresh supply); and depends on production and harvesting systems that are finely tuned to distribution requirements.

Progress in this field will require further technological development but will depend mainly on the **coordination and integration among the different value chain actors**. Chile may strengthen subsector boards that can lead such integration and that can develop subsector marketing strategies and a brand image. The coordination between suppliers and distributors is a pure private affair, which will not require government support, but may benefit from strengthened professional support as described earlier.

D. Enhancing Quality Compliance and Certification Systems

Quality management has to go beyond providing a product with the physical characteristics that the market demands. Increasingly quality is defined by how and where a product has been produced and by the guarantee that certain standards have been met. For example, Chile's forestry sector will gain a competitive advantage if its products can be traced back to where and how they were produced and if the supplier is certified for compliance with a well-known set of ecological standards.

Three types of certification standards are gaining importance. The first type concerns **standards on the ecological impact of production and processing**. Such standards refer to organic production systems, sustainable forest exploitation, animal welfare, and ecological and greenhouse gas footprints. The second set of standards refers to **consumption and nutrition indicators**: absence of pesticides and other chemical compounds, nutritional and functional value, date of harvest, GMO or non-GMO products. The third type of certification standards refers to **fair trade**: the type of producers and the guarantee that they have received a fair deal.

The other quality dimension that will require attention is **sanitary and phyto-sanitary management**. Animal diseases, especially the zoonotic ones (that can infect humans) may have very significant effects: markets may be closed, herds may need to be culled, and processing facilities may need to be closed. Plant diseases have similar effects. Chile is shielded from the spread of many diseases by sea, desert, mountains and arctic climates and has a comparative advantage to most other countries in its ability to control the inflow of pests and diseases.

E. Improving the Human Resource Base, Especially Within the Value Chains

Chile's agricultural sector needs personnel able to operate sophisticated quality-driven production systems. Input supply will increasingly be location- and time-specific; the management of production systems will be more tuned to ecological and consumer concerns; harvesting and distribution systems will be defined based on the final market. With increased mechanization and ICT use, **farm labor will need to be trained in machinery and computer applications.** In addition, farm management, also in large and medium sized enterprises, will need to be improved in order to reduce inefficiencies and to ensure supply according to the requirements of the value chain. While Chile may not need a larger agricultural labor force, it needs to ensure living conditions that will make a more educated labor force stay in the countryside. And it needs to find the **right balance between better-trained labor and the corresponding pay.**

Not only should the labor force that is working directly in the different value chains be improved. At the same time, **the quality of different support services will need to be enhanced** technical assistance agents will need to provide tailor-made solutions, farm by farm, but at a low cost. Such support will go beyond production to areas such as energy, ecology, (phyto)sanitary, quality, and value chain management. **The scientific support to the sector will need to be expanded** and will require an increased number of highly specialized researchers.

The third report that the World Bank and MINAG have agreed upon will define how these issues can be elaborated in an **Action Plan** that brings public and private sector together, and considers new policies, new organizations, new incentives and new investment modalities.

