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SCIENCE AND TECHNOLOGY FOR REGIONAL DEVELOPMENT

Progress and results of the Regional Centers created by CONICYT and
the Regional Governments



Programa
Regional



PROGRAMA
REGIONAL
CONICYT

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Science and Technology for Regional Development:
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Regional Scientific and Technological Research Program
National Commission for Scientific and Technological Research (CONICYT)

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SCIENCE AND TECHNOLOGY: AN ALTERNATIVE FOR THE TERRITORY



Francisco Brieva Rodríguez
President
CONICYT

Chile is a territorially complex country, with sharp geographic contrasts according to the cardinal points, subject to a permanent process of geological and geophysical evolution, with a diverse population, as a result of a social and economic history that sometimes seems to go against common sense. At the same time, it provides generous, diverse opportunities of all types that could very well sustain a more equitable, sustainable and inclusive society than the one we observe today.

The desert, the valleys of the central zone, and the southern zone, which extend throughout the ocean coastline, are sources of inspiration, of a relative economic well-being, and of spaces that may be conquered. Unfortunately, we have not been up to the challenge. This territorial generosity has not been matched by the intelligence that knowledge provides, intuitive actions or traditions; it has not yet been overcome by the alternatives suggested by science: the technology that simplifies is still more a distant spectator than a close, friendly ally. The reasons are many and diverse, but they have many common elements, including a low social connectivity, the scarce density of higher education that limits innovation processes with a scientific-technological foundation, and a cultural resistance to what is different.

One way to disturb the historical national development, characterized by a dominant centralizing component, was the path followed by CONICYT when it created, at the beginning of this century, the first Regional Research Centers. Located between Arica and Magallanes, they sought to create capacities in science, technology and innovation, with an emphasis on local problems, developing collaborative work, and with shared funding between the regional government and CONICYT. Over the years, these centers have developed capacities and led their area of influence on issues such as mining, water resources, anthropology, sustainable tourism, food, polymers and Sub-Antarctic ecosystems, to mention just a few. This has established a model that searches for answers to the issues and problems that each region faces.

After more than a decade of operation, the concept of the Regional Research Center has been refined and perfected. There are noteworthy cases of success, and other regions that have had a hard time identifying the impact that science, technology and innovation have on their own development. We have learned from the difficulties that arise between

the different actors in each community, with their sensibilities, with the expected acknowledgements; there are issues related to the infrastructure required to operate a center; the matter of the property or control over this type of organization, which interrupts the traditional order of the field and its established universities or public institutions, has not been fully resolved. Fortunately, in the end, when these issues are solved we may move forward.

Long-term funding for the regional centers is an open conversation. Until now, if we analyze where the economic resources to sustain these centers comes from, we will see that the dominant source of funding (over 90%) is public, either regional or national. This raises a crucial question regarding the level of self-financing which, if it exists or is enforceable, would be appropriate.

There is little doubt that the idea of promoting research through regional centers which focus on demands that the territory establishes -regional problems- is one of the interesting initiatives being implemented to decentralize scientific-technological work in Chile. When complemented by the tasks of placing advanced human capital and working with national and international university networks, among many others, we are on our way towards creating a new strategy that may help capitalize the national territory and its virtues to respond to the concerns and demands of future generations.

Today, this issue has become even more relevant in the context of the presentation of the report produced by the Presidential Committee "Science for Chilean Development". We hope that the actions proposed therein may generate greater and better opportunities for doing better science and technology in every corner of the nation.

SCIENCE IN REGIONS: LEARNING FROM EXPERIENCE



Christian Nicolai
Executive Director
CONICYT

Our country has come to a broad consensus among various sectors, in terms of its support for scientific and technological research as a motor for its economic and human development.

From this perspective, and with the idea of breathing life into this goal throughout Chile, the CONICYT Regional Program has worked with regional governments on the creation, continuity and strengthening of Scientific and Technological Research Centers, a model that is established based on the needs and issues that are relevant to each region, an experience that we would like to present in this document, reporting on the extent of its main results.

There are currently 13 centers that receive funding and support from the Regional Program, distributed throughout 11 regions of the country, where Valparaíso is the only region that has three centers. We are moving towards the creation of centers in three regions that still lack one, such as the case of Atacama and Los Ríos, and we soon expect to also have one operational in the Region of Los Lagos.

It is important to point out that, until now, six of the regional centers have already completed their first ten years in the stages of Creation and Continuity, and have begun the stage of Strengthening Continuity, a process that CONICYT has decided to support with core funding for three additional years. Once this period is over, we will face the challenge that will force us to reflect on the need for a long-term policy of financial support for these centers, which will also provide job security for researchers and support staff that works there, while also establishing a solid foundation for the creation of science in and for Chile's regions.

We will face this challenge in 2016, with the CEAZA and CEQUA centers, which are about to complete their three-year cycle of core funding after year ten, and later with another four centers that are beginning this stage and require information on their future perspectives. Ensuring sustainability for the regional center model is currently an urgent need.

Meanwhile, there is also an opportunity to create new regional center cohorts dedicated to specific local problems, which would have the possibility to learn from those who have had the most success. This means providing a tool for continuous improvement to the system, where the new centers may draw on the management experience of others that

have grown and are currently making important contributions to the development of their regions. In this sense, the oldest centers, CEAZA, CEQUA and CGNA, represent a good example. The latter won the Avonni 2014 Award for Innovation in the category of Natural Resources, for its development of the *AluProt*-CGNA seed, which has a protein level superior to that of soybean, an as yet unsuspected market potential, and which also has an innovative business model in which small farmer cooperatives in La Araucanía founded the NG-Seeds corporation, benefitting directly from science and innovation.

Notwithstanding, the path to achieving an economic and social impact at the regional level through science has not been without problems for the regional centers; some projects have not been pursued further; others, such as those mentioned above, have been able to endure. What has been the main factor in determining their success? The common element is that their regional governments believed in them, maintaining solid funding without expecting results “just around the corner”, but rather understanding the particular cycles of scientific research and the value of moving from an isolated science project to the creation of and support for an institution that remains over time and that implements the regional innovation strategy. The regional governments that were constantly supportive of their regional centers are now reaping the benefits of science in the sustainable development of their territories. This is why a long-term commitment between regional governments and regional research centers is a fundamental aspect of the structural base that will determine the decentralized development of science.

There are many challenges, and the CONICYT Regional Program has the spirit and willingness to face them all: to advance in the development of metrics to register and evaluate the achievements, results and impacts of the centers; to strengthen their management as a portfolio, but also to focus initiatives such as the Annual Call for Reinforcement on the weaker aspects of their operations; to work more closely with the boards of each center and with the regional governments to determine a roadmap for flagship projects, to mention just a few.

And although we have much to do, we feel that we have made significant progress in this adventure of the regional centers, with outstanding results, that we wish to present in greater detail in this document in order to make them available to different communities within our country and abroad. We invite you, then, to review its content and learn about its impacts and potential.

THE CENTER'S AREA OF CONICYT REGIONAL PROGRAM



Juan Paulo Vega Haristoy
Director
CONICYT Regional Program

The CONICYT Regional Program was created in 2000 in the framework of an agreement between our institution and the Subsecretariat of Regional Development of the Ministry of the Interior (SUBDERE), to support the decentralization of science and technology through various instruments.

With the goal of creating new research capacities, or strengthening existing ones, designed to provide solutions for territorial problems and contribute to local economic development, in 2001 the first contest for the Creation of Regional Centers was implemented, which led to the creation of the Research Center of the Man in the Desert (CIHDE) and the Center for Quaternary Studies in Fuego-Patagonia and Antarctica (CEQUA), projects funded for five years by CONICYT and the regional governments of Tarapacá and Magallanes, respectively¹.

The main goal of this instrument has been to expand, from a geographic and institutional perspective, the distribution of human, financial and material resources for research and development. Also, the research done has been focused on issues that are relevant for the development of each region where a center has been established.

Beginning with the second contest, in 2002, which led to the possibility of allowing the centers created to apply for a funding extension of another five years as a maximum limit, these projects were awarded to the Center for Advanced Studies in Arid Zones (CEAZA), in the Region of Coquimbo, and the Research Center for Advanced Polymers (CIPA), in the Region of Biobío.

In 2004, the third call for this contest created the Scientific and Technological Research Center for Mining (CICITEM), the Agriculture and Aquaculture Nutritional Genomic Center (CGNA), the CIEN Austral Research and Development Center (not currently a CONICYT project) and the Center for Research on Patagonia Ecosystems (CIEP), located in the regions of Antofagasta, La Araucanía, Los Lagos and Aysén, respectively.

In 2006, the Regional Center for Healthy Food Studies (CREAS), in Valparaíso; the Regional Center for Research and Sustainable Development

¹ With the creation of the Region of Arica y Parinacota, in 2007, CIHDE became part of this region. Later, in 2009, the Center for Research and Development in Water Resources (CIDERH) was created in the Region of Tarapacá.

(CRIDESAT), in Atacama, and the Engineering Center for Innovation (CIN) in Los Ríos (these last two not currently CONICYT projects) were all created. In 2009, projects were awarded to the Center for Research and Development in Water Resources (CIDERH) in Tarapacá; the Center for Studies in Processed Foods (CEAP) in El Maule; and the Center for Advanced Studies in Fruit Culture (CEAF), in the Region of O'Higgins.

Finally, in 2011 the Valparaíso Regional Center for Hortofruticulture Innovation (CERES) and the Tourism and Patrimony Research Center (CITYP) were created by initiative of the Regional Government of Valparaíso, which have core funding solely from the region itself and to which CONICYT has only provided technical support and competitive funding through annual calls for projects designed to strengthen regional centers.

In the medium term, these research centers are expected to stimulate the regional development of specific disciplines or areas, becoming national reference points in their fields of competence and strengthening associativity among universities or other research institutions already established in the region, in order to begin joint activities with the regional centers and thus achieve new levels of excellence.

These are undoubtedly very ambitious goals, considering the core funding² initially considered to finance these types of research centers. For this reason, in 2006 the Regional Program created an instrument for the Reinforcement of Regional Centers³, which made specific resources available for investments in scientific equipment, management improvement, and advancement of human resources. These reinforcement projects have been funded with CONICYT resources and, to a lesser degree, with resources from the Regionally-Allocated Innovation Fund for Competitiveness (Regional FIC)⁴.

Over time, our program has perfected its initiatives for the promotion of regional research. In 2012, it created an instrument of Support for Continuity (Strengthening of Continuity, beginning in 2014) –with the participation of external peers for the evaluation of proposals, which has noticeably improved the process–, with the goal of allowing centers that completed ten years of effective operations to apply for CONICYT core funding for three additional years. The reason for this was that it had been observed that, empirically, the financial self-sustainability of the regional centers was not entirely possible due to their particular size and objectives; there could also be potential negative effects –in terms of credibility– in the regional context if, driven by the need to ensure their own funding, the centers would have been forced to make a shift towards an exclusively competitive and market-driven position, with no true incentives to create “public goods”⁵.

There are currently 13 regional centers. Six of these have completed their first ten years in the stages of Creation and Continuity, and have begun a period of Strengthening Continuity, a stage in which CONICYT has decided to maintain its core funding for up to three additional

² These did not include investments in infrastructure for the centers themselves.

³ During the 2001–2014 period, the Regional Program provided the regional centers, through this instrument, with around 3.5 billion Chilean pesos.

⁴ Beginning in 2008, the Regional Program manages FIC resources provided by the regions to finance research and development projects.

⁵ Defined as those which are profitable from a social perspective (of the system as a whole); since not all its benefits are internalized by the private sector, it has no incentives to provide them.

years. Five of the other seven centers are at different moments of their Continuity stage, and two are just entering the last third of their Creation stage.

The situation described above allows us to be optimistic regarding the future perspectives of an initiative promoted by CONICYT and which has made significant progress in the field of the scientific research conducted in each of Chile's regions.

DATA SOURCES AND CLARIFICATIONS ON CONCEPTS USED IN THE SECTION ON REGIONAL CONTEXT

Regional GDP (2013): Chilean Central Bank figures, in chained Chilean pesos (reference 2008). The percentage of the national total that regional GDP represents is calculated considering the regionalized subtotal of the national GDP.

Main sectors by contribution to regional GDP (2012): Chilean Central Bank figures. Percentages are calculated based on chained Chilean pesos (reference 2008).

Business composition (2013): Internal Revenue Service (SII) figures. Microenterprises are those with annual sales of up to 2,400 UF (categories which the SII defines as Micro 1, Micro 2 and Micro 3).

Exports (2013): National Statistical Institute, based on data from the National Customs Service (in current U.S. dollars).

Higher education entities (2015): Data from the Ministry of Education's Higher Education Information Service (SIES). Data on available graduate programs (2014) are disaggregated by field, according to the OECD classification: agriculture; sciences; social sciences, business and law; education; humanities and the arts; engineering, manufacturing and construction; health care and social services; and services.

Regional competitiveness index (ICORE) 2012: created by the Economy and Business Research Center of the School of Economy and Business at Universidad del Desarrollo. It consists of 7 dimensions which include a total of 65 quantitative variables, obtained using administrative data provided by public and private institutions. After processing the data, each region's final index is a value between 0 and 1.

Business innovation (2011–2012): figures from the 8th Survey on Business Innovation 2011–2012 of the National Statistical Institute (INE). The survey is cross-sectional, considering 2011 and 2012, and is representative nationally by economic sector (13 sectors), by region, by size of business, and by comparing sector and size of business. The target population are businesses with a level of annual sales greater than 2,400 UF (excluding microenterprises). The innovation rate corresponds to the percentage of businesses that produce some type of innovation.

Articles published in indexed scientific journals (2003–2012): data from SCImago Journal and Country Rank (data source: Scopus), cited by Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), Programa de Información Científica (2014), *Principales Indicadores Científicos de la Actividad Científica Chilena 2012; Informe 2014: una mirada a 10 años* (Madrid-Valparaíso). The number of articles published refers to the total number of documents produced within a specific unit of analysis (institution, region, sector or country); international collaboration corresponds to the percentage of documents produced by authors from more than one country; normalized impact is an index that compares the average number of citations received by documents published with the number of citations received by worldwide scientific production during the same period (a value above 1 indicates a normalized impact greater than the global average); normalized impact for leaders is the same as the previous index, calculated only regarding the total scientific production led by the unit of analysis.

	Research Center of the Man in the Desert	12
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RESEARCH CENTER OF THE MAN IN THE DESERT CIHDE

REGION OF ARICA AND PARINACOTA

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REGIONAL CONTEXT¹

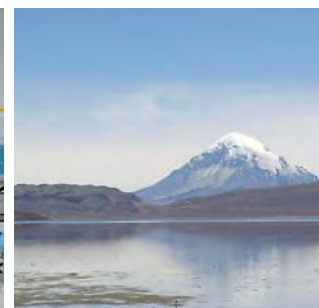
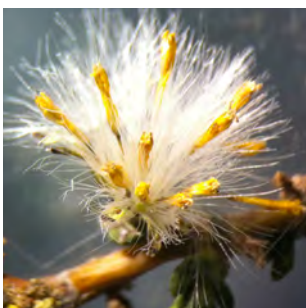
SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 701,459 (0.7% of the national total).
Main sectors by contribution to regional GDP (2012)	Personal services (17.2%), manufacturing industry (15.9%), public administration (15.3%), trade, restaurants and hotels (13%), transportation and communications (9.3%) and mining (7.6%).
Business composition (2013)	There are 14,207 businesses in the region, which employ 50,566 workers. 76.5% of these are microenterprises, which employ 12.9% of all workers. After trade and transportation, the most important sectors are agroforestry, which represent 10.1% of all firms (and 4.1% of all workers) and non-metallic manufacturing, which is 4.7% (12.6% of all workers).
Exports (2013)	MMUSD 225.6 (0.3% of the national total). The industry generates 72.4%, including 32.5% in the basic chemical product industry and 26.6% in the food industry. Mining other than copper and iron contributes 11.7%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 6 universities in the region, including Universidad de Tarapacá, which has its main campus in the region. In 2014, the graduate degrees available in the region included 4 Ph.D. programs and 41 Master's programs, mainly in the fields of social sciences, business and law (16), science (8) and education (8).
2012 regional competitiveness index (ICORE)	The region ranks 14 th in the country (index of 0.276). It ranks 3 rd in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 22.9%, very similar to the national average (23.7%). The technological innovation rate (18.2%) is also close to the national rate (18.8%), but non-technological innovation (8.9%) is quite lower than the national average (16.4%).
Articles published in indexed scientific journals (2003-2012)	A total of 800 articles (1.3% of the national total). The annual number increased at an average rate of 8.3% during this period. The rate of international collaboration was 52.4% (the same as the national rate). The normalized impact of production is 0.67, which falls to 0.52 in the case of production led by the region.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy (2009)* proposes a mission for the region that, among other characteristics, includes scientific-technological advances, the valuation of history and cultural diversity, and the promotion of economic development with an emphasis on productive infrastructure for a rational use of its water and solar resources, and particularly in support of tourism, agriculture and services. Its goals include projecting the cultural characteristics of the community, respecting its ethnic diversity and its signs of historical identity; strengthening traditional sectors so that they may modernize their management processes and enter new markets (tourism, agricultural and fishing, among others); strengthening emerging sectors that may become alternatives for future growth (water and energy resources, agricultural initiatives which integrate technology and innovation, products manufactured in the precordillera and altiplano zones, and the promotion of mining activities and aquacultural resources); and positioning scientific and technological production and innovation as fundamental factor for regional development.

The *Regional Innovation Strategy, 2012-2016* establishes a series of nine thematic areas: technified agriculture, special interest tourism, logistics and specialized industrial services, mining and technified suppliers, prospection and transformation of fishing and aquacultural resources, development and transformation of cattle resources (camelids and sheep), solutions based on solar energy and other renewable energy sources, services and technologies for an efficient management of water resources, and entrepreneurial capital.

RESEARCH CENTER OF THE MAN IN THE DESERT (CIHDE)

CIHDE was created in 2002, and established in 2004 as the Regional Scientific and Technological Development Corporation of the Man in the Desert (CODECITE). Since 2013 -following the creation of the Region of Arica and Parinacota in 2007- this entity has included Universidad de Tarapacá (UTA) and CONICYT, and the incorporation of the Regional Government is underway. Its executive director is Elías Lafertte Montoya.

The Center is dedicated to scientific and technological research and the transfer of knowledge on patrimonial and natural resources, which are relevant issues for regional strategic development, considering the extremely arid conditions that characterize the region's landscape and life. The Center provides highly qualified human resources, and seeks to contribute to the cultural development of humanity from a regional perspective. CIHDE's vision is to become a reference point for scientific and technological research that will help improve the patrimonial and natural resources of the Region of Arica and Parinacota.

GOALS

CIHDE's goal is to promote scientific and technological research and its transfer, which focuses on studying the interactions between men and the desert environment, using a multidisciplinary approach that combines high-level training, the improvement of scientific and technological production and research, and the dissemination of this knowledge as contributions to the region's economic and social development, by diversifying the productive base through sustainable economic forms, strengthening the agricultural and tourism sectors, promoting a more efficient use of water resources, and favoring the development of tourist activities.

For this purpose, until 2014 the Center worked in the research lines of archeology and anthropology; human genetics and biomedicine; and natural resources. In 2015, CIHDE began a new stage and reorganized its efforts to focus on using applied research and creating solutions to local problems, through two lines: culture, society and regional identity; and Andean agriculture and ethnobotany (which are described later).

RESEARCH LINES²

ARCHEOLOGY AND ANTHROPOLOGY

Goal: the study of the Pre-Hispanic populations that inhabited the Atacama Desert, including their ways of life, material culture and inventions. In addition, to study the interactions between these populations and their environment, including paleoclimatological studies that help understand human adaptation to extreme environments.

Technical team: Calogero Santoro (Dr., line coordinator, UTA/CIHDE). Researcher employed by CIHDE: Thibault Saintenoy (Dr.). Researcher from the partner institution: Eugenia Gayó (Dr., UTA). Research support (CIHDE): Daniela Osorio (Bach.) and Paula Ugalde (Bach.).

HUMAN GENETICS AND BIOMEDICINE

Goal: the study of the genetic composition of human populations in the Region of Arica and Parinacota to understand its origins and effects on their lifestyle; and to study regional endemic plants which may potentially be used to produce functional foods or new pharmaceutical products.

Technical team: Francisco Rothhammer (Dr., line coordinator, UTA). Researcher employed by CIHDE: Carlos Echiburú (Dr.). Research support (CIHDE): Felipe Figueroa (Bach.), Francisca Álvarez, Macarena Fuentes and Iván Pulgar.

NATURAL RESOURCES

Goal: the study, monitoring, distribution and dynamics of chemical elements in desert environments and its components, such as water, marine and edaphological resources; this line also tackles the challenge of providing technological solutions, taking advantage of renewable energies (especially solar energy), which may allow it to foster the zone's economic development.

Technical team: Lorena Cornejo (Dr., line coordinator, UTA). Researcher employed by CIHDE: Juan Mancilla (Dr.). Research support (CIHDE): Jorge Acarapi (M.Sc.), María Arenas (Bach.), Hugo Lienqueo (Bach.), Israel Valenzuela (Bach.) and Patricia Vilca (Bach.).

In 2015, the Center reorganized its efforts into two research lines. The culture, society and regional identity line will conduct multidisciplinary studies to explain the cultural dynamics that forged the regional identity of Arica and Parinacota, using science to serve the region's social and cultural interests. This line will develop research and sociocultural actions that promote the appreciation of cultural diversity as a central element of regional identity. This research is being conducted under Dr. Thibault Saintenoy.

The Andean agriculture and ethnobotany line, meanwhile, will investigate the region's flora, seeking to value this resource and thus strengthen the economic

and social development of local communities. This will be a participatory process that involves works with communities to ensure the sustainable development of each proposal. It aims to take advantage of the region's characteristics as a natural laboratory with great floral biodiversity, adapted to extreme environmental conditions, as well as its potential for applications in preventive medicine, which has been demonstrated by the traditional indigenous medicine that is part of the region's ethnobotanical patrimony. The team for this line consists of researchers Carlos Echiburú (Dr.), Nandy López (Dr.) and Patricia Acosta (M.Sc.), with the support of Felipe Figueroa (Bach.) and Francisca Álvarez.

² Information on the three research lines described first corresponds to the period until 2014; after that, the two lines that the Center has been working on since 2015 are described. The abbreviation "Bach." indicates that the professional has earned a bachelor's degree, such as a B.A. or B.Sc.



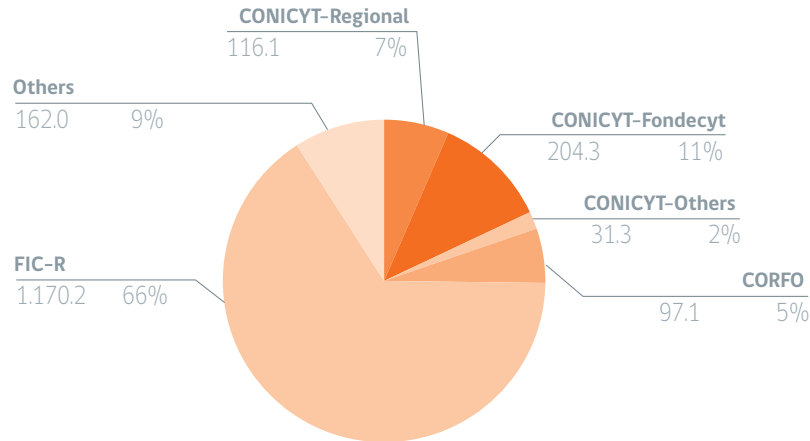
RESOURCES OF THE CENTER DURING THE 2011-2014 PERIOD³

Core funding from CONICYT Regional Program *	MMCLP	814,0
Core funding from Regional Government of Arica and Parinacota**		----
Resources awarded through projects from different sources	MMCLP	1.781,0

* CONICYT has committed core funding for the Center until 2018.

** The Center was implemented in 2002, before the creation of the Region of Arica and Parinacota (2007).

CIHDE: resources awarded through projects from different sources, 2011-2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CIHDE and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Assigned Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CIHDE'S ACTIVITIES BETWEEN 2011 AND 2014

Through scientific research and the transfer of results to the community, CIHDE has sought to contribute to social well-being, quality of life and sustainable territorial development in ultra-arid regions across the world, such as the Atacama Desert, creating knowledge of its environmental conditions, its natural resources and the interactions and cultural and biological evolution of human populations in these surroundings.

In the natural laboratory represented by the driest territories in the world (a natural context that also helps project the advance of desertification processes on other continents), during the 2011-2014 period the Center produced basic and applied science to help understand the factors and mechanisms through which various biological species have adapted and survived in these zones characterized by extreme environmental conditions. For this purpose, it has conducted studies on the desert and its inhabitants through different

disciplines: archeology, anthropology, genetics, biomedicine, environmental sciences, ecology and chemistry, among others. The line of archeology and anthropology, in particular, produced studies on the Pre-Hispanic populations that inhabited the Atacama Desert, their lifestyles, material culture and inventions, as well as the interaction between these populations and their environment, including paleoclimatological studies which help understand human adaptation to extreme conditions.

Thus, through its various research lines (all those active until 2014 or which started in 2015), CIHDE conducts interdisciplinary research that has led to the award and execution of scientific research projects, in the fields of archeology, water resources, solar energy, aquaculture and biomedicine, among others, as well as scientific publications and participation in events for the dissemination of science (specialized congresses and seminars). The Center also offers training and field work (especially in rural areas), collaborates with the productive sector on projects of communal interest, and participates on public committees and roundtables.

³ In current Chilean pesos of each year.

RELATIONSHIP WITH REGIONAL POLICIES

CIHDE's work is clearly aligned with regional policies for Arica and Parinacota, since it seeks to contribute to the valuation of the region's historical patrimony and cultural diversity, as a central element to generate its identity and promote its development. As a result of its work in various research lines, it also supplies the region with knowledge and technologies that support the productive development of sectors which are regional development priorities, such as agriculture and fishing, tourism, renewable energies and the use of water resources, among others. This put science, technology and innovation at the service of regional development with a clear cultural identity, thus taking advantage of the territory's valuable resources.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

Until December 2014, CIHDE's research team consisted of 18 people, including 8 researchers (7 with a Ph.D.)⁴. 5 of the researchers, professionals and technicians worked in the archeology and anthropology line, 6 in the human genetics and biomedicine line, and 7 in the natural resources line. Their work is supported by a management team of 7 people.

Technical team in December 2014	Employed	Associated	Total
Researchers with a Ph.D.	3	4	7
Researchers with a Master's degree	1	0	1
Professionals and technicians who support research	10	0	10
Total	14	4	18

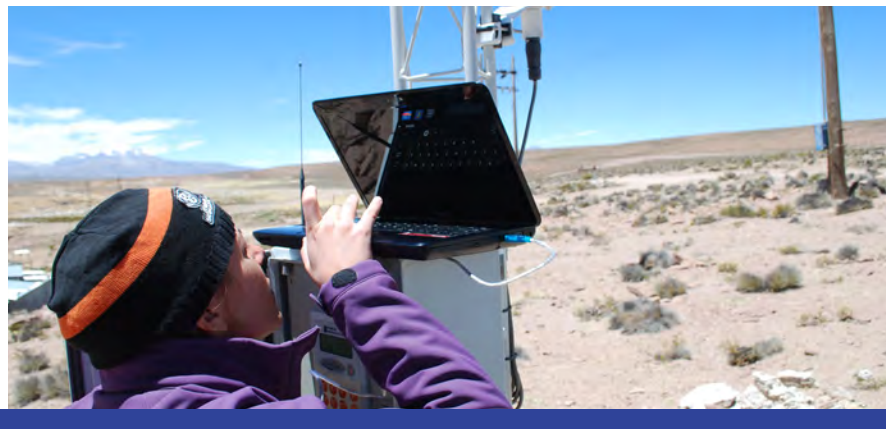
Its main office is located on the Velasquez campus of Universidad de Tarapacá, in Arica, where its different lines have specialized laboratories for analyzing water, soil and vegetable samples, as well as archeological samples and paleoecological materials, among others. The human genetics and biomedicine line implemented a biotech laboratory for conducting studies on proteins, genetic expression, cellular cultivation, cellular analysis, genetics and proteomics and the production of vegetable extracts, among others.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

CIHDE has scientific collaboration agreements with a series of entities both in Chile and abroad. Internationally, it has formal agreements with the Universidad de Coimbra's Instrumentation Center (Portugal), to study non-destructive X-ray techniques; the Australian Centre for Ancient DNA, at the University of Adelaide, to conduct joint research on ancient DNA variation in prehistoric human samples (from the Pica 8 archeological site) and with Axon, Social Innovation (Spain), to study local and regional development; it also has agreements for collaboration in common fields of interest and knowledge exchange with the College of Arts and Social Sciences of the Australian National University, Flinders University (Australia) and Universidade de Lisboa's Atomic Physics Center (Portugal).

In terms of project development, the Center collaborates with entities such as Université de Rennes (France) (ECOS-CONICYT project), studying the first human populations in the Atacama Desert through archeometric analyses; and the Almeria Solar Platform (Spain), which belongs to the Center for Energy, Environmental and Technological Studies (CIEMAT), the largest European center for research and development on solar concentration technologies, which is executing two projects on solar radiation. It also has an alliance with the Centre for Pharmacognosy and Phytotherapy

⁴ The list of the Center's researchers (in 2015) is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.



(University College of London, United Kingdom), to develop projects, internships and joint publications, and with the Universidad Nacional Jorge Basadre Grohmann (Peru), to train human capital and develop applications for epidemiological projects in the genetics and biomedicine line.

Nationally, the Center has working agreements with the Regional Government of Arica and Parinacota, the Regional Council of Culture and the Arts, the Center for Advanced Studies in Arid Zones (CEAZA) and the *National Television Council's* Novasur. It also collaborates with Pontificia Universidad Católica de Chile, among other entities, on projects in the archeology and anthropology line; and with the Solar Energy Research Center (SERC-Chile) in solar energy studies.

Relationship with local organizations, industry-related and government agencies

The Center has established a close relationship with the regional productive sector, mainly by providing services and consultancy to water and sewage, mining, food and other businesses; and by developing projects together with Chilean and foreign businesses in the sectors of mining, energy and vegetable raw material processing for the production of food and phytopharmaceuticals, among others (in the latter case through an initiative which also includes agricultural producers).

It has supported the productive improvement of the artisanal fishing sector (Municipality of Camarones) through the thermal desalinization of seawater (at a plant powered by solar and photovoltaic energy), in order to improve the operating and sanitary conditions of post-extractive activities, thus supporting the commercial scaling of artisanal fishermen.

In terms of public entities, the Center collaborates with the National Indigenous Development Corporation (CONADI) on the potential creation of an indigenous development area. It also has an active presence in the regional community, especially among schools and higher education institutions, through activities designed to raise awareness regarding the value of the region's cultural and natural patrimony, on subjects such as cultural diversity, intercultural tourism and the early colonization of the territory, as well as training on entrepreneurship.



RESULTS AND IMPACTS IN THE REGION

Seeking to value Arica and Parinacota's cultural patrimony and its characteristics as a natural laboratory, CIHDE develops research and technologies to understand the past and project the region towards the future. Besides its studies on the first inhabitants of the region and the continent, it also conducts research on the potential of solar energy and the medicinal use of vegetable species, as well as technologies for using water in post-extractive fishing activities, in support of productive development and strengthening regional identity.

The archeology and anthropology line features research on the first human populations to inhabit the Atacama Desert, with the goal of characterizing human migration and settlements in one of the driest environments on the planet, and understanding processes of human exploration and adaptation. In this



field, there is a Fondecyt project on the evolution of the landscape in the ultra-arid zone of Atacama during the transition between the Pleistocene and Holocene eras; this study has led to scientific articles of great national and international relevance and impact, with the participation of practically all researchers in this line, regarding the first human beings to populate the Atacama Desert some 13,000 years ago.

Also, one of CIHDE's main achievements is the discovery of evidence of conservation that dates back 12,000 years, in the very fragmented remains found in Quebrada Maní 12, which is a very interesting finding for the scientific community.

Also noteworthy is the Center's participation in the "Altos de Arica" research program, an initiative developed by an international team of archeologists, geographers and anthropologists, along with UTA, the Archeology Laboratory of the Americas (ARCHAM) of the National Center for Scientific Research (CNRS) in France and the French Institute for Andean Studies (IFEA), with funding from CONICYT and the French Ministry of Foreign Affairs. This program seeks to document the history of the sierra de Arica mountains by studying its archeological footprint. For this purpose, an international team is developing an interdisciplinary methodology with a multi-scale focus that combines field prospection and excavation, the archeometric analysis of artifacts, and territorial analyses based on cutting-edge geomatic technologies.

In the human genetics and biomedicine line, the Center has participated significantly in the "Consortium for analyzing the diversity and evolution of Latin America," a multidisciplinary international consortium that includes specialists in the biological diversity of Latin American peoples and sociocultural surroundings. Its current research focuses on urban populations in Brazil, Chile, Colombia, Mexico and Peru, and aims

to test a series of hypotheses that are relevant to anthropological, biological and medical research, such as the relationship between identity self-perception and external physical aspects, genetic ancestry and the sociocultural environment.

In a more recent field, it conducts studies to identify and learn more about the characteristics of the region's native flora, as far as its functional and medicinal compounds, which may represent a valuable opportunity for productive development. In particular, it is developing a project to analyze a broad range of phytochemical compounds present in vegetable species, which may be used in functional foods or medicinal products. This innovative technological packaging initiative is being developed jointly with national and foreign processing businesses and farmers from the communities of Socoroma and Belén (Municipality of Putre), among others, and may soon lead to a local productive chain involving native indigenous groups in a high-tech process.

In the natural resources line, the Center's work is concentrated mainly in the field of solar energy. An important achievement was the development of the project called "Construction of a solar map for the Region of Arica and Parinacota: characterization and measurement of solar radiation by satellite images in the perspective of creating regional innovation and development by implementing thermosolar energy in Chile". This initiative helped to prove that the region boasts one of the best sources of solar radiation in the world and that, by investing in this field, this tremendous potential for energy production could represent a great opportunity for economic development in the zone. At the same time, the project has helped position the region as a relevant actor in the management and future application of renewable energies at the regional and Latin American level.

Between 2011 and 2014, CIHDE’s team developed a total of 34 projects⁵. During this period, its researchers published 43 scientific articles (ISI) in journals with an average impact index of 3.134. They also produced 69 scientific works, which were presented at 47 congresses. In the context of its research lines, the Center also supported the development of 8 Ph.D., 15 Master’s and 17 undergraduate theses.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI publications	6	7	10	20	43
Impact index	0.781	6.522	0.974	3.733	3.134
Non-ISI publications	0	0	11	1	12
Number of scientific works presented at scientific congresses	7	10	25	27	69
Number of scientific congresses at which the Center presented works	4	8	17	18	47
Ph.D. and Master's theses underway with the support of the Center*	0	4	14	11	23
Undergraduate theses underway with the support of the Center*	0	4	8	8	17

* As theses last more than a year, they are counted in each year of their development.



In its laboratory, equipped with modern technology for conducting R&D, CIHDE is currently studying the nutritional and medicinal properties of the native vegetable resources of the Region of Arica y Parinacota, with the goal of producing added value.



Using three measurement stations at different altitudes, the Solar Mapping Project has helped measure the region’s radiation levels, proving that these levels are among the best in the world, comparable to places such as the desert of New Mexico, Spain or Saudi Arabia.

⁵ The list of the Center’s projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.



CENTER FOR RESEARCH AND DEVELOPMENT IN WATER RESOURCES

CIDERH

REGION OF TARAPACÁ

www.ciderh.cl - contacto@ciderh.cl - (56-57) 2530800

REGIONAL CONTEXT ¹

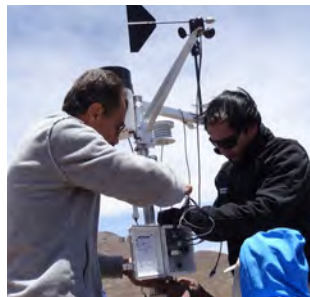
SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 2,785,773 (2.7% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (38.5%), trade, restaurants and hotels (17.9%), construction (12.7%) and personal services (8.1%).
Business composition (2013)	There are 18,155 businesses in the region, which employ 97,438 dependent workers. 67.6% are microenterprises, which employ 9.0% of all workers. The agroforestry sector represents 0.9% of all firms and employs 0.2% of all workers, while fishing represents 0.1% and employs 0.3%, respectively.
Exports (2013)	MMUS\$ 3,740 (4.9% of the national total). Mining creates 92.4% of the value of regional exports, including 81% that corresponds to copper and iron mining. This industry generates 6.9%, while the food industry, in particular, generates 4.9%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 6 universities in the region, including Universidad Arturo Prat, which has its main campus in this region. In 2014, available graduate degrees in the region included 2 Ph.D. programs and 26 Master's programs, mainly in the fields of social sciences, business and law (14) and education (6).
Regional competitiveness index (ICORE) 2012	The region ranks 5 th in the country (index of 0.439). It also ranks 12 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 22.0% (compared to 23.7% nationally). The technological innovation rate (21.1%) is somewhat higher than the national rate (18.8%), but non-technological innovation (8.1%) is much lower than the national rate (16.4%).
Articles published in indexed scientific journals (2003-2012)	A total of 337 articles (0.5% of the national total). The annual number increased at an average rate of 3.3% during this period. The rate of international collaboration was 46.0% (compared to the national average of 52.4%). The normalized impact of regional production is 0.71, which falls to 0.43 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, 2011-2020* proposes the regional goal of consolidating its strategic productive fields -industries that supply the mining, fishing, aquaculture, logistics, commercial, tourism and self-sustainable agricultural fields- through integration in a competitive regional productive chain. It also establishes the regional aspiration of having a platform of infrastructure and services that is internationally competitive and has alternative energy sources and water resources.

The *Regional Innovation Strategy for Tarapacá, 2012-2018* establishes the mission of developing within the region a global, innovative and sustainable knowledge-based economy, improving its innovation capacities and strengthening cooperation between system agents, in order to increase regional competitiveness and improve the quality of life of its inhabitants. It highlights a series of sectors that are considered strategic priorities, including desert agriculture, water resources and aquaculture.

CENTER FOR RESEARCH AND DEVELOPMENT IN WATER RESOURCES (CIDERH)

CIDERH was created in late 2009. Its current members are the Regional Government of Tarapacá, Universidad Arturo Prat (UNAP) and the National Indigenous Development Corporation (CONADI). While it is formally established as a legal entity, UNAP is acting as the responsible entity. In 2015, its interim director is Jorge Olave.

The Center's work aims to create and promote scientific knowledge of water resources in arid zones, with a multidisciplinary team of researchers who are linked to national and international networks. CIDERH's vision aspires to become a research center of reference at the regional, national and international level in the sustainable and efficient management of water resources in arid zones.

GOALS

The Center's goal is to develop research on the management of water resources in arid zones, in order to support the decision-making process regarding public policies and to provide technical assistance to regional stakeholders in the decisions made in terms of the management of water resources and the implementation of related projects. The Center seeks, on the one hand, to study the components that define the dynamics of the water cycle, to characterize the behavior of groundwater resources, and to describe the physical-chemical, bacteriological and isotopic characteristics of water resources in arid zones; and, on the other hand, to increase the availability of high-quality water in the region, developing technological tools capable of creating a greater amount of usable water resources from conventional and non-conventional sources in order to diversify the water matrix.

For this purpose, the Center works on research lines involving an integrated management of water resources and technological innovation in water systems.

RESEARCH LINES²

INTEGRATED MANAGEMENT OF WATER RESOURCES

Goal: to help produce a better knowledge and an integrated management of water resources in the Region of Tarapacá.

Technical team: Sonia Amaro (Dr., line coordinator, CIDERH). Researcher from the partner university: Venecia Herrera (Dr., UNAP). Research support: José Miguel Aguilera (Bach.), Fernando Arancibia (Bach.) and Jazna Rodríguez.

TECHNOLOGICAL INNOVATION IN WATER SYSTEMS

Goal: to increase the supply of high-quality water through reuse and natural sources.

Technical team: Jorge Olave (Dr., line coordinator, UNAP). Researcher employed by CIDERH: Betzabé Torres (Dr.). Research support: Wladimir Chávez (Bach.) and Óscar González (Bach.).

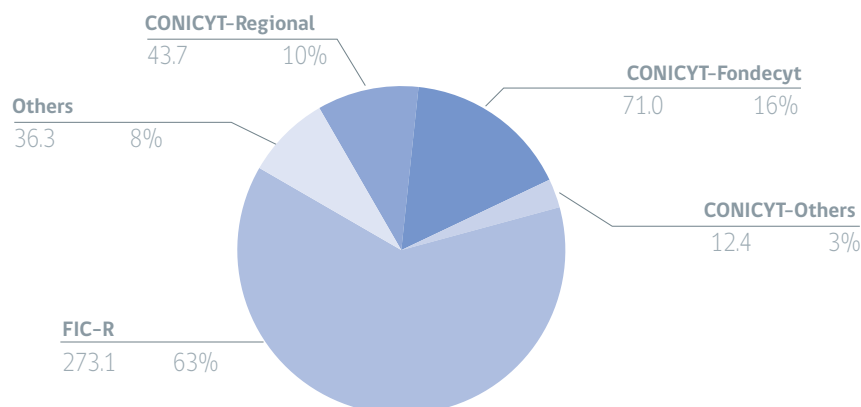
² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.

RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding of CONICYT Regional Program*	MMCLP 740.0
Core funding of Regional Government of Tarapacá	MMCLP 747.7
Resources awarded through projects from different sources	MMCLP 436.5

* CONICYT has committed core funding for the Center until 2019.

CIDERH: resources awarded through projects from different sources, 2011–2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CIDERH and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CIDERH'S ACTIVITIES

In the line of integrated management of water resources, CIDERH works to create knowledge of the characteristics of surface and groundwater resources in arid zones, as the foundation for an integrated and sustainable management. It develops research in the fields of hydrogeology, hydrology, hydrogeochemistry, analytical environmental chemistry, integrated management of water resources, climate and geography.

In the scientific-technological field, this line seeks mainly to study the components that define the dynamics of the water cycle in arid and semiarid zones; to characterize the behavior of groundwater resources and to create knowledge on the physical-chemical, isotopic and bacteriological characteristics of water resources in these zones.

In the technological innovation line in water systems, the Center's work focuses on conducting advanced and applied research in order to increase the supply of high-quality water through reuse and natural sources. This research is developed in the fields of technologies for removal of contaminants in natural and wastewater, water efficiency, environmental technology, agriculture, industry, mining and population.

In the scientific-technological field, this line aims to study innovative technologies for the treatment and adaptation of waters from natural sources in order to obtain different qualities according to the required use; to evaluate wastewater treatment alternatives that may be used in urban and rural communities and industries, to decrease discharge into the environment and promote strategies for reuse; and to adapt, innovate and apply innovative technologies to increase the efficiency of the use of water resources in industries and crops and by the population.

³ In current Chilean pesos of each year.

Both lines develop work synergies to create strategies designed to generate conservation, restoration, sustainable use and management of the water-soil-plant system present in arid and semiarid zones,

and research and development of innovative tools for implementing an integrated and sustainable management of water resources in arid zones.

RELATIONSHIP WITH REGIONAL POLICIES

CIDERH's work is clearly aligned with the development and innovation strategies of the Region of Tarapacá, which emphasize sustainability as a fundamental factor in productive activities, placing a special emphasis on the relevance of water resources. The Center's main strength in support of the implementation of these policies lies in the specialized human capabilities it has gathered, dedicated to conducting research on water resources as a whole, seeking to establish the knowledge base required to develop technologies that help improve the management of this resource. Thus, along with contributing to the sustainable management of the region's water resources, CIDERH's work also helps incorporate innovations that promote the development of key productive sectors in the region, such as agriculture.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

A central aspect in the implementation of CIDERH has been the creation of a specialized human team, on an issue that is essential for the region and which features no higher education initiatives at the local level. CIDERH's technical team currently includes 9 professionals, including 4 researchers with a Ph.D. (2 of them employed by the Center)⁴. Its work is supported by a management team of 8 people.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	2	2	4
Researchers with a Master's degree	0	0	0
Professionals and technicians who support research	5	0	5
Total	7	2	9

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.



Five of the researchers, professionals and technicians work in the line of integrated management of water resources and 4 in the line of technological innovation in water resources⁵. The team includes 3 foreign researchers and 1 from another region, each of whom has specialized skills and has come to the Region of Tarapacá in the context of the Center's work, providing access to scientific networks, especially at the international level.

CIDERH's main offices are located in Iquique. In 2014, its laboratory was inaugurated within the facilities of Universidad Arturo Prat, in this same city, which has cutting-edge technology that is unique in the North of Chile and which helps study the water-soil-plant system. The Center has also purchased equipment for a future laboratory for the treatment of waters of different qualities (ocean water, salt water, natural water, wastewater, among other types), and includes a greenhouse for the line of technological innovation in water systems.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

CIDERH has established agreements with several entities. Internationally, it works with the Madrid Institute of Advanced Water Studies (IMDEA Agua) (Spain), the Center for Hydrosystems (CEHIDRO) (Portugal), Université de Montpellier II (France) and Berlin Technical University (Germany). Within the country, it has agreements with Universidad de Santiago de Chile, Pontificia Universidad Católica de Chile's Atacama Desert Center (CDA), Universidad de Chile and Universidad de la Frontera, among others; and with public entities such as the General Directorate of Waters (DGA), the Institute of Agricultural Research (INIA), the National Geology and Mining Service (SERNAGEOMIN) and the Natural Resource Information Center (CIREN).

Relationship with local organizations, industry-related and government agencies

In the development of its work, CIDERH has increasingly been establishing ties to different regional stakeholders

⁵ One professional works in support of both research lines.

associated to water resources, including agricultural producers from Camiña and Colchane, lemon producers from the Pica oasis, and the Aymara Indigenous Community in Cancosa, which is involved in quinoa farming, among other communities, in a direct relationship, in some cases for the implementation of experimental plots and workshops. There is also an agreement with the Agricultural Development Institute (INDAP), for the transfer of information to farmers, so that they may begin to apply the advances that are made, while also training the professionals who work at this entity. CIDERH also collaborates with the regional water and sewage company and with several mining businesses operating locally.

As a specialized center, CIDERH has collaborated with authorities and public institutions, contributing scientific and technical knowledge on emerging issues that are regionally relevant, such as the construction of reservoirs, or the presence of arsenic and boron in potable and irrigation water. It has also been increasing its participation in public-private spaces, in the framework of the regional work being done by different ministries, as well as in the Regional Health and Indigenous Peoples Roundtable (Rural Potable Water Commission) and the Regional Water Roundtable of Tarapacá, among others.

RESULTS AND IMPACTS IN THE REGION

The installation of CIDERH has made it possible for the Region of Tarapacá to have a specialized team of researchers (several of them with a Ph.D.) who are, for the first time, tackling issues that are crucial to the region, regarding the availability and quality of water, in order to improve the management of water resources, based on current knowledge of the regional reality, and to develop innovative technologies in response to local needs.

The management of information on regional water resources represented the first significant stage, during which the Center produced a diagnosis of the





The use of treated wastewater in the production of cut flowers, besides representing a significant scientific achievement for CIDERH, also benefits the region in terms of both the environment and its productive development.

existing information. This diagnosis was included in the document *Región de Tarapacá: diagnóstico y sistematización de la información*⁶, and the creation of the Water Observatory, a web platform designed to manage and transfer this data. This process, which required creating a database, reference stations, maps and documentation, helped identify existing information gaps and direct the Center's research, as well as creating the first product with a local impact and capable of generating regional acknowledgement.

In terms of the goal of complementing information on this subject, CIDERH has worked on the network for monitoring water resources managed by DGA, performing a critical analysis of the existing network and creating a proposal for a new network. Using innovative technology adapted to the local context, international experiences and a precise meteorological, hydrological and hydrogeological analysis of the region, it proposed a monitoring system for users of water resources that is capable of generating trustworthy, representative, sufficient and timely information. This system provided new

⁶ Región de Tarapacá: diagnóstico and sistematización de información.

hydrogeological information and conceptual models for the region's main aquifer, the Pampa del Tamarugal, and the Camiña and Tarapacá basins.

In the research on the chemical characteristics of the region's surface water and groundwater, the main progress has been a study of arsenic and its regional distribution -an issue of concern in this area, due to the health risks implied when it is present above certain levels- as well as water quality baselines in two basins within the region and the Pampa del Tamarugal aquifer.

In one of its most relevant achievements -since reuse is practically nonexistent in Chile- CIDERH developed a pilot experience for taking advantage of treated wastewater, in order to increase the water supply through reuse, making it possible to use this water to produce cut flowers. This led to a close collaboration with the regional water and sewage business and the Center's first significant collaboration with the local productive sector.

Work is also being done in the field of the hydroponics, developing recirculation systems that may provide water for a second crop, while also helping improve efficiency. This experience is being developed in Pica,



where farmers are investing in greenhouses in order to manage their crops and later use this water to irrigate fruit orchards, thus using it twice.

In terms of the development of innovative technologies for increasing the efficiency of water resources with different purposes, the main progress has been an improved efficiency in the irrigation of lemon orchards in Pica, which has had a positive impact on agricultural activity in this oasis. This favorable experience is being expanded to quinoa crops on the *altiplano* and white garlic in Quebrada de Camiña.

Progress has also been made in identifying the ecology of the arbuscular mycorrhizae present in the region's native flora, which shall later help improve the resistance of plants to arid climate conditions, as well as protecting and repairing the ecosystems affected by anthropic pressures (those caused by human activity). There is also work being done to evaluate non-collective water treatment systems

using artificial wetlands, which will help reuse water and reduce contamination.

Between 2011 and 2014, CIDERH researchers published 3 scientific articles (ISI) in journals with an impact index of 2.722. These publications are the result of a long process, in which the team first had to generate basic data on the issues being studied by the Center, in order to then perform analyses and generate results. This work has been growing more intense, and several articles are currently in the process of being published soon. During this period, the CIDERH team also produced a total of 73 works, which were presented at 46 scientific congresses.

In the context of the Center's work, 14 projects⁷ were also executed between 2011 and 2014, along with the development of 2 Ph.D. theses, 4 Master's theses and 28 undergraduate theses, all associated to projects of the Center.

⁷ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI Publications	1	0	2	0	3
Impact index	3.576	-	2.296	-	2.722
Non-ISI publications	0	1	4	13	18
Number of works presented at scientific congresses	10	13	26	24	73
Number of scientific congresses at which the Center presented works	6	9	17	14	46
Ph.D. and Master's theses underway with the support of the Center*	0	1	4	6	6
Undergraduate theses underway with the support of the Center*	4	5	10	17	28

* As theses last more than a year, they are counted in each year of their development.



The characterization and monitoring of waters in the Region of Tarapacá will help improve the management of water resources, which must be studied constantly.

SCIENTIFIC AND TECHNOLOGICAL RESEARCH CENTER FOR MINING CICITEM

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REGIONAL CONTEXT ¹

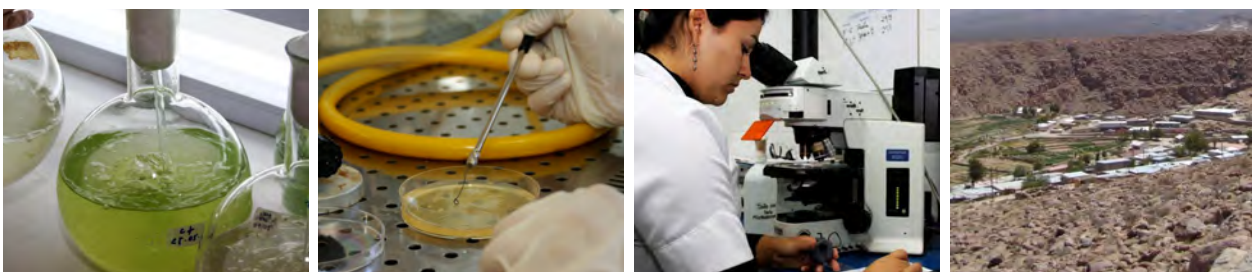
SOCIOECONOMIC PROFILE OF REGION

Regional GDP (2013)	MMCLP 11,242,902 (10.9% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (61.6%), construction (12.1%), transportation and communications (5.0%) and manufacturing industry (4.4%).
Business composition (2013)	There are 29,398 businesses in the region, which employ 176,486 dependent workers. 65% of these are microenterprises, which employ 7.1% of all workers. After construction and trade, the greatest percentage of workers (10.9%) are employed by the metal manufacturing industry, while mining employs 6.0%.
Exports (2013)	MMUSD 25,535 (33.5% of the national total). Mining generates 94.2% of the value of exports, including 87.9% corresponding to copper and iron mining. Manufacturing generate 5.7%, with 4.1% corresponding to the basic chemical products industry.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 10 universities in the region, including two that belong to the region itself, Universidad Católica del Norte and Universidad de Antofagasta. In 2014, the graduate degrees available in the region included 9 Ph.D. programs and 40 Master's programs, mainly in the fields of social sciences, business and law (15), sciences (15) and engineering, manufacturing and construction (8).
Regional competitiveness index (ICORE) 2012	The region ranks 2 nd in the country (index of 0.591). It ranks 4 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate (29.9%) is higher than the national average (23.7%). The technological (24.4%) and non-technological (24.2%) innovation rates are similar and both are above the national rates (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 1,808 articles (2.9% of the national total). The annual number increased at an average rate of 3.1% during this period. The rate of international collaboration is 60.3% (compared to a national average of 52.4%). The normalized impact of regional production is 0.67, which falls to 0.53 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy 2009-2020 "Participa, Imagina, Construye"*, proposes a series of seven guidelines. One of them, the territorial economic development guideline, aims to help consolidate the mining, industrial and specialized services productive complex, oriented towards territorial economic development, and to promote the diversification of the regional economic structure.

The *Regional Innovation Strategy for the Region of Antofagasta* proposes a vision of the region as a global reference point of local innovation in the fields of mining and the sustainable valorization and use of Atacama Desert's resources. This strategy's mission is to ensure appropriate institutional, technological and budgetary support for the development and management of cooperation networks between diverse public, private, academic and community agents regarding the main pillars of innovation in region. The strategy is built around four priority fields: human, social and cultural capital for regional innovation; SMEs of the Region of Antofagasta which provide innovative goods, services and processes; innovation for regional economic diversification; and innovation for the sustainability of the regional economy.

SCIENTIFIC AND TECHNOLOGICAL RESEARCH CENTER FOR MINING (CICITEM)

CICITEM was created in 2006 and established as a private non-profit corporation in 2009. Its founding partners are Universidad de Antofagasta (UA), Universidad Católica del Norte (UCN), the Regional Government of Antofagasta and CONICYT. Its director is Luis Rojas (Dr.).

The Center's mission is to support innovation, development and sustainability in the mining industry and related productive sectors, both national and regional, through high-level scientific and technological research. Its vision is to become a Scientific and Technological Research Center that is a national reference point, with a clear international projection, in the field of mining.

GOALS

CICITEM's work seeks to help establish a regional mining cluster by creating a scientific and technological research center for mining, and to promote the development of the Region of Antofagasta -a mining region- by producing scientific and technological research and development for mining. For this purpose, the Center works in three research lines: process technology; biomining; and bioenergy and environmental sustainability.



CICITEM, through an agreement with CODELCO's Radomiro Tomic Division, installed a water treatment plant to remove arsenic and provide a safe resource for the consumption of the *atacameño* indigenous community of Toconce.

RESEARCH LINES²

PROCESS TECHNOLOGY

Goal: work in this line is oriented towards the design and improvement of mining processes, making them more efficient and reducing their environmental impact (studying phenomena such as leaching, flotation, crystallization, phase equilibrium and thickening), as well as modelling and optimization, developing models and tools that help improve the operation and design of plants and their related phenomena.

Technical team: Antonio García (Dr., line coordinator, UCN). Researchers employed by CICITEM: Mario Mellado (Dr.), Cynthia Torres (Dr.), Marcelo Montenegro (Dr.(c)), Freddy Lucay (M.Sc.) and Elsa Flores (Bach.). Researchers from the partner institutions: Óscar Benavente (Dr., UCN), Luis Cáceres (Dr., UA), Luis Cisternas (Dr., UA), Gerardo Fuentes (Dr., UCN), Héctor Galleguillos (Dr., UA), Teófilo Graber (Dr., UA), María Elisa Taboada (Dr., UA), Lilian Velásquez (Dr., UCN), Edelmira Gálvez (Dr.(c), UCN) and Pedro Vargas (Dr.(c), UA). Research support (CICITEM): Renato Acosta (Bach.), Camilo Collao (Bach.), Nanette Merello (Bach.), Rafael Quiroz (Bach.) and Larry Zúñiga (Bach.).

BIOMINING

Goal: work in this line is oriented towards the study of biological systems that provide important environmental and economic advantages over conventional processing technologies.

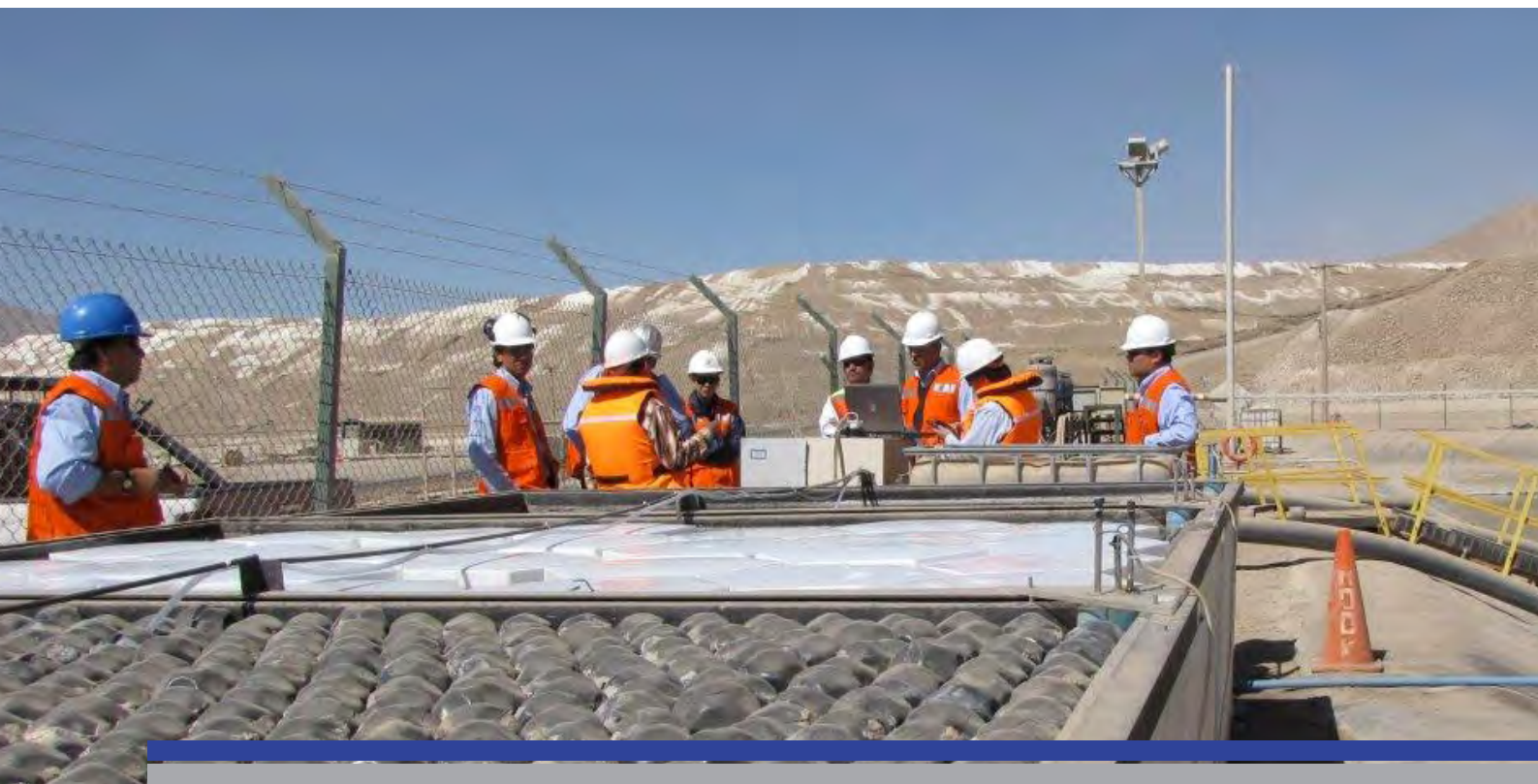
Technical team: Cecilia Susana Demergasso (Dr., line coordinator, UCN). Researchers employed by CICITEM: Lorena Escudero (Dr.), Pedro Galleguillos (Dr.) and Víctor Zepeda (Dr.(c)).

BIOENERGY AND ENVIRONMENTAL SUSTAINABILITY

Goal: work in this line is oriented towards the production of clean and renewable energy using biological organisms such as bacteria, plants, microalgae and seeds, among others. It is also focused on a key aspect for mining zones: remediation to reduce environmental contamination through physical treatments, as well as live organisms, plants and their by-products.

Technical team: Mariella Rivas (Dr., line coordinator, CICITEM). Researchers employed by CICITEM: Arturo Reyes (Dr.) and Manuel Zapata (Dr.). Researcher from partner institution: Ana Mercado (Dr., UA). Research support (CICITEM): Juan Aguilera (M.Sc.) and Daniel Ordenes (Bach.).

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a BA. or B.Sc.

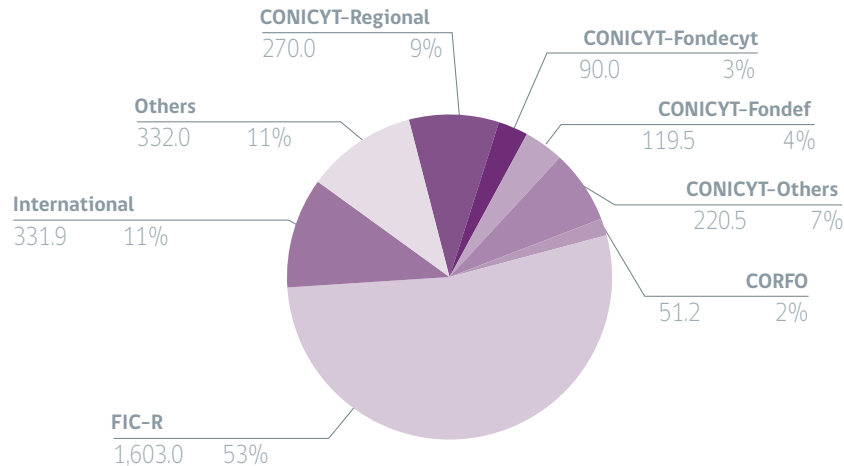


RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP	752.8
Core funding from Regional Government of Antofagasta	MMCLP	800.0
Resources awarded through projects from different sources	MMCLP	3,018.1

* CONICYT has committed core funding for the Center until 2015.

CICITEM: resources awarded through projects from different sources, 2011–2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CICITEM and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CONICYT-Fondef: CONICYT's Fund for the Promotion of Scientific and Technological Development. CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CICITEM'S ACTIVITIES

In the process technology research line, CICITEM's work focuses on the fields of process engineering and modeling and optimization. Process engineering involves the design and improvement of mining processes, in order to make them more efficient and reduce their environmental impact. Some of the phenomena being studied are leaching, flotation, crystallization, phase equilibrium and thickening. In the field of modeling and optimization, the goal is to develop predictive models and tools that help improve the operation and design of processing plants and their associated phenomena.

Efforts in the biomining line are focused specifically on bioleaching, which seeks to take advantage of the environmental and economic superiority of biological systems over conventional mineral processing

technologies. Mining businesses, increasingly aware of this reality, are using this technology to recover base metals and precious metals from low-grade minerals and searching for isolated micro-organisms from extreme environments which may have biotechnological potential.

In the bioenergy and environmental sustainability line, CICITEM's work focuses on two main fields, remediation and biofuel production. Remediation seeks to reduce the contamination of an environment using engineering, live organisms, plants and their by-products. In terms of biofuels, the work is oriented towards the development of alternatives to produce clean and renewable energy using biological organisms such as microalgae, and studying them to exploit potential metabolites of biological interest.

³ In current Chilean pesos of each year.

RELATIONSHIP WITH REGIONAL POLICIES

CICITEM's work is clearly aligned with the regional development strategy, since it focuses on scientific research, technological development and innovation that tends to support the consolidation of the regional mining productive sector, providing solutions that help strengthen its competitiveness and sustainability, with a clear concern for the environment in which this industry exists. With a highly specialized human team, the Center also places its capacities at the service of the development of the region as a whole, through initiatives that impact agriculture, water and energy resources, among other sectors, and also makes a significant contribution to regional human capital development, at the university and technical education levels.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CICITEM's technical team consists of 31 researchers and professionals, including 17 with a Ph.D. (6 employed by the Center and 11 from partner institutions)⁴. Its work is supported by a management team of 8 people.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	6	11	17
Researchers with a Master's degree	5	2	7
Professionals and technicians who support research	7	0	7
Total	18	13	31

From the total of researchers, professionals and technicians, 21 work in the process technology line (including 10 employed by CICITEM), 4 in the biomining line (3 employed) and 6 in the bioenergy and environmental sustainability line (5 employed).

Besides gathering this work team, CICITEM has contributed significantly to the development of advanced human capital in the region of Antofagasta, providing advanced training for personnel abroad and helping to create and strengthen Master's and Ph.D. programs at partner universities.

The Center has its offices in the city of Antofagasta and laboratories in facilities at both partner universities, in the same city. The process technology line has a laboratory and a flotation pilot plant for last-generation minerals, at UA facilities, which are available for both researchers and Ph.D. students.

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS

Networks for scientific collaboration

CICITEM is part of an active national and international network. Internationally, it collaborates with entities from different countries. In the case of Finland, it has agreements with the Technical Research Center (VTT), to strengthen regional management capacities in innovation, and with the Mining School at the University of Oulu, the Technological University of Lappeenranta and the Geological Service of Finland (GTK). In the case of Spain, it has established agreements with Universidad de Huelva and the Institute of Fats (part of the High Council on Scientific Research) and, in the case of the Republic of South Korea, with the Research Institute of Industrial Science & Technology (RIST). It also has agreements with the Royal Institute of Technology (KTH) (Sweden), the Swedish Environmental Research Institute (IVL) and Universidad de San Luis de Potosí (Mexico), as well as a collaborative agreement with L'Eau Pure, a French water treatment corporation, for conducting studies on the absorption of arsenic in water, and with the Montpellier Membrane Institute.

Within the country, the Center participates in initiatives of excellence, such as the Research Ring (CONICYT) "Atacama Ocean Water, the integration of processes for water and energy savings," along with UCN, the Center for Technological Research on Water in the Desert (CEITSAZA), the National Mining Society (SONAMI) and Aguas Antofagasta; and the Center of International Excellence in Mining and Mineral Processing of the CSIRO Chile Research Foundation⁵, funded by CORFO, along with Universidad de Chile, Universidad de Antofagasta and mining businesses. It also has a framework cooperation agreement with CODELCO's Radomiro Tomic Division, to develop projects on community improvement issues and with SONAMI for the creation of research and collaboration

⁵ Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the national science agency of Australia.

projects with the industry, for example, in the treatment of gold and silver minerals.

Relationship with local organizations, industry-related and government agencies

CICITEM works closely with large and small mining businesses, on its diverse research projects. Recently, the Center created an SME department, with the goal of strengthening its relationships with small mining through the transfer of technology and provision of low-cost solutions.

It also has work agreements with higher education institutions, such as Pontificia Universidad Católica de Chile, Universidad Técnica Federico Santa María and Universidad Santo Tomás (Iquique campus). In the field of school education, it works together with technical public schools in the region, to place students in projects, services and professional internships, as well as training activities with students and professors.

RESULTS AND IMPACTS IN THE REGION

Through its highly specialized human team, CICITEM is creating technological solutions that help strengthen and open new opportunities for the regional and national mining industry. Working with nanoparticles, microalgae and other microorganisms, it is developing technologies to optimize mining processes and explore potential applications in other sectors, such as the development of solar filters and the procurement of pigments, antioxidants and carbohydrates.

The process technology line features work on heat energy accumulation. The region has many locations with salts that have thermal potential, which may be used, for example, in housing refrigeration systems. This is the case of salts such as magnesium chloride, which is present in large quantities in the region, or sodium chloride and other high-potential salts. These salts can be liquefied to provide heat at certain times of the day, or crystallized at other times to absorb or release heat at different moments. The studies aim to identify and classify these salts according to their thermal capacity and to investigate their possible applications.

In the framework of the project called Research Circle on Ocean Water, research is focused on the use of ocean water in mining and also domestic water (direct use, desalinization, reuse and recycling of water in the industry). It is studying potential uses of ocean water in leaching or mineral flotation, for example,

to understand the balance between ocean water and copper extraction processes. Ocean water is currently being used, but there are no important studies on this subject. This initiative seeks to provide all the diagrams necessary to understand how leaching in chlorinated environments must be implemented, and in which regions.

Another subject currently being studied is flotation, with the goal of determining how the system's physical-chemical conditions may be integrated with different qualities of water, different types of minerals, the contamination that may occur with processes or circuits, associated to decision-making processes with multiple goals: physical-chemical conditions, circuits, water quality.

Since 2014, a pilot plant and a mineral flotation laboratory have been available. In this field, the main clients are businesses which are providers for the mining sector. For example, there are balls being sold on the market and they want to know what effect these could have on flotation; or they need to discover the impact on flotation of the reagents being used.

Work is also being done to search for solutions to problems that mining SMEs face, for example, in the search for strategies to refine, improve mineral processing (copper and gold) to achieve new added value and develop it into a scalable prototype, or in the management of the environmental liabilities (residues of the processing) produced by businesses. In this field, it is relevant to mention the creation within the Center of a work group on the closure of mines and the management of abandoned mining sites.

Studies have been conducted on how to process copper that has been combined with sulfur (copper



sulfide), using non-traditional methods, which consist of concentration and later melting to produce copper molds (anodes). For this purpose, studies have been conducted on the hydrometallurgical processing of copper sulfides, which is considered to have less associated costs and is a cheaper and less polluting method, since it avoids the production of pollutant gases. This issue, which is of great interest to businesses, is one that CICITEM must continue to explore further.

There is a patent issued in the field of hydrometallurgy: "Integrated system for the mitigation of water losses and automatic measurement of evaporation rates in heaps, pools or tanks used in mining". This invention has attracted the attention of small entrepreneurs who are supporting the formation of a pilot plant to evaluate the combination of different technologies used for water heating (including the patented system). Equipment valued at 4 million Chilean pesos has been provided, and a possible business management process will be decided after obtaining the results of this evaluation.

In the biomining line, research has focused mainly on biomining and geomicrobiology in arid zones, areas that are working on mining processes with micro-organisms. Biotech tools have been developed to help understand microbiological processes in leaching heaps. This is a very important issue, since the heaps in this region are observed all over the world. The Center's laboratory publishes this information, which has led to worldwide recognition.

In this line, it is important to mention the work being done in the production of arsenic nanoparticles produced by bacteria and the use of micro-organisms in bioflotation processes. In the field of geomicrobiology

in arid zones, collaborative work has been done with NASA specialists (Arizona) who are working on desert microbiology. Searches for micro-organisms have been conducted in salt flats, high-altitude lakes and soils, in order to study their potential uses in different aspects of mineral exploitation and environmental remediation.

The subject of arsenic was studied in the framework of a Fondecyt project, leading to the discovery of micro-organisms that produce nanoparticles of arsenic sulfide. Two projects are currently underway to produce this nanoparticle, which may be useful in cancer treatments. They are also nanocables, which are useful as semiconductors. Another project is also being developed to produce arsenic sulfide for solar cells, with bacteria that produce these nanoparticles (producing nanoparticles chemically is generally quite expensive, but producing them using bacteria is practically free of cost).

Another line of work is the production of micro-organisms that absorb ultraviolet light, which can be used as solar filters. For this purpose, as another field of potential use for these micro-organisms, a cosmetic production project is being developed.

In the bioenergy and environmental sustainability line, CICITEM has an Algae Biotechnology Laboratory, which has begun work to develop biofuels from microalgae. The Center participated in the initial stages of the Desert Bioenergy Consortium, created in 2012, a consortium for this type of biofuels.

Work is currently being done with microalgae to obtain bio-compounds with commercial potential oriented towards aquaculture and food for human consumption (pigments, antioxidants). There is a project with the



The Center has the most modern flotation laboratory in Chile, which helps generate research for future mining processes in the country.

European Union (Miracles), with the participation of 26 entities from different countries, research centers, universities and businesses, including CICITEM and UA. The goal is to strengthen the biotech industry and the integral development of bio-refinery technologies to create bio-products from microalgae, studying their applications in food, aquaculture and other strategic areas, throughout the entire chain, from the identification of the micro-organism to product placement on the market. This group (UA-CICITEM) works to isolate the types of micro-organisms which are the best candidates (those that are being isolated from the altiplano), and other groups will then study the best way to extract pigments, antioxidants and carbohydrates from them, among other components of interest. Another result of potential protection is the discovery of bacteria with cellulolytic activity (cellulase).

In the framework of the aforementioned Research Circle on Ocean Water (awarded to UA), two researchers in this line are leading the projects called "Removal of calcium and magnesium from ocean water using CO₂" and "Removal of calcium and magnesium from ocean water using biological methods." In this context, they work to improve mining processes with ocean water, since, even though all mining companies are currently extracting water directly from the ocean, there are problems with calcium and magnesium ions, which are the main interfering factors in leaching processes or ocean water use in other mining processes, since these reduce the performance of mineral extraction by competing with copper.

On the issue of remediation, in the framework of a Fondecyt project, work is also being done on bacterial

bioremediation in sites that have been contaminated with organic compounds and heavy metals.

Work has also been done with the farmers of the Association of Alto La Portada (150 people), seeking to implement best practices in agricultural activities, to manage agricultural waste, and to add value to their production. By a Technology Transfer process, these producers received techniques for composting, vermicomposting, waste management, insecticides and water reuse.

In the social sphere, CICITEM, through an agreement with CODELCO Radomiro Tomic Division, developed a water treatment project to eliminate arsenic, in order to provide water for consumption in the *atacameño* indigenous community of Toconce (Calama). This project, in collaboration with the French corporation L'Eau Pure, has now made it possible to safely offer a supply of this resource to the entire community.

Between 2011 and 2014, CICITEM developed a total of 58 projects⁶. Its researchers produced 45 scientific articles (ISI), published in journals with an average impact index of 1.930, and a total of 91 works, that were presented at 53 scientific congresses. During these years, CICITEM supported the development of 23 Ph.D., 15 Master's, and 43 undergraduate theses on subjects related to their work lines.

⁶ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI publications	5	16	11	13	45
Impact index	1.774	1.871	1.824	2.155	1.930
Non-ISI publications	0	1	0	0	1
Number of works presented at scientific congresses	17	44	7	23	91
Number of scientific congresses at which the Center presented works	6	26	5	16	53
National and international patents requested and/or granted	2	2	0	1	5
Ph.D. and Master's theses underway with the support of the Center*	7	7	3	22	38
Undergraduate theses underway with the support of the Center*	20	20	13	15	43

* As theses last more than a year, they are counted in each year of their development.



CENTER FOR ADVANCED STUDIES IN ARID ZONES CEAZA

REGION OF COQUIMBO

www.ceaza.cl – info@ceaza.cl – (56-51) 2204378

REGIONAL CONTEXT¹

SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 3,255,336 (3.2% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (40.4%), personal services (11.7%), trade, restaurants and hotels (9.2%) and construction (7.8%).
Business composition (2013)	There are 37,670 businesses in the region, which employ 194,929 dependent workers. Almost 71% are microenterprises, which employ 9.7% of all workers. After trade, the sector that concentrates the most firms (11.9%) is agroforestry, which employs 16.7% of all workers.
Exports (2013)	MMUSD 4,900 (6.4% of the national total). Mining produces 88.6%, the agroforestry and fishing sectors produce 7.7% (including 7% which corresponds to fruit culture) and industry produces 3.3% (including 2.2% which corresponds to the food industry).

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 10 universities in the region, including Universidad de La Serena. In 2014, available graduate degrees included 4 Ph.D. programs and 22 Master's programs, mainly in the fields of science (6), social sciences, business and law (6) and education (5).
Regional competitiveness index (ICORE) 2012	The region ranks 9 th in the country (index of 0.332). It ranks 11 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 26.1% (compared to a national rate of 23.7%). Both the technological innovation rate (19.3%) and the non-technological innovation rate (17.7%) are slightly higher than the national average (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 2,444 articles (3.9% of the national total). The annual number increased at a rate of 2.8% during that period. The rate of international collaboration was 71.5% (compared to a national average of 52.4%). The normalized impact of regional production is 1.24, which falls to 1.05 in the case of production led by the region.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Region of Coquimbo, until 2020* proposes a regional vision based on a regional identity linked to a territory of valleys, mountains, watersheds and seashores, where mining, agriculture, fishing and aquaculture, services, tourism and energy production are the main activities, among other features.

The *Regional Innovation Strategy, Region of Coquimbo (2012)* aims to develop innovation capable of dealing with three main challenges: to connect R&D&I with the needs of society, expand and modernize the productive base of the regional economy, and develop business productivity to foster competitiveness. It also proposes four strategic pillars: articulating networks for the development and implementation of R&D&I within the territory; promoting a knowledge-based economy for sustainable development; fostering a creative, innovative and competitive society, and stimulating interactions between universities and regional stakeholders.

CENTER FOR ADVANCED STUDIES IN ARID ZONES (CEAZA)

CEAZA was created in 2003 and established as a private non-profit corporation in 2008. Its founding partners are Universidad de La Serena (ULS), Universidad Católica del Norte (UCN, Coquimbo campus), the Institute of Agricultural Research (INIA, Intihuasi Regional Research Center) and the Regional Government of Coquimbo. Its executive director is Bernardo Broitman and its corporate manager is Claudio Vásquez.

CEAZA's mission is to promote regional scientific-technological development, through high-level scientific and technological research designed to help understand the effects of climatic/oceanographic oscillations of the water cycle and biological productivity (natural and under cultivation) in arid and marine zones of Chile's central-northern territory, collaborating in the formation of human capital in science and technology, regional productivity, environmental protection and education, thus contributing to the progress and quality of life of the region's inhabitants. In the short term, the Center aims to become a research consortium of consolidated excellence, whose work may be required by the main regional productive sectors (agriculture, aquaculture and mining), with strong ties to and commitments with the private sector.

GOALS

The main goal of CEAZA's scientific activities is to study the impact of climate oscillation on the water cycle and biological productivity in arid zones of Chile's central-northern territory, through the integration of researchers and the development of scientific and technological projects. Since its creation, its efforts have focused on the research lines of water resources, ecology and conservation, an integrated forecast system, species exploration and breeding, and biotechnology. Today its work is concentrated in three research lines: geosciences, biological sciences, and technology for adaptation.

RESEARCH LINES²

WATER RESOURCES

Goal: to analyze the dynamics of the different components of the water balance and its interactions, and aspects related to the management of water resources, in order to develop a tool for supporting decision-making processes in water management.

Technical team: Shelley Mac Donell (Ph.D., line coordinator, CEAZA). Researcher employed by CEAZA: Eric Sproles (Ph.D.). Researchers from the partner institutions: Ricardo Oyarzún (Ph.D., ULS), Sonia Salas (Ph.D., ULS) and Francisco Meza (M.Sc., INIA). Research support (CEAZA): Sebastián Vivero (M.Sc.), Lorena Bugeño (Bach.), Cristián Campos (Bach.), Arturo Cruz (Bach.) and Rodrigo Ponce (Bach.).

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a bachelor's degree, such as a B.A. or B.Sc.

ECOLOGY AND CONSERVATION

Goal: to design conservation, restoration and value-added biodiversity plans for the arid zones of Chile's central-northern territory, and to create and propose models to improve the use of biodiversity and ecosystem services in these zones.

Technical team: Antonio Maldonado (Ph.D., line coordinator, CEAZA). Researchers employed by CEAZA: Moisés Aguilera (Ph.D.), Bernardo Broitman (Ph.D.), Marco Molina-Montenegro (Ph.D.), Marcelo Rivadeneira (Ph.D.) and Alexandra Stoll (Ph.D.). Researchers from the partner institutions: Carlos Gaymer (Ph.D., UCN), Julio Gutiérrez (Ph.D., ULS), Guillermo Luna (Ph.D., UCN), Francisco Squeo (Ph.D., ULS), Martin Thiel (Ph.D., UCN) and Julio Vásquez (Ph.D., UCN). Research support (CEAZA): Francisco Araya (Bach.), Jaime Bravo (Bach.), Lorena Bugeño (Bach.), Antonio Cruz (Bach.), Leticia González (Bach.), Katherine Jenó (Bach.), Stefanie Maldonado (Bach.), Carla Saguas (Bach.) and Carlos Sierra (Bach.).

INTEGRATED FORECAST SYSTEM (SIP)

Goal: to create an integrated forecast system that links both atmospheric and oceanographic components, as well as their interactions with regional agricultural and aquacultural productive factors.

Technical team: Bernardo Broitman (Ph.D., line coordinator, CEAZA). Researchers employed by CEAZA: José Rutland (Ph.D.), Gary Shaffer (Ph.D.) and Beatriz Yannicelli (Ph.D.). Researchers from the partner institutions: Praxedes Muñoz (Ph.D., UCN), Enrique Novoa (Ph.D., ULS) and Eduardo Pérez (Ph.D., UCN). Research support (CEAZA): David López (M.Sc.), Osvaldo Painemal (M.Sc.), Carola Aparicio (Bach.), Cristóbal Juliá (Bach.), Cristián Orrego (Bach.), Pablo Salinas (Bach.), María Valladares (Bach.), José Luis Castro and Robinson Godoy.

SPECIES EXPLORATION AND BREEDING

Goal: to explore, develop and make breeding of agricultural and aquacultural species for the region.

Technical team: Katherina Brokordt (Ph.D., line coordinator, CEAZA). Researcher employed by CEAZA: Luisa Bascuñán (Ph.D.). Researchers from the partner institutions: Pilar Haye (Ph.D., UCN), Pedro León (Ph.D., INIA), Germán Merino (Ph.D., UCN), Angélica Salvatierra (Ph.D., INIA), Wolfgang Stotz (Ph.D., UCN), Federico Winkler (Ph.D., UCN) and Antonio Ibacache (M.Sc., INIA). Research support (CEAZA): María Montoya (Bach.) and Rodrigo Zurita (Bach.).

DEVELOPMENT OF A BIOTECH PLATFORM

Goal: to set the basis for a R&D&I center designed to produce biotech solutions and products for regional productive sectors, based on terrestrial and marine biotic resources, thus increasing their added value and sustainability in arid zones of the North of Chile.

Technical team: Katherina Brokordt (Ph.D., line coordinator, CEAZA). Researchers employed by CEAZA: Nicolás Gouin (Ph.D.) and Alexandra Stoll (Ph.D.). Researchers from the partner institutions: Vilbett Briones (Ph.D., ULS), Claudio Miranda (Ph.D., UCN), Mario Pérez (Ph.D., ULS), Pedro Toledo (Ph.D., UCN) and Antonio Vega (Ph.D., ULS).



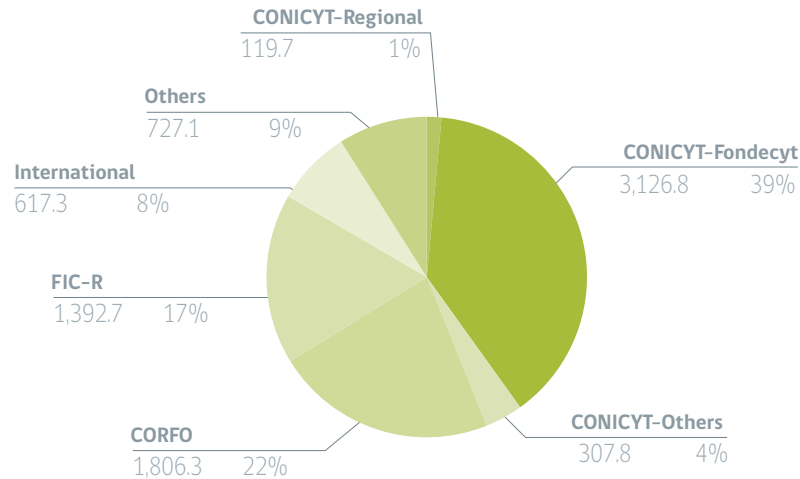
RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP	740.0
Core funding from the Regional Government of Coquimbo**	MMCLP	800.0
Resources awarded through projects from different sources	MMCLP	8,097.7

* CONICYT has committed core funding for the Center until 2016.

** The Regional Government has approved increased multiannual funding for the coming years.

CEAZA: resources awarded through projects from different sources, 2011–2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CEAZA and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Assigned Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CEAZA'S ACTIVITIES

Through its different research lines, CEAZA's efforts focus on creating scientific knowledge that may be implemented in the region, on local climate dynamics and their effect on regional activities (whether they be productive, environmental, social, public or private), in order to help strengthen regional competitiveness, thus favoring regional development and the quality of life of its inhabitants.

For this purpose, its work focuses mainly on forecasting climatic and oceanographic conditions, in order to support the creation of action strategies to respond to these conditions; developing technologies for use in productive activities to reduce environmental impacts; and increasing the degree of resistance to high levels of environmental stress among species of regional productive interest, both agricultural and aquacultural.



Penitentes are ice formations commonly found in the semiarid Andes Mountains. CEAZA's glaciology laboratory studies them to learn more about their influence in glacier dynamics or their water contribution, while also analyzing the effects of climate change on them, and the contribution of snowfall and ice to the region's waterways.

³ In current Chilean pesos of each year.

RELATIONSHIP WITH REGIONAL POLICIES

CEAZA's work is fully aligned with the regional development and innovation strategies, since it aims to develop and transfer scientific knowledge and technologies that support decision-making and productive activities, in fields of great regional interest such as water resources, coastline management and agriculture. In this sense, its main strengths are its goal of attracting and strengthening high-level human capacities for the development of cutting-edge research; its relationship with the regional environment and the needs of the territory, thus contributing to informed decision-making; its orientation in response to regional requirements in productive issues; and its vocation for projecting these efforts towards society as a whole.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CEAZA combines the high-level capabilities of the researchers of the Center (14) and its partner entities (24), most holding a Ph.D.⁴. They are joined by a team of professionals and technicians who support their research (23) and a number of thesis students, forming a group of over one hundred people working on science projects. A management team of more than 15 people also supports this work. The Center is a space that has currently attracted high-standard researchers and helped create an awareness of the region's richness as a "natural laboratory for science."

10 of the researchers, professionals and technicians work in the water resources line (including 7 employed by the Center), 21 in ecology and conservation (15 employed), 11 in species exploration and breeding (4 employed), 8 in the development of a biotechnological platform (3 employed) and 16 on an integrated forecast system (13 employed)⁵.

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

⁵ Five team members work in two research lines.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	14	22	36
Researchers with a Master's degree	0	2	2
Professionals and technicians who support research	23	0	23
Total	37	24	61

The Center participates in graduate and undergraduate programs, including the Ph.D. in biology and applied ecology at ULS and UCN, which it helped create and which has already graduated three generations. It has received students from its partner universities, with over 300 interns and thesis students involved in the undergraduate and graduate programs it participates in.

CEAZA has its own facilities and also operates at the Andrés Bello (ULS) and Guayacán (UCN) campuses, as well as INIA's Intihuasi Center. Its offices and laboratories are located on its main campus in La Serena (1,300 m²), with spaces destined to offices and data processing in Coquimbo (500 m²), laboratories and offices at UCN in Coquimbo (100 m²) and a plant physiology laboratory at INIA (300 m²). The Center has already conducted feasibility studies for its future facilities, expected in 2017.





RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

CEAZA participates in collaborative research initiatives of excellence at the national level, such as the Millennium Nucleus on Ecology and Sustainable Management of Oceanic Islands, the Millennium Center for the Study of Multiple Drivers on Marine Socio-Ecological Systems (MUSELS), the Wageningen UR Chile Center for Excellence, and the Institute for Ecology and Biodiversity.

At the international level, it collaborates with Agrópolis International, which includes French research institutions, such as the University of Montpellier, CIRAD (Center for International Cooperation on Agricultural Research for Development) and INRIA (National Institute for Research on Informatics and Automation), among others. These relationships are part of the existing relationship between the Regional Government of Coquimbo, the Department of L'Herault and, since its creation, CEAZA. Also noteworthy are the relationships with the University of California (Davis and

Santa Barbara), in the fields of agricultural research and marine ecology, with researcher exchanges, internships and visits by entrepreneurs; with the Cologne University for Applied Sciences (Institute of Technology in the Tropics and Subtropics, ITT) (Germany), in the field of scientific research on hydrological modeling, and the Research for Development Institute (IRD) in France, on scientific research on hydrology and oceanography, among others.

Relationship with local organizations, industry-related and government agencies

CEAZA has obtained recognition in this field as an entity that creates scientific knowledge and disseminates it through different activities, in support of decision-making processes at different levels. The Center has had an active participation in the Senate Commission on Future Challenges, has supported the Ministry of the Environment in developing the analyses used to write the glacial protection bill, and has participated in the national debate on regional funding for science.

The Center maintains a permanent collaborative relationship with the Regional Government of Coquimbo on contingent issues, such as water scarcity, and in some fields this work has extended to the regions of Atacama and Antofagasta. It is part of the Regional Energy Board and the Regional Water Board, entities created by Coquimbo's Regional Productive Development Corporation and the Regional Government, contributing its knowledge to their decision-making. Through a multinational project called ProEcoServ (Global Environmental Facility (GEF)-United Nations Environment Programme (UNEP)-Ministry of the Environment), the Center supported the creation of environmental policies for San Pedro de Atacama. Meanwhile, in the framework of an FNDR (National Regional Development Fund) project, supported by Promar Pacifico and UCN, it also worked with the community of the Peninsula of Mejillones (Region of Antofagasta) to help generate an environmental diagnosis and implement pilot measures for the conservation of marine biodiversity and the maintenance of ecosystem services.

It has also collaborated with municipal councils by disseminating information for decision-making processes, and is currently supporting the municipalities of Combarbalá, Río Hurtado, Monte Patria and Los Vilos with information on crops adapted to the lack of water resources.

In the productive sector, the Center has worked with irrigation organizations, monitoring boards and productive corporations in its different research lines.

RESULTS AND IMPACTS IN THE REGION

CEAZA is among the main national research institutions in regard to scientific productivity⁶. The generated information support regional decision-making processes and different productive sectors; for example, it offers a degree of control over agricultural activities by providing climate information. It has also done significant promotion among citizens.

In the school field, it aims to impact the quality of education in the region, developing several initiatives from the preschool level onwards, designed for both teachers and students, thus providing new generations with scientific knowledge of their territory, using novel methodologies and high-level teaching materials.

In the field of water resources, CEAZA's work has generated and provided key information for understanding the dynamics of water resources in the zone. The Center systematized the territory's water stock and produced data and mathematical models that help determine where the resource is located and how large it is, as well as evaluating the costs of obtaining it. CEAZA participates in the development of satellite products designed to study mountain snow in order to improve the planning of water resource use. It has also produced studies and publications which, for the first time, quantify the contribution of snowfall to the water balance and the presence of glaciers in the mountains, which are the main factors that regulate

water availability in the *Norte Chico* zone. One example of this is the project called "Characterization and Monitoring of Rocky Glaciers in the Río Elqui Basin and Calculation of *Glaciar Tapado* Mass". This work was done together with the General Directorate of Waters (DGA) and the Center for Water in Arid and Semiarid Zones of Latin America and the Caribbean (CAZALAC)—the first initiative that provided information on the contribution of glaciers to regional water resources.

In the field of ecology and conservation, the Center has created nationally-relevant knowledge which helps understand how climate change will affect the distribution of native and cultivated species in the future. This information has contributed to the regional dialogue on issues of high environmental sensibility and social conflict. The empirical contributions of these studies have led to a high demand for information by private interests that wish to assess project feasibility or ensure their environmental sustainability. It has also helped identify many of the unique environments that characterize the marine and terrestrial biodiversity of the Norte Chico region, which is home to a great number of endemic species and overlaps with areas of great economic potential. Another project in this field is oriented towards the search for biocontrollers of the main diseases that affect fruit and vegetable species that are grown in the region.

In terms of the Integrated Forecast System (SIP), CEAZA's greatest achievement has been to generate weather forecasts at the regional level, providing indications of great public impact, which contribute

⁶ CONICYT (2014), Principales Indicadores Cientométricos de la Actividad Científica Chilena 2012; Informe 2014: una mirada a 10 años (Madrid-Valparaíso).



CEAZA's meteorology area manages a network of 46 weather stations in the Region of Coquimbo, which gathers data that may be accessed online by its users (agricultural and aquacultural farmers, tourism operators and others). The unit also collects and analyzes information on ice coverage, clouds and vegetation indexes, generates daily weather forecasts, and measures solar radiation.

to decision-making in the fields of agriculture and aquaculture, for example, for drought management with an anticipation of between 8 and 10 months. For this purpose, the Center has implemented CEAZAMET, a complete network of automated environmental monitoring stations for the entire region, which uses its website (www.ceazamet.cl) to provide a great amount of information on meteorological and oceanographic variables, which are useful to various users, regional authorities, entrepreneurs who require environmental data to implement energy or agricultural projects, among others, or producers who use this data to plan irrigation or other activities. It has also implemented the Integrated Oceanographic Forecast System (SIPO), which helps evaluate the impact of coastal environmental oscillation in species of commercial and ecological interest in the region, implementing an oceanic-coastal forecast model for this purpose, an operational bioeconomic forecast model for the industrial aquaculture sector of oysters in the Region of Coquimbo, and a biological forecast model of the larval stages of species of commercial interest.

In terms of species exploration and breeding, the Center works on exploring native vegetable species, particularly those of commercial interest, such as *quinua*, *lucumillo*, *canelo* and *olivillo*, as well as, among marine species, oysters and abalone. Its studies on the potential of different varieties of grapevines and papaya have also had a regional impact. One of the scientific milestones has been the identification of the genetic diversity of different species of plants and animals of the *Norte Chico* zone, which is the foundation for planning future ecosystem management.

An important achievement has been the creation of the Marine Physiology and Genetics Laboratory (FIGEMA), whose work focuses on understanding the responses of marine organisms through their physiology and

genetics, with an emphasis on the research of aquaculture-applied problems and ecology studies. Today, CEAZA oversees the only two genetic breeding programs for mollusks of commercial interest in Chile (abalone and oysters), which are very scarce worldwide. This line seeks to improve some of the productivity indexes of oysters that are grown, in order to provide the businesses operating in this field with a useful tool.

In the framework of the activities of the Center for Biotechnology in Arid Zones (BIOTECZA), CEAZA has developed cutting-edge tools designed to improve the efficiency of various productive systems in the aquacultural, agricultural and environmental fields, and to support medical and mining production. The Center has worked on the adaptation of crops (such as grapevines) to water scarcity, the identification of *quinua* genes associated to tolerance to this stress, the development of bioproducts derived from marine animals with applications in biomedicine, the improvement of productive efficiency in the copper industry, and the improvement of the caliber of species such as northern oysters, among others.

During the 2011–2014 period, CEAZA executed 109 projects⁷, and its researchers published a total of 351 scientific articles (ISI) in journals with an average index impact of 2.478. They also produced 347 works that were presented at a total of 168 scientific congresses. Finally, the Center also supported the development of 68 Ph.D. theses, 46 Master's theses and 90 undergraduate theses related to its research lines.

⁷ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

Main indicators	2011	2012	2013	2014	2011–2014 period
ISI publications	103	114	70	64	351
Impact index	2.771	2.409	2.044	2.605	2.478
Non-ISI publications	1	7	5	9	22
Number of works presented at scientific congresses	134	85	78	50	347
Number of scientific congresses at which the Center presented works	59	38	41	30	168
Ph.D. and Master's theses underway with the support of the Center*	43	49	44	47	114
Undergraduate theses underway with the support of the Center*	49	48	41	31	90

* As theses last more than a year, they are counted in each year of their development.

REGIONAL CENTER FOR HEALTHY FOOD STUDIES

CREAS

REGION OF VALPARAÍSO

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REGIONAL CONTEXT ¹

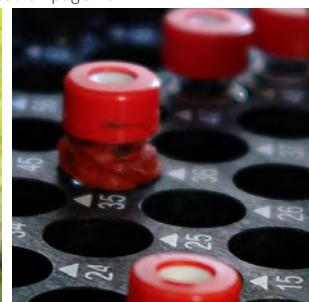
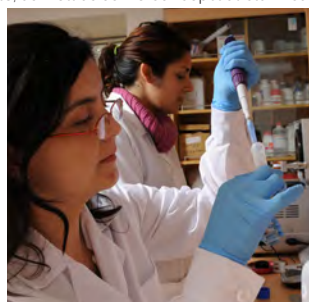
SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 8,461,149 (8.2% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (16.8%), transportation and communications (14.5%), manufacturing industry (14.3%) and personal services (12.4%).
Business composition (2013)	There are 100,558 businesses in the region employing 585,709 dependent workers. 66.2% of these are microenterprises, which employ 10.1% of all workers. The agriculture, cattle and forestry sectors represent 7.2% of all businesses and employ 9.8% of all dependent workers.
Exports (2013)	MMUSD 5,961 (7.8% of the national total). Mining generates 54.6%, industry 29.2% and the agricultural, forestry and fishing sectors 15.0% of all regional exports. In terms of specific subsectors within these sectors, fruit culture generates 13.7% of the regional total, while the food industry generates 5.3%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 13 universities in the region, including Pontificia Univ. Católica de Valparaíso, Univ. de Playa Ancha de Ciencias de la Educación, Univ. de Valparaíso and Univ. Técnica Federico Santa María, which belong to the regional itself. The graduate degrees available in the region in 2014 included 31 Ph.D. programs and 148 Master's programs, mainly in the field of social sciences, business and law (47), sciences (32), education (29), engineering, industry and construction (29) and humanities and art (18).
Regional competitiveness index (ICORE) 2012	The region ranks 4 th in the country (index of 0.531). It ranks 5 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 18.8% (compared to the national average of 23.7%). The technological and non-technological innovation rates were the same (15.4%), which is lower than both national averages (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 6,115 articles (9.6% of the national total). The annual number increased at an average of 5.9% during this period. The rate of international collaboration was 53.2% (compared to the national average of 52.4%). The normalized impact of production is 1.15, which falls to 0.75 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Region of Valparaíso 2020* proposes a vision of a region characterized by an even development of all its territories; a quality of life expressed in healthy lifestyles and a friendly and welcoming social, cultural and environmental context; a diversified economy and sustainable growth characterized by dynamic services, logistics and productive sectors; and a great involvement of its universities and research centers with the public and business sectors, which has helped stimulate innovation processes, strengthening both competitiveness and regional development. The main goals proposed to achieve this vision include, in the economic field, creating a more dynamic regional productive system; the promotion of entrepreneurship and innovation, favoring the creation of opportunities and regional competitiveness; and the valuation of human capital by strengthening technical-professional competencies.

The *Regional Innovation Strategy (2014)* proposes six strategic areas for strengthening development and promoting innovation among businesses. After prioritizing these, four main fields of action were selected (logistics, agrifood, sustainable tourism and creative industries). The agrifood sector includes both the agriculture sector and the agrifood industry (manufacturing, transformation, preparation, conservation and packaging of foods for human and animal consumption).

REGIONAL CENTER FOR HEALTHY FOOD STUDIES (CREAS)

CREAS was created in 2007 and established as a private non-profit corporation in 2012. Its founding partners are Pontificia Universidad Católica de Valparaíso (PUCV), Universidad Técnica Federico Santa María (USM), Universidad de Valparaíso (UV) and the Institute for Agricultural Research (INIA), La Cruz Regional Research Center. Its executive director is María Elvira Zúñiga.

The Center's mission is to become a platform of excellence, a national and international reference point in food products and processes with positive effects on human health, in order to strengthen regional R&D&I capabilities, improve the competitiveness of the productive sector, and articulate the relationship between science and the private business sector. Its vision is to become an interdisciplinary center of excellence, a national and international reference point in research, development and innovation in the production of healthy foods, which will achieve self-sustainability by responding to the demands of businesses, the public sector, and the scientific community.

GOALS

CREAS was created with the goal of establishing itself as a technological center of excellence for strengthening Chile's production of healthy and functional foods in the Region of Valparaíso, adding value to the productive chain by inventing functional ingredients and healthy foods that may benefit the overall health of the Chilean population.

For this purpose, CREAS works in three research lines: the development of technologies for sustainable agriculture to obtain healthy foods; the development of sustainable products and processes to obtain bioactives and healthy foods; and the assessment of the health, functional and sensorial properties of foods and products.



RESEARCH LINES²

DEVELOPMENT OF TECHNOLOGIES FOR A SUSTAINABLE AGRICULTURE TO OBTAIN HEALTHY FOODS

Goal: to develop agricultural management technologies to obtain safe products with healthy properties in plant species of agricultural interest, and to develop new agricultural technologies for environmental protection and human health.

Technical team: Juan Pablo Martínez (Ph.D., line coordinator, INIA). Researcher employed by CREAS: Lida Fuentes (Ph.D.). Researcher from partner institution: Raúl Ferreyra (M.Sc., INIA).

DEVELOPMENT OF SUSTAINABLE PRODUCTS AND PROCESSES TO OBTAIN BIOACTIVES AND HEALTHY FOODS

Goal: to develop biotechnological and physical-chemical technologies to obtain products and processes for manufacturing bioactive products; to study preservation processes for bioactive foods and products; and to design products and processes to obtain healthy foods, ingredients and bioactive compounds.

Technical team: Line coordinators: Sergio Almonacid (Ph.D., USM) and Claudia Altamirano (Ph.D., PUCV). Researchers employed by CREAS: Eduardo Caballero (Ph.D.), Araceli Olivares (Ph.D.), Carmen Soto (Ph.D.) and Mónica Valdenegro (Ph.D.). Researchers from the partner institutions: Ricardo Simpson (Ph.D., USM), Alejandra Urtubia (Ph.D., USM) and María Elvira Zúñiga (Ph.D., PUCV). Research support (CREAS): Christopher Gepp (Bach.) and Francisca Perales (Bach.).

ASSESSMENT OF THE HEALTH AND FUNCTIONAL PROPERTIES OF FOODS AND PRODUCTS

Goal: to determine *in vitro* and *in vivo* bioactivity, and to conduct sensorial evaluation.

Technical team: Raul Vinet (Ph.D., line coordinator, UV). Researchers from the partner institutions: Claudia Altamirano (Ph.D., PUCV), María Fernanda Cavieres (Ph.D., UV), Caroline Weinstein (Ph.D., UV) and Paola Vera (M.Sc., UV).

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.

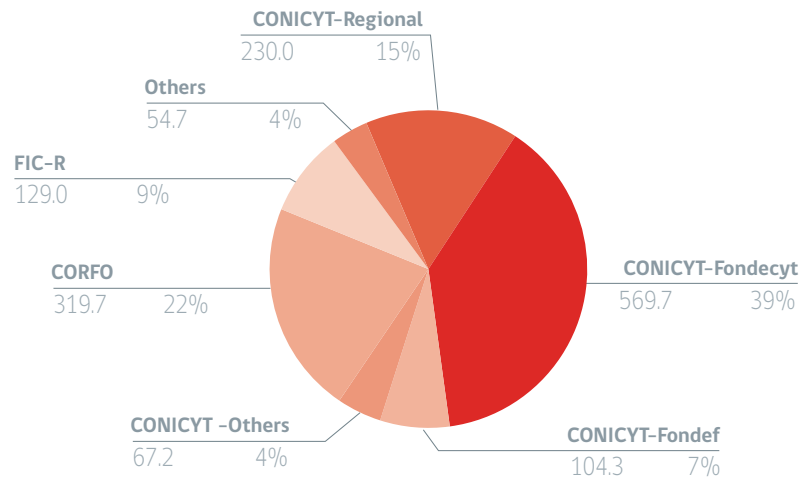


RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP	785.0
Core funding from Regional Government of Valparaíso	MMCLP	532.6
Resources awarded through projects from different sources	MMCLP	1,474.6

* CONICYT has committed core funding for the Center until 2017.

CREAS: resources awarded through projects from different sources, 2011–2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CREAS and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CONICYT-Fondef: CONICYT's Fund for the Promotion of Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CREAS' ACTIVITIES

CREAS' activities in the scientific-technological field focus on creating new knowledge, strategies and technologies that may help produce raw materials, processes, ingredients, compounds and final products for foods. In the field of technological management, the Center works to transfer knowledge to the productive sector and thus add value to its technological processes and products.

Activities in the research line for the development of technologies for a sustainable agriculture to obtain healthy foods are focused mainly on the evaluation of environmental effects on the nutritional and health characteristics of agricultural products.

The research line for the development of sustainable products and processes to obtain bioactives and

healthy foods focuses its work on developing protocols for food preservation processes; designing new healthy food products and developing various technologies that help create bioactive food products and processes.

The activities of the research line for the assessment of the health and functional properties of foods and products seek to help increase the competitiveness of food industry products in the region and the country, through the biological validation of their health and functional properties. This work has focused mainly on providing nutritional assessment services for the industrial sector, at the Center's pilot plant.

³ In current Chilean pesos of each year.

RELATIONSHIP WITH REGIONAL POLICIES

CREAS' work is clearly aligned with the priorities of the regional development and innovation strategies, since it aims to help support entrepreneurship and innovation, in one of the four priority areas for economic development: the agrifood sector. To achieve this goal, it conducts applied research in the field of healthy foods and nutraceuticals, and develops processes and products designed to meet the requirements of this industry, working in close collaboration with businesses in this sector. Thus, with highly specialized human capabilities and modern infrastructure, it uses science and technology to strengthen regional competitiveness and economic development.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CREAS has a research team of 18 professionals, 14 of whom are researchers with a Ph.D., including 5 employed by the Center and 9 from its partner institutions⁴.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	5	9	14
Researchers with a Master's degree	0	2	2
Professionals and technicians who support research	2	0	2
Total	7	11	18

From this total of specialists, 11 work in the line for the development of sustainable products and processes to obtain bioactives and healthy foods; 3 in the development of technologies for a sustainable agriculture to obtain healthy foods; and 5 in the assessment of the health and functional properties of foods and products⁵. They are joined by a management team of 7 people.

The Center has its own building, in PUCV's Technological Park, at the Curauma campus in Valparaíso. This 400-square-meter construction has equipment that is unique in the region, with a pilot plant for food and bioactive products processing, and drying of bioactive ingredients. The pilot plant, which is certified by the Health Service to produce foods, has equipment that helps validate methodologies not applicable in laboratories. It also allows for rapid changes to operating conditions, a capability used by the Center to execute its own projects and provide businesses and other entities in this sector with an offer of more than 20 services. It is important to mention that CREAS is Chile's only provider of freeze-drying services at a pilot

scale. There has also been a considerable investment in the equipment available in the laboratories that belong to the Center's partner institutions.

With an initial investment of over 100 million Chilean pesos, the plant was implemented with equipment specially manufactured in the United Kingdom, with the specific function of creating a dynamic relationship between scientific research and regional industry. This space also houses the Prototype Assessment Unit, which has four sensorial evaluation cabins, a professional kitchen, a microbiology laboratory, and a critical nutrient laboratory. Besides this infrastructure, more infrastructure is also available through the partner institutions for the Center to use.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

CREAS is part of a robust national and international collaboration network. In the country, it has work agreements with a series of universities: Universidad de Chile, Pontificia Universidad Católica de Chile, Universidad de la Frontera, Universidad de Concepción, Universidad de Los Andes, Universidad de La Serena and Universidad de Talca, as well as Fundación Chile, the Forestry Institute (INFOR) and the National Forestry Corporation (CONAF). These collaborations have allowed CREAS to complement its research capacities in its various lines.

Internationally, the Center has collaboration agreements with established technological entities in the field of food science and technology, such as the Science Park in Madrid and Golsman Partners for Business, which helped organize the I and II Spanish-Chilean Forum on Healthy Food, "Perspectives of the ingredient and functional food sector," held in Spain and Chile in 2011, and which led to the development of joint projects. It also has agreements with the Seafood Research and Education Center and the Food Innovation Center, both at Oregon State University (USA), and with the Food Industries Center and the

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

⁵ One of the specialists works in two research lines.



CREAS conducts concept tests and creates prototypes of freeze-dried fruit, which helps maximize conservation of its flavor and aroma.

Department of Foods, Agricultural and Biological Engineering, both at Ohio State University (USA), which were established in the context of a CONICYT project for networks and international cooperation (knowledge on business management models and technological transfer applicable to CREAS).

The Center also has agreements with the Agricultural Sciences Institute of Zurich (Switzerland), the Lactobacillus Reference Center (CERELA) in Argentina, the Madrid Institute of Advanced Food Studies (IMDEA Foods), Universidad de Vigo (Spain), Universidade do Minho (Portugal), Universidade Católica Portuguesa, the University of Reading (United Kingdom), the Brazilian Agricultural Research Corporation (EMBRAPA) and the Biomedical Sciences Research Institute at the Ulster University (United Kingdom), among others, entities with which it executes projects and initiatives for researcher internships and student mobility.

CREAS has also participated in creating initiatives for the Iberoamerican Program of Science and Technology for Development (CYTED) and the European Framework Program, with institutions such as Universidad de Castilla La Mancha (Spain), Braganza Politechnical Institute and Universidade de Oporto (both from Portugal), Universidad Veracruzana (Mexico) and Universidad Nacional Autónoma de México, among others. It also participates in the international network BiValBi (Biotechnologies to Valorise Regional Food Biodiversity in Latin America), whose goal is to develop foods and ingredients from wastes of the fruit and vegetable industry.

Relationship with local organizations, industry-related and government agencies

As part of its work, CREAS collaborates with private businesses, universities, research and development centers, and public institutions. It maintains direct contact with more than 80 businesses, particularly in the food and nutraceutical sectors, which has led to the execution of applied R&D projects, commercial prospection missions, and other forms of collaboration. In particular, the Center has led several commercial prospection projects by Prochile (Chilean Promotion Bureau) with regional businesses, designed to strengthen their capacity for exporting functional foods and nutraceuticals, with missions to Spain, Italy and the United States.

It also maintains working relationships with the following public institutions: the Agricultural and Livestock Service (SAG), the Senate Committee on Future Challenges, the Quillota Health Service, the municipalities of Quillota, Viña del Mar, Valparaíso and San Antonio, and the Municipal Corporation of Valparaíso, among others.

Besides providing various services in its pilot plant, CREAS actively incorporates small businesses in its entrepreneurship projects for the creation of prototypes, while projecting the results of each scientific project towards the industry and identifying new businesses for joint work.

In terms of its regional relationships, the Center has also organized two seminars on food technologies, designed for regional SMEs; participated in the development of

five prototypes for regional entrepreneurs; and is a technical consultant for the Group of Quinoa Producers of Petorca. It also participates in the Regional Advisory Commission on Food Safety, and works with INIA La Cruz on the denomination of origin of the Limache Tomato.

RESULTS AND IMPACTS IN THE REGION

Working in close collaboration with businesses, CREAS is developing new alternatives for ingredients with a high nutritional and functional content, processes and products for adding value to regional and national food production. Components of pomegranate, *maqui* and propolis extracts, freeze-dried products, healthy snacks and bioactive packages are some of the developments the Center is using to strengthen competitiveness in this industry.

Since 2014, the research line for the development of technologies for a sustainable agriculture to obtain healthy foods has offered the productive sector a service for the evaluation of the nutritional and functional characteristics of new lines of processed beans.

A specific result of this line is the construction of a database to support breeding programs for different varieties of raspberries in Chile, based on the molecular

markers that regulate post-harvest quality, with the purpose of solving problems such as this fruit's propensity to soften and its short post-harvest life, or the small caliber of the fruit in the domestic market. It is important to mention our country's relevance in the international market for frozen raspberries, where it is the main exporter in the Southern hemisphere.

The research line for the development of sustainable products and processes to obtain bioactives and healthy foods is known for its high scientific productivity and the magnitude of the resources it leverages. It is also the line with the greatest number of agreements and services provided to the productive sector, and the largest number of projects and publications with other institutions. Researchers in this line, along with Swiss researchers (from the Agricultural Science Institute of the University of Zurich) are beginning studies designed to obtain Chilean potatoes with greater antioxidant activity.

Some of the achievements in product development have been: antioxidant extracts in functional ingredients (antioxidants, bioactive peptides, soluble fiber) of several plant species, including agroindustrial wastes; flours with a low glycemic index and high-soluble fiber; bioactive lipids; products that cause satiation; and solutions for technological problems.

This line does interesting work with extracts and packaging. Its results include the development of a protocol for extracting and concentrating polyphenolic



Low-calorie, high-FOS fiber (short-chain fructo-oligosaccharide) marmalade is another product developed by the Center.

components from pomegranate, propolis and maqui extracts, which have been evaluated for their antifungal activity when incorporated into an edible covering applied to commercial “clamshells” (transparent packaging with a hinge) for blueberries, with promising results. The use of active packaging with a cover made from anise extract has also been evaluated, studying its potential synergy with the extracts applied to fruits.

In another field, researchers have developed functional flour from discards generated by the banana import industry, in the framework of an Innova project. They are currently searching for a more innovative product, through a Fondecyt project oriented towards the development of an enzymatic process to obtain a functional food ingredient rich in resistant starch, dietary fiber and other bioactive compounds from discarded bananas. This initiative hopes to achieve more consolidated and patentable results, adding more value to the final product and the technology proposed for its development.

The work team in this line is in charge of operating the pilot plant and has obtained very interesting results in the framework of projects with businesses and services provided for businesses, which cannot be described in greater detail due to confidentiality agreements.

This line has developed five prototypes for entrepreneurs not related with the Center: honey capsules, freeze-dried fruit snacks, freeze-dried flowers, plum jelly, and freeze-dried maqui; and five

prototypes associated to research projects: two types of fruit jam/marmalade with high-fiber syrup instead of sucrose, cakes with high-fiber syrup instead of sucrose, probiotic microcapsules, and snacks made from apple discards.

The research line for the assessment of the health and functional properties of foods and products has supported businesses in the validation of their products through nutritional assessments (acceptability tests, nutritional labels, analysis of fatty acid profiles, for example) for products such as pineapples native to Easter Island, Limache tomatoes, carrot tea, and microalgae oil, among others.

Between 2011 and 2014, CREAS developed a total of 49 projects⁶. During this period, its researchers published 35 articles in indexed journals, with an average index impact of 2.236. They also presented 96 works at 53 scientific congresses, and supported the development of 5 Ph.D. theses, 3 Master’s theses and 27 undergraduate theses in fields in which the Center is competent. Although CREAS has not yet patented the advances achieved in recent years, in the framework of the five Fondecyt projects currently in execution, each under the responsibility of a researcher employed by the Center, it is producing critical information and evaluating the potential for patenting.

⁶ The list of the Center’s projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI Publications	8	2	14	11	35
Impact index	2.422	0.323	2.140	2.571	2.236
Non-ISI publications	8	1	5	1	15
Number of works presented at scientific congresses	6	13	27	50	96
Number of scientific congresses at which the Center presented works	4	6	17	26	53
Ph.D. and Master’s theses underway with the support of the Center*	0	1	7	3	8
Undergraduate theses underway with the support of the Center*	0	3	11	15	27

* As theses last more than a year, they are counted in each year of their development.

CENTER OF HORTICULTURE INNOVATION FOR THE REGIONAL DEVELOPMENT OF VALPARAÍSO

CERES

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REGIONAL CONTEXT ¹

SOCIOECONOMIC PROFILE OF REGION

Regional GDP (2013)	MMCLP 8,461,149 (8.2% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (16.8%), transportation and communications (14.5%), manufacturing industry (14.3%) and personal services (12.4%).
Business composition (2013)	There are 100,558 businesses in the region employing 585,709 dependent workers. 66.2% of these are microenterprises, which employ 10.1% of all workers. The agricultural, cattle and forestry sectors concentrate 7.2% of all businesses and employ 9.8% of dependent workers.
Exports (2013)	MMUSD 5,961 (7.8% of the national total). Mining generates 54.6%, industry generates 29.2% and the agricultural, forestry and fisheries sectors represent 15.0%. As specific sectors within these, fruit growing generates 13.7% of the regional total, while the food industry generates 5.3%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 13 universities in the region, including Pontificia Univ. Católica de Valparaíso, Univ. de Playa Ancha de Ciencias de la Educación, Univ. de Valparaíso and Univ. Técnica Federico Santa María, which belong to the region itself. In 2014, the graduate degrees available in the region included 31 Ph.D. programs and 148 Master's programs, mainly in the fields of social sciences, business and law (47), sciences (32), education (29), engineering, manufacturing and construction (29) and humanities and the arts (18).
Regional competitiveness index (ICORE) 2012	The region ranks 4 th in the country (index of 0.531). It ranks 5 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 18.8% (compared to a national average of 23.7%). The technological and non-technological innovation rates are equal (15.4%) and below the national averages (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 6,115 articles (9.6% of the national total). The annual number increased at an average of 5.9% during this period. The rate of international collaboration was 53.2% (compared to a national average of 52.4%). The normalized impact of production is 1.15, which falls to 0.75 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Region of Valparaíso 2020* proposes a vision of a region characterized by an even development of all its territories; a quality of life that favors healthy lifestyles and a friendly and welcoming social, cultural and environmental context; a diversified economy and sustained growth with dynamic services, logistics and productive sectors; and a great relationship between its universities and research centers with the public sector and businesses, which help develop innovation processes in order to strengthen competitiveness and regional development. In terms of the economic sphere, the following elements have been proposed for this purpose: a more dynamic regional productive system; the promotion of entrepreneurship and innovation, which favors the creation of opportunities and regional competitiveness; and adding value to human capital by strengthening technical-professional skills.

The *Regional Innovation Strategy (2014)* established six strategic pillars for strengthening development and promoting businesses innovation. After prioritizing these, four poles of activity were selected (logistics, agrifood, sustainable tourism and creative industries). The agrifood sector includes the agricultural sector (agricultural products of plant origin) and the agrifood industry (creation, transformation, preparation, conservation and packaging of food for human and animal consumption).

CENTER OF HORTICULTURE INNOVATION FOR THE REGIONAL DEVELOPMENT OF VALPARAÍSO (CERES)

Ceres was created in 2011 as a joint initiative of Pontificia Universidad Católica de Valparaíso (PUCV), the Regional Government of Valparaíso and CONICYT. Agricultural Quintil S.A. also participates as an associate corporation. The executive director of the Center is Eduardo Gratacós Naranjo.

Ceres is a research and innovation center that promotes a visionary development model for agriculture and the rural territories of the region, which seeks to create wealth and value while promoting sustainability. Its goal is to generate sustainable development in primary agrifood systems and the rural territories of the region, with a multifunctional perspective of agriculture for good living, which facilitates the production of healthy and nutritional food from the territories, the harmonious use of these territories, and the dynamic conservation of their landscapes and natural patrimony.

GOALS

The goal of Ceres' work is to develop sustainable primary agrifood systems capable of providing healthy food and reducing negative impacts in the region's territories. The Center favors a systemic approach with scientific research and innovation programs, acting as a regional center of international reference by developing new professionals with advanced studies and placing them in programs of regional importance, while implementing pertinent and effective strategies based on action-research, strengthening and articulating existing capacities to promote strategic thinking for the region and its public policies, in order to contribute effectively to good living in the rural territories of the Region of Valparaíso. For this purpose, it develops the following research lines: horticulture systems, territorial systems, and a regional horticulture innovation system.



RESEARCH LINES²

HORTICULTURE SYSTEMS

Goal: to strengthen regional horticulture development through research and innovation activities that aim to create scientific and technological products, which help to develop sustainable primary agrifood systems. For this purpose, the Center works on programs for biological soil restoration and the territorial management of insect populations of agricultural importance, and in the fields of assisted genetic breeding in cherries and development of bases for a seed productivity and quality assurance system.

Technical team: Carlo Sabaini (Bach., line coordinator, CERES). Researchers employed by CERES: Marta Albornoz (Dr.), Jaime Verdugo (Dr.), Solange Hualquil (Dr.(c)), Gonzalo Ávilas (M.Sc.), Eduardo Gratacós (M.Sc.) and Gustavo Briones (Bach.). Researchers from partner institution (PUCV): Ricardo Cautín (Dr.) and Patricia Peñaloza (Dr.). Research support (CERES): Jean Arriagada (M.Sc.), Francisca Carvajal (Bach.) and Víctor Vicencio (Bach.).

TERRITORIAL SYSTEMS

Goal: to help generate proposals for a harmonious and sustainable development of rural territories, integrating territorial organization and rural landscapes to their multiple uses. For this purpose, the program will propose territorial organization and rural landscape design strategies in locations within the region, characterizing territories of diverse natural and ecological value and strengthening their local identities.

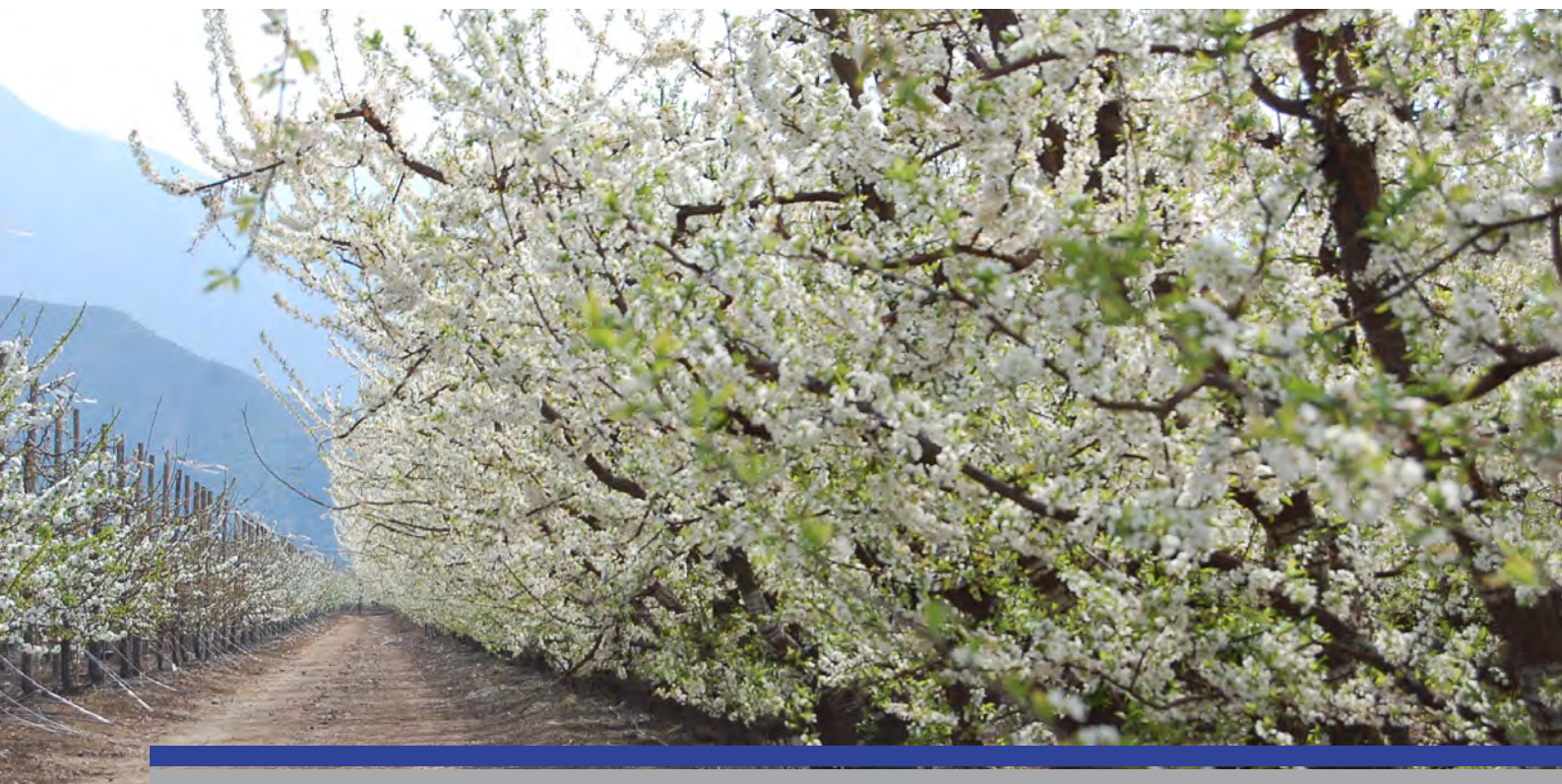
Technical team: Roxana Lebuy (Dr.(c), line coordinator, CERES). Researchers employed by CERES: Raúl Andrés (Dr.), Isabel González (Dr.(c)) and Jean Francois Casale (M.Sc.). Research support (CERES): Pablo Huerta (Bach.).

REGIONAL HORTICULTURE INNOVATION SYSTEM

Goal: to design and implement, together with key regional stakeholders, a development and management model for the regional horticulture innovation system, based on sciences of complexity. For this purpose, it will apply the Participatory Innovation Model, an action-research methodology that works with actors and that, as part of its work plan, must update its strategy using the knowledge it produces.

Technical team: Alfredo del Valle (Dr., line coordinator, CERES).

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.



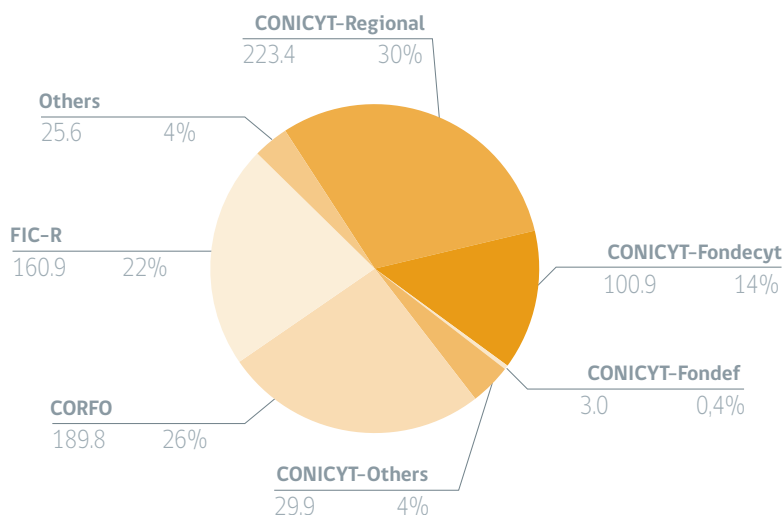
RESOURCES OF THE CENTER DURING THE 2012-2014 PERIOD³

Core funding from CONICYT Regional Program*	----
Core funding from Regional Government of Valparaíso	MMCLP 727.3
Resources awarded through projects from different sources	MMCLP 733.5

* The Center was created by initiative of the Regional Government and does not have core funding from CONICYT, but does have the technical support of this entity and competitive funding through public calls for the strengthening of the regional centers.

Ceres: resources awarded through projects from different sources, 2012-2014

(Millions of Chilean pesos and percentage distribution by funding source)



Source: CERES and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CONICYT-Fondef: CONICYT's Fund for the Promotion of Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CERES' ACTIVITIES

Besides being an agency that serves the regional community, Ceres aims to become a center of excellence in research and innovation, with high standards, in order to contribute effectively to the development of regional agriculture, generating pertinent and significant knowledge to support strategic decision-making at the public level and to improve the quality of life for people.

For this purpose, the Center works to develop a series of programs. The Biological Soil Restoration program seeks to create the conditions for farmers and other actors to understand the attributes of soil complexity and the multiplicity of ecosystem services they generate for the sustainability of territories, as well as their economic and social value. The program develops research and innovation, articulating capacities and networks to overcome processes of increasing deterioration in agricultural soils (hardening, loss of

organic matter and loss of biodiversity), which lead to a reduction of the agricultural patrimony and a lower regional agricultural productivity.

The Territorial Insect Management program is designed to improve the sustainability of primary food systems, strengthening the ability of agroecosystems to respond to insect population growth. The program seeks to rationalize and progressively reduce the use of agrochemicals in agriculture and its severely negative social and environmental impacts, through the development of technologies and methods of territorial management to deal with insect populations that are important to agriculture.

The program for Landscape, Territory and Rural Development for Good Living aims to help generate proposals for a harmonious and sustainable

³ In current Chilean pesos of each year.

development of rural territories, working on issues such as multiple uses of the territory, sustainability, cultural landscape, rural-urban migrations, land planning and rural landscape, rural culture, creation of wealth and new visions for development. For this purpose, the program will propose strategies for land planning and rural landscape designs in locations within the region characterize and value spaces and territories of diverse natural and ecological values, and value and strengthen the local identities of territories by using the potential of endogenous rural resources.

The program for the Management of Transitions Towards Sustainability works to develop and apply practical management and governance methods, together with the other programs, in order to build innovation networks that may have an impact and may produce transitions

towards regional agriculture sustainability. This work is based on sciences of complexity and systemic thinking, and its theoretical and methodological foundation is the general intervention model called Participatory Innovation. Its first contribution, with the participation and consensus of relevant regional stakeholders, has been to identify over 100 specific innovations that the region must promote to develop sustainable agriculture in its territories.

Besides the aforementioned thematic programs, the Center is also working in two other dimensions of regional agricultural development to establish medium-term thematic programs: the management and valorization of plant genetic resources, and the development of sustainable agrifood systems for the production of fruits and vegetables.

RELATIONSHIP WITH REGIONAL POLICIES

Ceres' activities are clearly aligned with the regional development strategy, since it aims to strengthen a key productive sector, agriculture, in the framework of a vision for development that combines social, cultural and environmental aspects, as well as economic aspects. For this purpose, in a collaborative process that relates the knowledge sector with business public actors associated to the rural world, the Center is developing a strategy to establish a regional horticulture innovation system, which will seek to achieve a more harmonious cooperation and articulate regional capacities with an equitable and sustainable development.

Besides promoting agricultural development, which is a priority of the regional innovation strategy, its approach also includes the strengthening of identity aspects, which contributes to the development of sustainable tourism, which this strategy also defines as relevant.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

Ceres' technical team consists of 18 people, including 6 researchers with a Ph.D. (4 of whom are employed by the Center) and 6 with a Master's degree (all employed by the Center), as well as 6 support professionals and technicians⁴. From the total of researchers, professionals and technicians, 12 work in the horticulture systems line, 5 in the territorial systems line, and 1 in the regional horticulture innovation system line. Their work is supported by a management team of 5 people.

Ceres' offices are located within the Experimental Station of the School of Agronomy at Pontificia University Católica de Valparaíso, in La Palma, Quillota;

an entity which develops collaborative work with the Center and has provided the necessary infrastructure to implement demonstrative agricultural modules and work offices.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	4	2	6
Researchers with a Master's degree	6	0	6
Professionals and technicians who support research	6	0	6
Total	16	2	18

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS

Networks for scientific collaboration

To develop its work, Ceres has established international relationships with the University of Winnipeg (Canada); with scientific organizations in Australia and New Zealand; universities and centers in the United Kingdom, such as the Systems and Cybernetics in Organisation (SCiO) network, which the Center has joined as a member, and the Centre for Systems Studies at the University of Hull, as well as others in Spain. Within the country, it works collaboratively with the following regional centers: the Research Center for Advanced Polymers (CIPA), the Center for Research on Patagonia Ecosystems (CIEP), the Center for Advanced Studies in Arid Zones (CEAZA) and the Tourism and Patrimony Research Center (CITYP). It has also worked with other regional centers to produce the document "Regional Research Centers, Development and Innovation, Proposal for a key instrument for decentralized development in Chile in the knowledge society," which was presented to the Senate Commission on Future Challenges.

Relationship with local organizations, industry-related and government agencies

The Center works together with the main regional actors in its area of work. It has worked on diverse initiatives with different public and private agencies, such as the Agricultural Development Institute (INDAP), the Agricultural and Livestock Service (SAG), the Municipalities of Quillota, Limache, San Antonio, Hijuelas, La Cruz, San Felipe, Los Andes and La Ligua, the network of Local Development Programs (PRODESAL) V Region, farmers' trade associations in Quillota, San Felipe and Los Andes, and several educational

institutions, including agricultural high schools and rural schools, among others.

In the regional horticulture innovation system line, with the goal to create a shared vision for development using a participatory innovation methodology, the Center has established a permanent action group, with the participation of the Regional Ministerial Secretariats of Agriculture and the Environment, the Chilean Economic Development Agency (CORFO) and other entities in the public and private sectors. The idea was to promote the action map to strengthen regional agricultural development, as defined previously in a workshop on its vision for regional development.

RESULTS AND IMPACTS IN THE REGION

With a comprehensive vision of territorial development that includes social, cultural and environmental aspects, as well as economic aspects, Ceres is working to promote sustainable and productive agriculture at the regional level. Biological soil restoration, territorial insect management, the valorization of rural spaces, and a participatory innovation model to create a regional horticulture innovation system are some of the strategies it is currently using.

In the horticulture systems line, the Center works complementarily in four areas. The Biological Soil Restoration program uses the concept of "live soil," considering factors such as the loss of sustainability and agricultural productivity, soil hardening, the reduction of infiltration and water retention capacity,



Ceres' demonstrative unit for agroecological techniques helps transfer to small farmers principles of agroecology and sustainability for the production of diverse, healthy foods.

the reduction of porous space, premature productive deterioration, and cost increases caused by a greater demand for chemical materials to sustain production. The most significant results in this area have been the validation and application of five indicators of the biological condition of soil. The first contribution has been to develop and validate in the region methods and tools that may allow farmers to assess the biological condition of their soils and motivate them to intervene and restore these soils to their full biological potential.

In the Territorial Insect Management program, with the purpose of rationalizing the use of agrochemicals, the Center works to create knowledge on the territorial dynamics of insects as a foundation for designing management strategies. These efforts have aimed to develop a multifactorial predictive model for the white greenhouse mosquito (*Trialeurodes vaporariorum*) and a strategy to protect the region's beekeeping patrimony. A digital work platform, version 1.0, was designed and implemented to monitor and analyze the population, farm and territorial dynamics of the white greenhouse mosquito, in order to create a multifactorial predictive model as one component of a territorial management strategy for other insects. It also began the study of the population curve of the *Varroa destructor* parasite in apiaries in the region and the development of a laboratory tool that evaluates the lethal and sub-lethal effects of chemical products on *Apis mellifera*.

In the genetic breeding of cherry trees, progress has been made in the production of segregating hybrids, developing successful hybridization protocols (which

has helped to reduce the time and costs of artificial pollination), with a characterization done by a panel of experts of the best parentals to use. Another topic has been increasing seed germination, which normally achieves yields close to 10%, and work has been developed with export businesses, fruit producers and nurseries to determine the characteristics of fruit that is of commercial interest. Researchers at the Center also learned about the experience of the Jerte Valley, in Spain, where "picota del Jerte" cherries are produced with denomination of origin, sustaining the development of the entire valley in terms of production and tourism. They also participated in a workshop on the COST (Cooperation in Science and Technology in Europe) cherry project, which includes 21 countries, with the purpose of forming research networks on this species within Europe.

In seed productivity and quality assurance, the Center has developed, implemented and applied monitoring and evaluation methodologies for reproductive events (flowering, pollen, pollination, fertilization). These tools have helped support productive processes and have also been applied to new species, which requires information in order to evaluate losses in the yield of fruits or seeds. This work has been developed in close collaboration with regional businesses, mainly through the provision of specialized services.

In the territorial systems line, the Center has produced information in two fields. In regional territorial data, it has compiled and systematized physical, social and productive territorial data on the region, which has



In the area of landscape, territory and rural development, the Center designs rural territorial planning strategies at different scales, to ensure a multiple, harmonious and sustainable use of the territory and its landscapes, in order to contribute to good living for its inhabitants.

helped build a solid foundation for generating territorial intervention projects. In site characterization, it has geographically, physically and productively described a diversity of agricultural sites in valleys and mountain ranges, of different sizes and in different territorial and cultural conditions, which has helped obtain a broad view of the diverse styles and limitations that characterize this region's agriculture.

Ceres has also implemented a demonstrative site unit for sustainable agricultural techniques, located in the La Palma Experimental Station (Quillota) at PUCV. This agro-ecological module helps to transfer and socialize agro-ecological techniques with the agricultural community, providing small farmers with tools for building their own self-sufficiency and selling quality products.

The regional horticulture innovation system line has implemented a participatory innovation model. The Center has summoned relevant stakeholders in the regional productive, public and knowledge fields to work on three main areas: innovation methodology and activation, water innovation, and labor innovation. This process has produced the following results:

- *Action Map of the Regional Horticulture Innovation System of Valparaíso*, organized into ten pillars, each of which includes established lines of action (with stakeholders, activities and impacts) and potential lines of action.
- Profile of Innovation Project, *"Design and implementation of a permanent governance system for water resources in the Region of Valparaíso"*, designed to respond to requirements for building an efficient and coherent governance of regional

water resources, protecting the ecosystems on which this resource depends, identifying and prioritizing needs, availabilities, qualities and uses, developing efficient systems for accumulation, control, distribution and use, ensuring an equitable participation on the benefits of water, and raising awareness and commitment among regional stakeholders.

- Strategic Innovation Portfolio: in five complementary fields, this includes cultural, governance and management, infrastructure and technological innovations for the *"Comprehensive management of water resources in the Region of Valparaíso"*; innovations that must be promoted in the region for the *"Improvement of labor conditions in horticulture"*; and innovations that the region must implement to ensure sustainability and competitiveness in terms of the *"Development of sustainable technologies for the management of soil resources," "Development of knowledge and competencies for commercial fruit culture,"* and *"Development of knowledge and competencies for commercial horticulture."*

In the framework of its different lines, between 2012 and 2014 Ceres' team executed a total of 11 projects⁵. During this period, its researchers completed 7 scientific articles (ISI), which were published on journals with an average impact index of 1.033, and produced 9 scientific works that were presented at 8 congresses. The Center also supported the development of 6 Master's and 2 undergraduate theses on subjects related to its work lines.

⁵ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

Main indicators	2012	2013	2014	2012-2014 period
ISI Publications	1	2	4	7
Impact index	0.310	1.004	1.229	1.033
Non-ISI publications	1	0	2	3
Number of works presented at scientific congresses	2	4	3	9
Number of scientific congresses at which the Center presented works	2	1	5	8
Ph.D. and Master's theses underway with the support of the Center*	4	3	3	6
Undergraduate theses underway with the support of the Center*	0	0	2	2

* As theses last more than a year, they are counted in each year of their development.



TOURISM AND PATRIMONY RESEARCH CENTER OF THE REGION OF VALPARAÍSO

CITYP

REGION OF VALPARAÍSO

www.cityp.org - cityp@cityp.org - (56-34) 2425974

REGIONAL CONTEXT ¹

SOCIOECONOMIC PROFILE OF REGION

Regional GDP (2013)	MMCLP 8,461,149 (8.2% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (16.8%), transportation and communications (14.5%), manufacturing industry (14.3%), personal services (12.4%) and trade, restaurants and hotels (8.0%).
Business composition (2013)	There are 100,558 businesses in the region employing 585,709 dependent workers. 66.2% of these are microenterprises, which employ 10.1% of all workers. The hotel and restaurant sectors represent 4.9% of all businesses and employ 4.4% of all dependent workers.
Exports (2013)	MMUSD 5,961 (7.8% of the national total). Mining generates 54.6%, manufacturing generates 29.2% and the agricultural, forestry and fisheries sectors generate 15.0%. The most relevant subsectors within these sectors are copper and iron mining (54.5%) and fruit culture (13.7%).

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 13 universities in the region, including Pontificia Univ. Católica de Valparaíso, Univ. de Playa Ancha de Ciencias de la Educación, Univ. de Valparaíso and Univ. Técnica Federico Santa María, which belong to the region itself. In 2014, the graduate degrees available in the region included 31 Ph.D. programs and 148 Master's programs, mainly in the fields of social sciences, business and law (47), sciences (32), education (29), engineering, manufacturing and construction (29) and humanities and the arts (18).
Regional competitiveness index (ICORE) 2012	The region ranks 4 th in the country (index of 0.531). It ranks 5 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 18.8% (compared to a national average of 23.7%). The technological and non-technological innovation rates are equal (15.4%) and below the national rates (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 6,115 articles (9.6% of the national total). The annual number increased at a rate of 5.9% during this period. The rate of international collaboration was 53.2% (compared to the national average of 52.4%). The normalized impact of production is 1.15, which falls to 0.75 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Region of Valparaíso 2020* proposes a vision of a region that includes, among other characteristics, an even development with solidarity among all its territories, thanks to the protection and valuation of people, patrimony, its landscape and natural resources; a diversified economy and a sustained growth known for its dynamic services, logistics and productive sectors; and a great relationship between universities and research centers and the public sector and businesses, which has helped promote innovation processes, favoring competitiveness and regional development. Some of the pillars proposed to establish this vision include, in economic terms, a more dynamic regional productive system for economic growth and job creation, particularly the goal of strengthening the region as a national and international tourism destination, as well as other sectors.

The *Regional Innovation Strategy* (2014) lays out a series of strategic pillars for strengthening development and business innovation and, in response to the need to prioritize its efforts, has selected four areas of activity: logistics, agrifood, sustainable tourism, and creative industries. Sustainable tourism includes all activities that people develop during their travels, lodging, restaurants, transportation, leisure, sports activities, recreational and entertainment activities, shopping, travel agencies and tourism operators, that are respectful of their natural, cultural and social environment, helping to produce an exchange of experiences between visitors and residents.

TOURISM AND PATRIMONY RESEARCH CENTER OF THE REGION OF VALPARAÍSO (CITYP)

CITYP was created in 2011. It includes the Regional Government of Valparaíso, the Pro Aconcagua Development Corporation, Universidad de Valparaíso (UV) and Pontificia Universidad Católica de Valparaíso (PUCV). Until the Center obtains its own status as a legal entity, the Pro Aconcagua Development Corporation shall act as its legal representative. The director of the Center is Jorge Negrete (Dr.(c)).

The Center's mission is to create new scientific and technological knowledge in special interest tourism and patrimony in the provinces of Los Andes and San Felipe; to promote a model of public-private cooperation between the network of science, technology and innovation actors and the industrial sector, in order to improve the competitiveness of the tourism and patrimony sector in these provinces, and to lead their transformation towards becoming a knowledge-intensive sector.

The Center's vision is to lead the research and promotion of scientific and technological knowledge in special interest tourism and patrimony in the provinces of Los Andes and San Felipe, consolidating it as a regional, national and international reference point in the creation of scientific capital and the

development of patrimonial and tourism products and services.

GOALS

CITYP's goals are to strengthen the scientific and technological foundation of the Region of Valparaíso, through an integrated series of projects, programs and studies in patrimony and special interest tourism that may produce new knowledge and applications, contributing to the training and placement of the human capital that the region requires; using the results of its research to contribute to regional development in the fields of patrimony and special interest tourism, through a series of programs that may ensure the exploitation of new knowledge and technological advances among public stakeholders and the business sector; and to design and implement a technology transfer model, with the purpose of disseminating knowledge and stimulate the use of new tourism and patrimonial processes, systems, services and products generated by the Center, in order to favor a territorial innovation and entrepreneurship system.

To achieve these goals, CITYP works in two research lines, special interest tourism and patrimony.

RESEARCH LINES²

SPECIAL INTEREST TOURISM

Goal: to understand the existing territorial model and tourism model in the territory, identifying its conditioning factors, and to propose, develop and implement a sustainable model for the development of special interest tourism, through studies in the fields of tourism and sustainability, management of tourism destinations, and new technologies and tourism.

Technical team: Laura Malermo (M.Sc., line coordinator, CITYP). Researchers employed by CITYP: Felipe Lazo (Dr.(c)), Juan Luis Delgado (Bach.) and Sandrino Llano (Bach.). Researchers from the partner institutions: Claudio Carrasco (Dr., UV), Andrés Garcés (Dr., PUCV), Carlos Lara (Dr., UV) and Luis Álvarez (M.Sc., PUCV). Research support (CITYP): Rubén Cecenque (Bach.).

PATRIMONY

Goal: to understand, preserve, conserve, add value and manage the archeological, historical/cultural and natural patrimony of the Region of Valparaíso, by developing basic and applied research in the fields of archeological patrimony, historical-cultural patrimony, and natural patrimony.

Technical team: Abel Cortez (Dr.(c), line coordinator, CITYP). Researchers employed by CITYP: Gabriela Carmona (Dr.(c)), Doris Sanhueza (M.Sc.) and Cristian Urzúa (Bach.). Researchers from the partner institutions: David Luza (Dr., PUCV), María Ximena Urbina (Dr., PUCV), Manuel Hernández (M.Sc., UV), Ángela Herrera (M.Sc., UV) and José Miguel Ramírez (Bach., UV). Research support (CITYP): Rubén Cecenque (Bach.).

² Information on the technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.



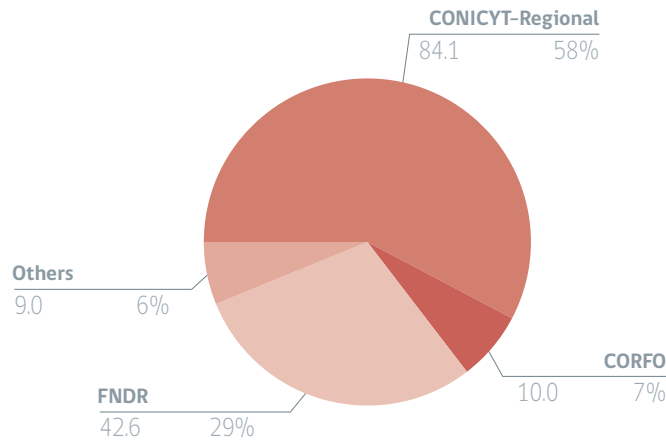
By strengthening special interest tourism and patrimony, CITYP aims to contribute to decentralization within the region, favoring the creation of a development hub in the interior zone of the Region of Valparaíso.

RESOURCES OF THE CENTER DURING THE 2012-2014 PERIOD³

Core funding from CONICYT Regional Program*	----
Core funding from Regional Government of Valparaíso	MMCLP 727.3
Resources awarded through projects from different sources	MMCLP 145.7

* The Center was created by initiative of the Regional Government and does not have core funding from CONICYT, but does have its technical support and competitive funding through calls for the strengthening of regional centers.

CITYP: resources awarded through projects from different sources, 2012-2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CITYP and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CORFO: Chilean Economic Development Agency; FNDR: National Regional Development Fund.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CITYP'S ACTIVITIES

CITYP is conceived as a scientific and technological center for the sustainable development of special interest tourism and patrimony in the Region of Valparaíso. Through its two research lines, it works to develop projects, programs and studies that may help promote research, innovation, technology transfer and the formation of advanced human capital, in order to contribute to the competitive development of its territories.

In particular, it seeks to improve the competitiveness of small and medium sized enterprises in the tourism sector, by creating innovative value chains using the results of its studies, fostering a model of public-private cooperation among the network of STI actors and the industrial sector. Complementarily, its activities are also oriented towards strengthening public and private human resources specialized in tourism and patrimony.

Along with consolidating the Center's specialized human capital, it has also proposed to strengthen research capacities, through the design and development of tourism and patrimony projects on the local, regional, national and international scale. As a result of these initiatives, CITYP aims to contribute feasible and timely solutions to problems related to special interest tourism and patrimony, in order to establish a foundation for developing a sustainable tourism model, in harmony with the nature, local culture and economic growth of the provinces of Los Andes and San Felipe.



Programa Regional CONICYT

³ In current Chilean pesos of each year.

RELATIONSHIP WITH REGIONAL POLICIES

CITYP's activities are clearly related to both regional development and regional innovation strategies, which have identified tourism as one of the essential activities for economic development in this region. The first of these strategies emphasizes the even development of all territories –a concern that is very present in the activities of CITYP, which has sought to promote decentralization within the region– as a result of the valuation of its people, patrimony and landscape, which is one of the fundamental goals of the Center's activities. Its decision is oriented precisely towards sustainable tourism, based on the respect, as well as the promotion and valuation of the natural, cultural and social environment, as proposed in the regional innovation strategy.

For this purpose, CITYP has the specialized capacities of its team of researchers, from the entity itself and from two partner universities, who work collaboratively on different initiatives with public agencies and stakeholders in the affected communities. The goals of CITYP are also within the framework of the strategic guidelines for tourism and patrimonial development of the Aconcagua Valley.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CITYP's technical team consists of 18 persons, 9 employed by the Center and 9 from its partner institutions, including 5 researchers with a Ph.D. and 9 researchers with a Master's degree⁴. 9 of these researchers, professionals and technicians work in the special interest tourism line and 10 in the patrimony line⁵. Its work is supported by a management team of 5 persons.

Technical team 2015	Employed	Associated	Total
Researchers with a Ph.D.	0	5	5
Researchers with a Master's degree	6	3	9
Professionals and technicians who support research	3	1	4
Total	9	9	18

The Center is located in the city of Los Andes and operates in the historical building of the city's former Train Station, in facilities assigned to the Pro Aconcagua Development Corporation. Thus, it seeks to contribute to decentralization within the region, favoring, especially since 2015, the creation of a development pole in the interior zone of the Region of Valparaíso, particularly the provinces of Los Andes and San Felipe. The Center also has a special concern for special interest tourism and patrimony in the most disadvantaged areas and those farthest from the main urban centers, where it aspires to promote local development using its own resources and endogenous forces.

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

⁵ One person works in both research lines.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

In the international sphere, CITYP has joint work agreements with Developing Natural Activities (DNA) (Spain), to develop academic, scientific and cultural projects that may help achieve the goals of both institutions; and with Spain's Institute for Responsible Tourism. It also has a work agreement with Université Montpellier (France), through the Master's degree in Tourism and Sustainable Development of Territories.

The Center is currently working to reach collaboration agreements with other foreign entities, such as Università Ca'Foscari Venezia (Italy), Colorado University (USA) and the National Council on Scientific and Technical Research (CONICET) in Mendoza (Argentina), to deal with various fields of interest in the framework of its work lines.

Relationship with local organizations, industry-related and government agencies

CITYP's work is made with the active participation of government entities related to patrimony and tourism, such as the National Tourism Service (SERNATUR), the National Monuments Council, municipalities, the National Forestry Corporation (CONAF), the Agricultural Development Institute (INDAP), chambers of commerce and tourism and business associations, which support the Center's work in terms of information, methodologies and community work, among other areas.

The Center has participated permanently in spaces that are relevant to the region's touristic and cultural development, such as the Cultural Tourism Roundtable organized by the National Council of Culture and the Arts (on the subcommittee for the Law on Cultural Donations). It was also part of the 32nd Meeting of the Integration Committee for the International Crossing Cristo Redentor System.

In research development, it has worked with the Eurochile Business Foundation, on the transfer, dissemination and implementation of good environmental and tourism practices to businesses in the sustainable tourism network of the Region of Aysén. It also was part of the Pro Aconcagua project called "Aconcagua Tourism 2020," which led to the creation of the Strategic Plan for the Organization and Promotion of Tourism in the Aconcagua Valley 2014-2020, a great agreement on the objectives, goals and strategies for tourism in the valley, based on a shared vision of development.

CITYP also participates actively in the networks of CONICYT's Explora Program, including the Scientific Culture Network, a common space for relationships between cultural, academic and social organizations, oriented towards actions and reflections on the influence of science and its benefits for culture. It also has a relationship with the community through the dissemination of natural and cultural patrimony, through scientific journals and mass media.

RESULTS AND IMPACTS IN THE REGION

Located in the center of the territory where it develops its work, CITYP is contributing to the acknowledgment, restoration and valuation of the natural, cultural and social patrimony of this region. Combining specialized knowledge with its work with public entities and communities, it is working to promote the sustainable development of tourism in the Region of Valparaíso.

During the 2011-2014 period, CITYP's patrimony line was involved with a broad range of stakeholders in the territory and created diagnoses that included the views on the region's existing patrimony, projecting the work in this line in terms of issues and territories, as well as understanding the Center's role regarding other actors which support the conservation and sustainability of the region's patrimony, and its use for special interest tourism.

Work in this line consolidated an inventory of the region's patrimony, the entities related to it, and current regulations for its management. All this information was included in the Center's Geographical Information System, producing thematic cartographies and identifying actions for each area.



Through its research and development activity, the Center seeks to transfer knowledge to the regional tourism industry and promote the inclusion of new tourism and patrimonial processes, systems, services and products.

This line's team also created proposals with the municipalities, to favor an economic development with patrimonial identity. In particular, it developed a project with the Municipality of Puchuncaví, to add value to the Paleontological Collection in the town's Natural History Museum.

Another important initiative was a program to restore the mud-base façade of houses with historical value in the Centenario de Los Andes (Alto Aconcagua) area, a project for the recovery and valuation of material and non-material patrimony associated to constructions built with mud (adobe and other techniques), promoting actions with public stakeholders, the community and students from the area. By recognizing the territorial identity of the Aconcagua Valley, the purpose was to begin to preserve an ordinary housing patrimony in one area of the city, involving inhabitants from the selected houses.

In the coastal area, in Ritoque, another relevant initiative in this line of work was the project "Accessibility, continuity and interpretation of the cultural and natural components of the Amereida Cultural Park".

Work in this line also dealt with issues related to the region's geobiodiversity, including its relevance for territories with a potential for ecotourism.

In the field of archeological patrimony, considering the potential for tourism related to cave paintings, efforts have focused on the Aconcagua Valley, developing a consultancy for the projection of the Paidahuén Archeological Park, and presenting a project to determine its state of conservation and a comprehensive management proposal. With the purpose of strengthening the team's capacities in this field, there was an internship in patrimonial conservation and restoration in Havana (Cuba), and then a project for the implementation of one of the methodologies acquired.

In the city of Valparaíso, another very interesting project was "Cultural patrimonial manifestations and their relationship with the territory and a new museology, to create a Model for the Exhibition and Narration of the History of the City of Valparaíso". Its goal was to help strengthen the city's cultural memory by promoting its cultural patrimony and characteristics of the territory, and by acknowledging the relevance of the Contemporary Museum as a space that concentrates knowledge on a specific place, establishes a close relationship with its inhabitants, and helps protect it.

The special interest tourism line has produced diagnoses on the tourism needs of different municipalities within the region, identifying the relationship between cultural landscapes, tourism and governance as the main emphasis of their activities, closely related with their goals and resources in the field of patrimony.

One of the projects developed in this line was the "Strategic Plan for the Planning and Promotion of Tourism in the Aconcagua Valley, development of the tourism sector of the valley based on innovation and sustainability," which had the goal of developing the valley's tourism sector by including, along with innovation and sustainability, the components of territorial organization and promotion, as well as the creation of a destination management department. In this framework, a series of valuable technical studies were conducted in the field on supply and demand, as well as workshops for business-persons and employees, led by international experts. This area also organized the Traditional Gourmet Fair of the Aconcagua Valley, together with the Municipality of Rinconada.

Another interesting project was "Baseline studies for producing files on high-value sites for the conservation of the V Region of Valparaíso, Ritoque dunes, Mantagua



wetlands, Las Cenizas–La Invernada dams, Los Maitenes wetlands and Quirilluca cliffs,” funded by the Ministry of the Environment.

This line also provided consultancy services on tourism sustainability, in the framework of the aforementioned Eurochile initiative organized in Aysén.

During the 2012–2014 period CITYP developed a series of 9 projects⁶. This work produced 1 scientific publication (ISI), which was published in a journal with an impact index of 2.855. Its researchers produced 22 scientific works, which were presented at 19 congresses. During this period, the Center also supported the development of 1 Ph.D., 3 Master's and 7 undergraduate theses on issues related to its research lines.

⁶ The list of the Center's projects is available at: www.conicyt.cl/regional/categoría/estudios-y-documentos/.

Main indicators	2012	2013	2014	2012–2014 period
ISI Publications	0	0	1	1
Impact index	-	-	2.855	2.855
Non-ISI publications	0	2	1	3
Number of works presented at scientific congresses	1	12	9	22
Number of scientific congresses at which the Center presented works	1	10	8	19
Ph.D. and Master's theses underway with the support of the Center*	0	4	1	4
Undergraduate theses underway with the support of the Center*	0	7	6	7

* As theses last more than a year, they are counted in each year of their development.





CENTER FOR ADVANCED STUDIES IN FRUIT CULTURE **CEAF**

REGION OF LIBERTADOR GENERAL
BERNARDO O'HIGGINS

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REGIONAL CONTEXT¹

SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 4,645,386 (4.5% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (25.6%), manufacturing industry (13.2%), agricultural and forestry sector (12.0%) and construction (9.2%).
Business composition (2013)	There are 53,334 businesses in the region, which employ 347,918 dependent workers. The majority (68.4%) are microenterprises, which employ 10.7% of all workers. The agricultural and forestry sector concentrates 21.8% of all firms and 35.2% of all workers.
Exports (2013)	MMUS\$ 3,894 (5.1% of the national total). The agricultural, forestry and fishing sectors produce 35.6% of all regional exports, including 31.8% which correspond to fruit culture. The industry generates 34.1%, while the food industry, in particular, generates 24.8%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 9 universities in the region, which focus their activities on teaching (without conducting any research), all of which have their main campus in other regions. In 2014, there was only one graduate degree program (a Master's degree in the field of education). It is important to mention that, in mid-2015, there is a law being discussed to create a public university in the Region of O'Higgins.
Regional competitiveness index (ICORE) 2012	The region ranks 12 th in the country (index of 0.290). It ranks 14 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 31.8% (compared to 23.7% nationally). The technological innovation rate (27.2%) is higher than non-technological innovation (16.8%) and both are above the national rates (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 76 articles (0.1% of the national total). The annual number increased at an average rate of 2.5% during this period. The rate of international collaboration was 39.5% (compared to the national average of 52.4%). The normalized impact of regional production is 0.66, which falls to 0.12 in the case of production led by the region.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, 2011–2020* proposes a vision of the Region of O'Higgins as an agrifood power, sustainable and integrated with the world, in which the main capital is its people. In the economic-productive dimension, the strategy highlights the agrifood and forestry sectors, and establishes the goal of developing the region as an agrifood power, strengthening the conditions for achieving sustainability, supporting innovation and the use of new technologies, strengthening human capital and promoting stakeholders associativity.

The *Regional Innovation Strategy, 2012–2015*, meanwhile, establishes the goal of promoting entrepreneurial innovation, strengthening the capabilities and articulation of the regional innovation system, in order to promote a sustainable growth of regional competitiveness. It outlines a vision of the region as a leader in innovation for competitiveness in the agrifood, tourism and mining sectors. To achieve these goals, it establishes the mission of strengthening and articulating the regional innovation system, connecting the offer of R&D&I with the needs of businesses and strengthening human capital, among other aspects.

CENTER FOR ADVANCED STUDIES IN FRUIT CULTURE (CEAF)

CEAF was created in 2009 and established as a private non-profit corporation in 2014. Its founding partners are the Regional Government of O'Higgins, the Institute of Agricultural Research (INIA), Universidad de Chile and the Association of Producers and Exporters of the Region of O'Higgins (ASPROEX). In 2015, its interim director is Mauricio Ortiz.

CEAF's mission is to improve the competitiveness, profitability and sustainability of the regional and national fruit industry, through scientific and technological solutions that are the result of proprietary or joint research and development, creating world-class human capital in research, as well as scientific and technological products that add value to the industry. In the short term, the Center aspires to become a legitimate producer of science and technology, fulfilling its mission to promote the regional fruit culture industry.

GOALS

CEAF was created with the goal of establishing a Center for Advanced Studies in Fruit Culture in the Region of O'Higgins, with top-rate scientists able to interact with international research groups, developing scientific and technological products of use for the fruit culture industry, and helping to improve regional scientific and technological competitiveness. The Center aims to develop research aimed to yield solutions to the problems of local fruit growers, and to generate innovative methods and environmentally-friendly technological products which improve the productivity of fruit species that are key to the region. For this purpose, it conducts activities in four research lines: breeding, genomics, stress physiology, and agronomy.

RESEARCH LINES²

BREEDING

Goal: to establish basis for the development of clonal rootstocks for stone fruit.

Technical team: Felipe Gainza (Dr., line coordinator, CEAF). Researchers employed by CEAF: Verónica Guajardo (postdoctorate) and Ismael Opazo (M.Sc.). Researchers from the partner institutions: Carlos Muñoz (Ph.D., U. de Chile) and Gamalier Lemus (M.Sc., INIA). Research support (CEAF): Sergio Millaleo.

GENOMICS

Goal: to create molecular characterizations of different clonal rootstocks for stone fruit, in terms of their growth potential, by studying the genes related to their adaptation to extreme conditions of water and nutrients availability.

Technical team: Rubén Almada (Dr., line coordinator, CEAF). Researcher employed by CEAF: Ariel Salvatierra (postdoctorate). Researchers from the partner institutions: Patricio Hinrichsen (Ph.D., INIA) and Boris Sagredo (Ph.D., INIA). Research support (CEAF): Ixia Lienqueo (Bach.).

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.

STRESS PHYSIOLOGY

Goal: to study the critical physiological and biochemical parameters associated to tolerance to stress due to hypoxia and drought in *Prunus* rootstocks, which may help to characterize and select tolerant genotypes efficiently.

Technical team: Paula Pimentel (Dr., line coordinator, CEAF). Researcher employed by CEAF: Guillermo Toro (Dr.(c)). Researchers from the partner institutions: Claudio Pastenes (Ph.D., U. de Chile), María Teresa Pino (Ph.D., INIA) and Manuel Pinto (Dr., INIA). Research support (CEAF): Marcia Bravo.

AGRONOMY

Goal: to establish water relations in *Prunus* rootstocks in limited soil conditions, and to establish and optimize soil and vegetable waste management in the region.

Technical team: Mauricio Ortiz (Dr., line coordinator, CEAF). Researchers employed by CEAF: Michelle Morales (Dr. (c)) and José Neira (Dr.(c)). Researchers from the partner institutions: Edmundo Acevedo (Ph.D., U. de Chile), Alejandro Antúnez (Ph.D., INIA) and Gabriel Sellés (Dr., INIA). Research support (CEAF): Marcelo Rivera.

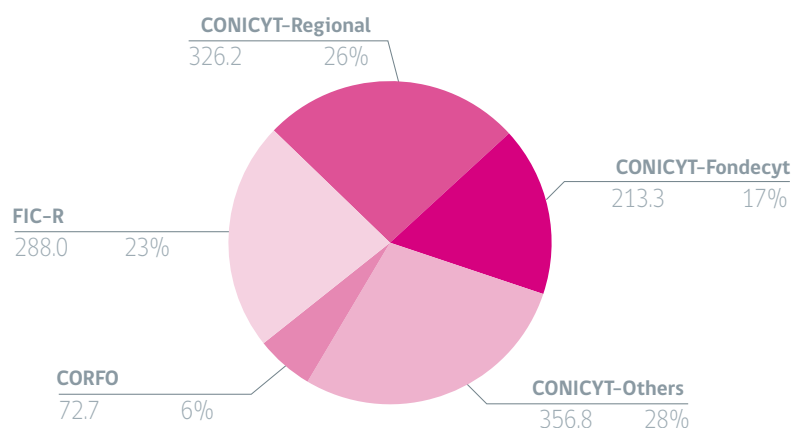
RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP	800.0
Core funding from Regional Government of O'Higgins	MMCLP	800.0
Resources awarded through projects from different sources	MMCLP	1,256.9

* CONICYT has committed core funding for the Center until 2019.

CEAF: resources awarded through projects from different sources, 2011–2014

(Millions of Chilean pesos and percentage distribution by funding source)



Source: CEAF and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS**FOCUS OF CEAF'S ACTIVITIES**

The Region of O'Higgins, with 25,684 hectares of peach, nectarine, plum and cherry orchards, concentrates almost 50% of the national planted surface of these species, and fruit culture generates almost one-third of the value of its exports. In this context, CEAF works to support the development of regional fruit industry

and provide solutions to the main problems that limit their expansion.

To pursue this goal, CEAF implemented, as a fundamental component of its work, a Breeding Program (PMG) of rootstocks for fruit of the genus *Prunus* (plum, peach, almond, apricot, cherry), seeking to select materials with compatible characteristics and an agricultural performance superior to rootstocks

³ In current Chilean pesos of each year.

currently on the market. The program also aims to favor the characteristics of low vigor, resistance and/or tolerance to abiotic stress factors (drought, salinity and radical asphyxia or hypoxia) and multiple resistances to the main plagues and diseases in the soil, in order to overcome the various factors that limit the development of these species in the region.

For this purpose, it has implemented the strategy of creating interspecific clonal hybrids –that is, a search for crosses between different species of the genus *Prunus*– to overcome barriers of resistance to diverse biotic and abiotic stresses.

Work in the other research lines has been designed to support the PMG. The genomics, physiology and agronomy lines are attempting to develop tools and techniques to facilitate the assessment of progenies

created by the PMG, in order to accelerate the material selection process. This is expected to produce rootstocks well-adapted to the soil and climate conditions in which *Prunus* orchards are planted in the region, as well as the conditions of zones towards which these crops may expand, in search of new productive fields or due to displacement caused by climate change.

The lines also develop studies that seek to expand current knowledge of genomics, physiology, water relations and soil physics, in order to understand the adaptation mechanisms of roots in the presence of stresses, including the implementation of the line for interactions between roots and microorganisms in the soil, as well as a phenotyping system that uses biological knowledge of rootstocks in stone fruit and their interaction with the edaphic medium and the aerial section of the plant.

RELATIONSHIP WITH REGIONAL POLICIES

CEAF's work is clearly aligned with the strategic development and innovation guidelines of the Region of O'Higgins. Its main strengths in the implementation of these proposals are its interest in providing solutions that help strengthen the competitiveness of the regional fruit culture industry; its high-level human capabilities and the strengthening of new specialized skills within the region; its cutting-edge scientific infrastructure and equipment; its relationship with specialized scientific centers (particularly abroad); and its joint work with the productive sector that will use the results of its work.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

The implementation of CEAF has significantly strengthened specialized human capabilities, in a region which does not have research universities. The 24 specialists currently working at the Center include 15 researchers with a Ph.D., including 3 line coordinators who moved to the region and work exclusively at the Center, and 5 researchers with a Master's degree⁴. This work is supported by a management team of 8 people.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	6	9	15
Researchers with a Master's degree	4	1	5
Professionals and technicians who support research	4	0	4
Total	14	10	24

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.



From the 24 specialists, 6 work in the breeding line (including 4 employed by the Center), 5 in the genomics line (3 employed by the Center), 6 in the stress physiology line (3 employed by the Center) and 7 in the agronomy line (4 employed by the Center). They are joined by undergraduate and Master's thesis students, several of whom have returned from studying in other regions to develop their theses here—which is now possible thanks to the presence of CEAf.

The installation of CEAf has also led to the development of research infrastructure in the Region of O'Higgins: its building in the Los Choapiños sector (Rengo) has more than 1,000 m² of laboratories and offices, with cutting-edge technology and an investment of 542 million Chilean pesos, as well as the implementation of an experimental field. The Center has top-rate scientific equipment in the molecular, physiological and agronomical fields, with an investment of 350 million Chilean pesos, and genomics equipment that is unique at the local level. It has implemented a microbiology and gas chromatography laboratory, and also has physiological research equipment.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

To achieve its scientific and technological goals, CEAf has established working relationships with different specialized entities. One of the most significant of these is the agreement with the Center for Advanced Scientific Research (CSIC) and Agromillora Research, in Spain, for the transfer of genetic material. Through this agreement, both CEAf and these two entities currently possess materials (progenies) from 7- to 8-year-old selection programs in that country, with characteristics that may adapt favorably to Chilean conditions.

The Center has also established ties with the National Institute for Agricultural Research (INRA) and the Sophia Agrobiotech Institute, in France; the universities of Wageningen (Netherlands), Jaume I de Castellón (Spain) and Clemson (South Carolina, USA); and with the National Clonal Germplasm Repository of the U.S. Department of Agriculture (Corvallis, Oregon, USA). Within the country,

it has agreements with Labser laboratories and the Center for Studies in Processed Foods (CEAP).

Relationship with local organizations, industry-related and government agencies

The regional productive sector participates in the Center through one of its partners, the Association of Producers and Exporters of the Region of O'Higgins, which has 56 total members, including regional production and export businesses. This organization has helped bring pertinence to CEAf's research lines, and will play a fundamental role when the material is taken to the field and starts being assessed in different locations during 2015.

RESULTS AND IMPACTS IN THE REGION

CEAf works to develop and provide producers with new alternatives in rootstocks for genus *Prunus*, capable of responding to the requirements of modern agriculture, adapting to the soil and climate conditions of the region and other latitudes (as well as conditions related to climate change). This work has a long-term horizon and seeks to create materials for use in Chile, but which can also be made available in the rest of the world.

The scientific strategy adopted consists of creating interspecific clonal hybrids, which are obtained by crossing different *Prunus* species. During these first five years, the focus has been on creating the materials (progenies), in order to select those that will be appropriate for commercial use within the span of a decade. Using CEAf's infrastructure and equipment, these timeframes may be reduced by developing early selection tools.

The goal is to create rootstock materials capable of adapting to different edaphoclimatic conditions and latitudes, so that they will not be for exclusive use within this region or country, but may also be





CEAF's pollen bank has helped expand the availability of germplasm for the Genetic Breeding Program of *Prunus* rootstocks, ensuring access to materials of diverse origins with variability for producing the desired characteristics.

offered abroad. Thus, the Center works with different characteristics, particularly resistance to hypoxia (radical asphyxia), a local condition of the region, and resistance to salinity and drought, conditions associated to climate change and desertification, which will require moving the orchards further south. Another goal is the structure that the rootstocks will generate: the goal is to produce smaller trees (dwarfism), which would help create pedestrian orchards where all fruit may be harvested by hand, thus reducing harvesting and labor costs.

It also seeks to produce rootstocks that are compatible with a wide range of local varieties with high commercial value. The rootstock PMG may last for 15 to 30 years. North American and European programs, which developed the materials that is being used today throughout the world, began 30 years ago and are no longer operative. This represents an advantage for CEAF's program, which is working with a 30-year horizon on an issue not being addressed elsewhere.

One relevant factor of this program has been its cooperation agreements with foreign entities (CSIC and

Agromillora), through which CEAF now owns materials discarded by the Spanish selection program, but which possess genetic and behavioral characteristics that are potentially capable of adapting well to Chilean conditions. A selection process is currently underway within the country, taking advantage of this background of several years of selection, so that in 5 to 7 years commercial scaling may begin.

In the current stage, the materials are ready to initiate field tests, through a network of evaluators to be determined with the support of ASPROEX, both within the region and in the VII, VIII, IX and X regions, as well as in the northern region of the country, where there are also *Prunus* orchards.

The PMG already has an arboretum with 36 rootstock genotypes, and this figure is expected to grow to 50, which would be a great achievement considering how difficult it is to comply with phytosanitary regulations for the internment of materials. *In vitro* materials subject to lower entry requirements have also been brought in, and instead of tree collections, pollen is also brought in. The Center has started a pollen bank,





Through the characterization of the physiological study of *Prunus* rootstock responses to stress caused by oxygen deficiency in the radical zone, the Center seeks to offer recommendations for different soil types present in the region.

which currently includes 85 different pollens, which give access to materials that would otherwise be impossible to obtain (from China, the United States and the Russian Federation). There are very few pollen banks worldwide, and a multi-specific bank such as CEAF's is truly pioneering. The Center's enormous collection of *Prunus* offers the possibility of conducting biological studies in pollen development, more detailed sexual compatibility studies (both molecular and physiological), and establishing a scientific development line.

The Center has also created a rhizotron with 180 pots to study roots. In another field, it implemented an edaphoclimatic data system for regional agricultural producers, which can be accessed free of cost through

the www.ceaf.cl/services/website.

For specific works in the different research lines, a set of molecular markers (microsatellites) was created to identify different varieties. This made it possible to identify a fundamental parameter for the PMG -the genetic identity of available rootstocks- and may be the foundation for a service provided to farmers and nursery operators.

Progress is also being made in the study of stress tolerance mechanisms for hypoxia and drought, and in the measurement of physiological parameters that may be useful for selection. Six varieties of cherry rootstocks are also being tested under specific low-



air conditions in the soil, and this may help provide recommendations for compact soils, soils with fine textures, and other types of soil present in the region.

Another field in which work is being done is the valuation of pruning waste management. The influence of mulch decomposition on the chemical properties of soils is being investigated. This is a common practice in the region, but there is no data on its valuation, and therefore these results may help inform producers of the advantages to certain types of management of this material. Since this management includes carbon, the study of carbon capture is being planned in order to discover indicators that may help promote the use of fruit in this condition.

Between 2011 and 2014, CEAF carried out a total of 13 projects, including the first Fondecyt projects awarded to the region⁵. During this period, the Center's researchers published a total of 13 ISI articles in journals with an average impact index of 2.403. They also presented 82 works at a total of 30 scientific congresses. In the context of the Center's work, 8 Ph.D. theses, 2 Master's theses and 10 undergraduate theses were also developed.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI Publications	0	7	5	1	13
Impact index	-	2.246	2.436	3.334	2.403
Non-ISI publications	1	1	0	1	3
Number of works presented at scientific congresses	12	31	22	17	82
Number of scientific congresses at which the Center presented works	5	8	6	11	30
Ph.D. and Master's theses underway with the support of the Center*	7	6	6	6	10
Undergraduate theses underway with the support of the Center*	0	1	4	8	10

* As theses last more than a year, they are counted in each year of their development.

⁵ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.



CENTER FOR STUDIES IN PROCESSED FOODS CEAP

REGION OF MAULE

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REGIONAL CONTEXT ¹

SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 3,502,197 (3.4% of the national total).
Main sectors by contribution to regional GDP (2012)	Manufacturing industry (16%), electricity, gas and water (15.9%), personal services (12.5%), agricultural and forestry sector (12.2%).
Business composition (2013)	There are 68,307 businesses in the region, which employ 345,637 dependent workers. 69.4% of these are microenterprises, which employ 9.7% of all workers. The agriculture, cattle and forestry sectors represent 26.6% of all firms and employ 29.7% of dependent workers.
Exports (2013)	MMUS\$ 2,270 (3.0% of the national total). Fruit culture generates 29.2% of the value of regional exports, while the food industry represents 19.8%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 9 universities in the region, including Universidad de Talca and Universidad Católica del Maule. In 2014, available graduate degrees in the region included 9 Ph.D. programs and 49 Master's programs, concentrated mainly in the fields of education (18 programs), social sciences, business and law (16) and sciences (9).
Regional competitiveness index (ICORE) 2012	The region ranks 13 th in the country (index of 0.290). It is ranked 10 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 25.6% (compared to the national rate of 23.7%). In terms of technological innovation, the regional rate (24.8%) is above the national average (18.8%), while its non-technological innovation rate (14.9%) is somewhat below the national rate (16.4%).
Articles published in indexed scientific journals (2003-2012)	A total of 1,733 articles (2.7% of the national total). During this period, the annual number of publications increased at an average rate of 7.2%. The rate of international collaboration was 44.0% (compared to the national average of 52.4%). The normalized impact of production is 0.63, which falls to 0.54 in the case of production led by the region.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy for Maule, 2020* proposes a desired image of Maule as a region which, among other characteristics, seeks to help Chile become a major food and forestry player based on knowledge, innovation and entrepreneurship, as a result of a constant articulation of public-private actors.

Considering the different elements that define development, the strategy proposes a series of 12 strategic goals, including positioning itself as a region with great economic and productive competitiveness, through its transformation into a major food and forestry player within Chile and in the world, a region of services and a region for special interest tourism. In the economic dimension, it highlights the fruit and vegetable growing, winemaking and cattle industries as its main activities.

CENTER FOR STUDIES IN PROCESSED FOODS

CEAP was created in 2009 and established as a private non-profit corporation in 2013. Its founding partners are the Institute of Agricultural Research (INIA), Universidad de Talca (U. Talca), Universidad Católica del Maule (UCM) and the agroindustrial corporations Surfrut Ltda. and Sugal Chile. Its executive director is Ricardo Díaz (M.Sc.).

The Center's proposed mission is to add value to the products and processes of the fruit and vegetable agroindustry of the Region of Maule, through R&D&I (research, development and innovation), in order to increase its national and international competitiveness. Its vision is to become a research and development center for applications that add value to businesses related with the processing of regional agroindustrial products.

GOALS

CEAP works with the strategic goals of creating new agroindustrial products at the final consumer level; optimizing agroindustrial processes in the region's main fruit and vegetable areas; increasing the environmental sustainability of regional agroindustries; creating a national and international network, in order to transform the Center into a national and international reference point in R&D&I; providing the Center and the region with highly specialized researchers by attracting and/or training new researchers, and developing technologies, products, processes and services, to be applied in the fruit and vegetable processed food industry, with the potential to create technological businesses capable of producing an impact within the region.

For this purpose, it develops three research lines, organized under the New Product Development Program, the Process Improvement Program, and the Waste Sustainable Management and Valuation Program.

RESEARCH LINES ²

NEW PRODUCT DEVELOPMENT PROGRAM

Goal: to support the fruit and vegetable agroindustry of the Region of Maule in the development of new and improved products that may increase its competitiveness, focusing its efforts in three main fields: improving the quality and quantity of fruits and vegetables used in agroindustrial processing; creating new products and/or ingredients that may be developed by this industry; and product differentiation through distinctive characteristics, new processing technologies and physical presentation and packaging.

Technical team: Aníbal Concha (Ph.D., line coordinator, CEAP). Researcher employed by CEAP: Susana Arredondo (M.Sc.). Researchers from the partner institutions: Marcelo Alarcón (Ph.D., U. Talca), Rodrigo Giacamán (Ph.D., U. Talca), Margarita Gutiérrez (Ph.D., U. Talca), Rodrigo Moore (Ph.D., U. Talca), Marco Mora (Ph.D., UCM), Iván Palomo (Ph.D., U. Talca), Iris Pereira (Ph.D., U. Talca), Marisol Reyes (Ph.D., INIA), Guillermo Saud (Ph.D., UCM), Guillermo Schmeda (Ph.D., U. Talca), Carolina Torres (Ph.D., U. Talca), José Antonio Yuri (Ph.D., U. Talca), Cristián Adasme (Ph.D.(c), UCM) and Elba Leiva (M.Sc., U. Talca). Research support (CEAP): Rosío Rodríguez (Bach.) and Bárbara Sáez (Bach.).

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.

PROCESS IMPROVEMENT PROGRAM

Goal: to support the fruit and vegetable agroindustry of the Region of Maule by providing technological solutions for the improvement of its processes, focusing its efforts on the creation of the scientific and technological knowledge required to develop new processing technologies and the optimization and management of agroindustrial processes.

Technical team: Carlos Zambra (Ph.D., line coordinator, CEAP). Researcher employed by CEAP: Francisco Javier Pérez (M.Sc.). Researchers from the partner institutions: Marcela González (Ph.D., U. Talca) and Alfredo Iriarte (Ph.D., U. Talca).

WASTE SUSTAINABLE MANAGEMENT AND VALUATION PROGRAM

Goal: to support the qualitative and quantitative improvement of the environmental sustainability of the fruit and vegetable agroindustry of the Region of Maule, focusing its efforts on innovative technologies used to manage solid waste and muds, and the treatment and sustainable management of liquid waste, thus reducing management costs and complying with all pertinent regulations, and the valuation of waste produced by this industry through the creation of new subproducts (animal feed, energy sources, among others) or the search for functional properties in waste products.

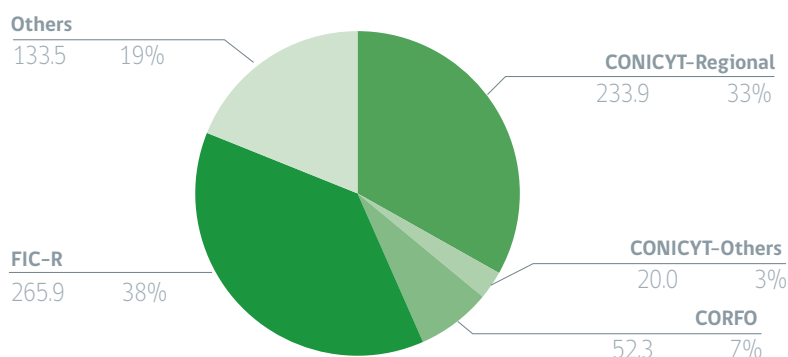
Technical team: Oscar Candia (Ph.D., line coordinator, CEAP). Researchers employed by CEAP: Cecilia Cordero (M.Sc.) and Javiera Ledermann (Bach.). Researchers from the partner institutions: Fernando Cataldo (Ph.D., UCM), Felipe Gordillo (Ph.D., UCM), Juan Guevara (Ph.D., UCM), Roberto Jara (Ph.D., U. Talca), Jorge Villaseñor (Ph.D., U. Talca), Eduardo von Bennewitz (Ph.D., UCM), Diógenes Hernández (M.Sc., U. Talca) and Nelson Loyola (M.Sc., UCM).

RESOURCES OF THE CENTER DURING THE 2011-2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP 740.0
Core funding from Regional Government of Maule	MMCLP 751.2
Resources awarded through projects from different sources	MMCLP 705.6

* CONICYT has committed core funding for the Center until 2019.

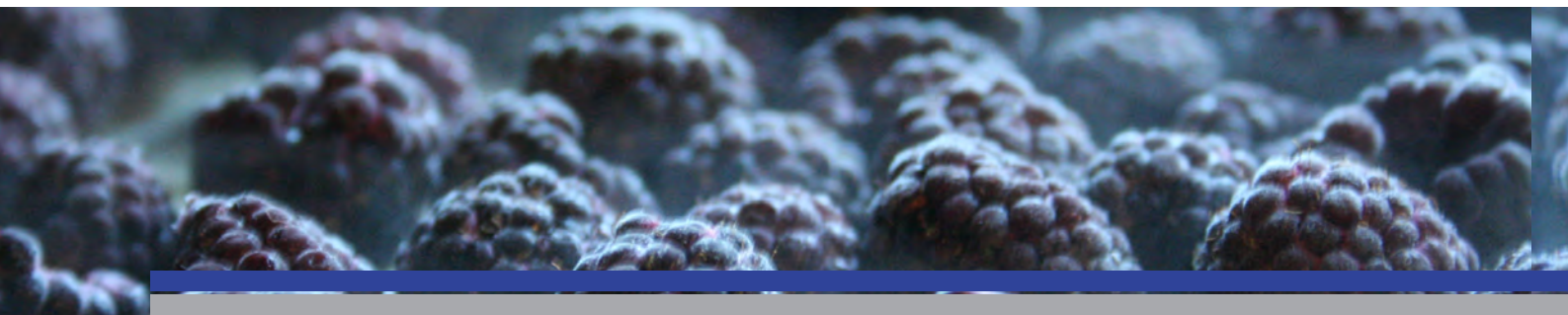
CEAP: resources awarded through projects from different sources, 2011-2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CEAP and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

³ In current Chilean pesos of each year.



PROGRESS, RESULTS AND IMPACTS

FOCUS OF CEAP'S ACTIVITIES

CEAP's activities and programs are focused on developing solutions and alternatives that may lead to new products, new and improved technologies, and more sustainable production processes, in support of the competitiveness of the regional agroindustry, dealing with the main limiting factors that restrict it and offering new solutions for its diversification and growth.

The Center's New Product Development Program conducts research and development mainly on waste products from agroindustrial processes, evaluating its properties and its contribution to the health of consumers and conditioning these products to become components of food. Another line of work in this program is the search for interesting compounds which may have functional properties (that is, which may provide health benefits and reduce the risk of suffering diseases), in order to evaluate their use as alternatives for industrial production. For this purpose, CEAP works in the field of food, the assessment and improvement of technologies which may be used to develop new products, a better incorporation of functional compounds, and technologies for dealing with microbiological risks; in the agricultural field, it investigates subproducts to develop compounds that may be used agriculturally to obtain quality raw materials, and studies field practices that may impact the ability to obtain better agroindustrial products and increase industrial performance; and in the field of functionality, it researches different properties which produce health benefits.

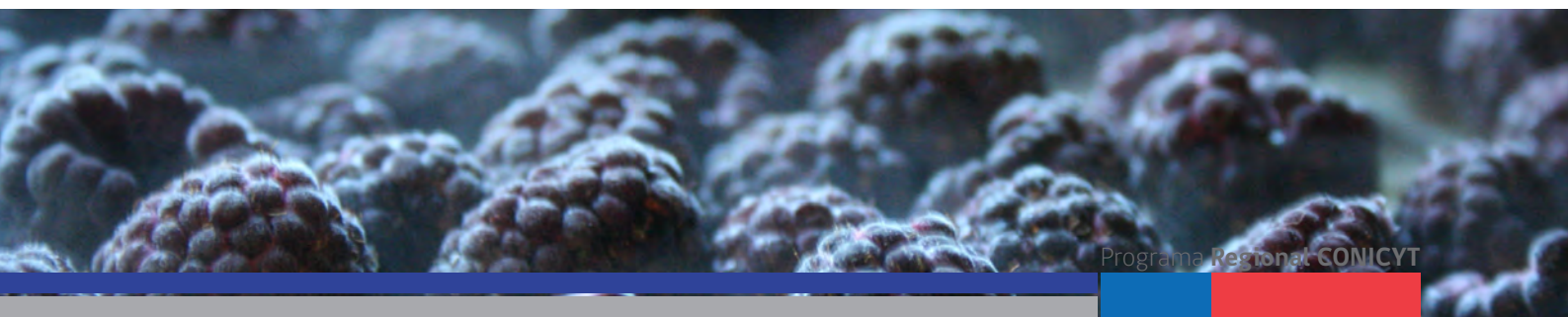
In the Process Improvement Program, CEAP researchers also work in three fields. In the field of membrane separation, they seek to improve the processing technologies used to produce juices, oils and extracts, as well as to recover the organic compounds produced by certain types of waste. In computer mechanics, they create mathematical and engineering applications for drying, dehydrating, and extracting compounds added to food. In the field of operations management and logistics, they apply mathematical models for the optimization of management, a field absent from many



The functional properties identified by CEAP in pomace (a waste product of industrial tomato processing) will help develop high-quality food ingredients and increase the competitiveness of this agroindustry, which is very relevant to this region.

regional industries and which very few national food sector researchers are working on.

In the Waste Sustainable Management and Valuation Program, the Center focuses on developing alternatives for animal feed using waste, mainly in the regional agroindustry, a field which aims to impact the activity of small and medium farmers in the dry coastal region, who face food scarcity during some periods of the year. Another essential field is the design of low-cost liquid agroindustrial waste treatment systems, which seek to reduce costs for regional agroindustry.



RELATIONSHIP WITH REGIONAL POLICIES

CEAP's work is clearly aligned with the regional development strategy guidelines, since it aims to promote the growth of Maule's agrifood industry, fostering innovations that range from primary production processes and industrial fruit and vegetable processing, to the organization and management of processes, with a strong emphasis on sustainability as a general factor. For this purpose, the Center is developing new products and technologies that should bring wide benefits for the whole regional agroindustry and, indirectly, for related primary products. Thus, it is also contributing to the goal of helping Chile become a major agricultural player, from a region in which agroindustry generates 28.5% of Chilean processed fruit exports and 45.5% of processed vegetable exports (ODEPA figures for 2014).

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CEAP's research team consists of 33 professionals, with 9 researchers employed by the Center (including 3 with a Ph.D.) and 24 researchers from partner institutions (including 21 with a Ph.D.)⁴.

From the 33 specialists, 18 researchers and professionals work in the New Product Development Program (4 employed by the Center), 4 in the Process Improvement Program (2 employed by the Center) and 11 in the Sustainability Program (3 employed by the Center). They are joined by a management team of 7 people.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	3	21	24
Researchers with a Master's degree	4	3	7
Professionals and technicians who support research	2	0	2
Total	9	24	33

The Center's main office is located in the city of Talca and different research lines have facilities in distinct spaces that belong to its partner institutions: the Curicó campus (Los Niches), the Talca campus and Universidad de Talca's Pomaceas Center; the main campus (Talca) and the San Isidro campus (Curicó) of Universidad Católica del Maule, and the Villa Alegre campus of INIA.

Universidad de Talca has also provided the Center with another space, which since late 2015 will house a pilot fruit and vegetable processing plant (120 m²), an experimental kitchen (30 m²), a sensory assessment hall with six cabins (20 m²), laboratories for the product development and sustainability programs (120 m²), a

laboratory for the process improvement program (25 m²), cold and refrigeration chambers (25m²) and offices, among others.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS Networks for scientific collaboration

Through its different programs, CEAP does collaborative work with different specialized entities in Chile and abroad. Internationally, it has worked in the software optimization field with Brazilian corporation Gapso, with which it studied the gaps between regional businesses in different sectors; with Spain's National Center for Food Technology and Safety (CNTA), which supported the identification of requirements associated to the new facilities to be implemented by CEAP; and with the Food Innovation Center at Oregon State University (USA), through an internship in the field of new product development. It has also developed an exchange of experiences through visits between researchers from these centers and CEAP, a relationship which has led to the implementation and execution of joint projects.

The Center also has an agreement with the Spanish corporation Vivendio, which works on energy efficiency,



⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.



Using waste export fruit, a healthy snack alternative was developed, with the characteristics of a functional food and a high antioxidant potential.

a collaboration which has produced ten diagnoses of energy efficiency in regional agroindustrial businesses and the joint organization of workshops designed for this sector.

At the national level, it has worked with Universidad de Talca's Pomaceas Center and Universidad de Santiago de Chile in the area of membranes, and with Universidad de La Serena on computer simulations. This collaboration has allowed them to jointly design and execute projects, produce scientific articles, develop business transfer activities, and facilitate spaces and equipments, among other activities.

With INRIA Chile, a foundation created in Chile by the French public entity INRIA (National Institute for Research on Computers and Automatization), CEAP has a collaboration agreement which seeks to study anaerobic digestion for biogas and to identify the most appropriate waste for this purpose; in particular, they are studying waste produced in the extraction of olive oil (*alperujo*) and joint research projects have been presented.

Relationship with local organizations, industry-related and government agencies

During the first stage of its work, CEAP has collaborated with 20% of the agroindustrial businesses in the Region of Maule on some type of research, development and innovation activity. This collaboration has helped establish an ecosystem for innovation and entrepreneurship, the creation of semi-commercial prototypes, and the development of technological solutions, with over 800 people participating in different promotion and training activities.

RESULTS AND IMPACTS IN THE REGION

To add value to agroindustry in the Region of Maule, developing its potential and offering solutions for its technological requirements, CEAP is creating new products and new technological alternatives and options to strengthen process sustainability, through initiatives that favor the competitiveness of agroindustry as a whole, as well as prominent sectors such as tomato, berry and olive oil processing, among others.

In the field of new products, CEAP's team has developed a healthy snack alternative, with the characteristics of a functional food and a high antioxidant potential, produced 100% with waste from export fruits. This product, which is patent pending, will not only help improve the competitiveness of regional fruit producers, but also represents a benefit for the Chilean population, which has a high obesity rate.

Research on pomace (a waste product of industrial tomato processing) has helped identify functional properties (which are antithrombotic and protective of endothelium⁵). This achievement, which has also led to a series of scientific publications, helped apply for a patent for the production of this extract and its functionality. This research, pioneering at the international level, led by researchers of the New Product Development Program, will help develop high-value food ingredients from agroindustrial waste produced in the Region of Maule, clearly in line with CEAP's strategic goals of increasing agroindustrial sustainability (by reducing waste), creating new products and creating technological businesses associated to intellectual property. At the same time, it helps improve the valuation of these waste products, which directly benefit 100% of regional tomato processing businesses and over 500 farmers indirectly, a sector which represents 62% of all national exports of this product.

In another achievement in the valuation of agroindustrial waste, the Center's researchers have developed a pilot program for a food supplement given to caprine and bovine cattle, an advance which could potentially benefit thousands of small farmers in dry zones, as well as significantly improving the sustainability of all regional businesses that process olive oil and apple pulp, which produce this type of waste.

⁵ Tissue that covers the internal walls of some organic cavities.

In another field, the Center has developed a pilot computer application, designed to provide a solution for the need to modernize and optimize stocking and processing operations in the frozen berry industry at the Maule region. This advance will benefit the entire regional industry, whose exports represent 47% of the national total, directly impacting over 40 small and medium regional businesses and indirectly affecting over 10,000 farmers, who concentrate almost 40% of the national planted surface of these species. This achievement has also led to new challenges, in terms of traceability, online invoicing, and electronic data capture, among others, which CEAP continues to work on.

In terms of sustainability, a project is being developed to establish an associative waste management platform for the region's entire agroindustrial sector, with the goal of reducing the existing information gap between "waste suppliers," that is, agroindustry, and potential "waste demanders," which has thus far limited the creation of businesses linked to the valuation of these materials in the region.

CEAP has promoted the sustainability of regional agroindustry as a fundamental pillar of its work, creating high levels of synergy between its different research lines, which is evident in most of the initiatives that the Center is developing. The use of agroindustrial waste as a source of new high-value compounds that help create new products and require new and more efficient processing technologies, reflects the coherence of these research programs, in terms of environmental sustainability and the promotion of a more competitive regional agroindustry.

Between 2011 and 2014, CEAP developed a series of 15 projects⁶. The Center's researchers published a total of 31 ISI articles, in journals with an average impact index of 2.525. They also produced 37 works, which were presented at 30 scientific congresses. During this same period, the Center's activities led to 3 patent requests. Finally, CEAP supported the development of 3 Ph.D. theses, 2 Master's theses and 16 undergraduate theses related to its research lines.

⁶ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.



Main indicators	2011	2012	2013	2014	2011-2014 period
ISI Publications	0	4	11	16	31
Impact index	-	1.668	2.341	2.866	2.525
Non-ISI publications	0	0	2	1	3
Number of works presented at scientific congresses	4	17	11	5	37
Number of scientific congresses at which the Center presented works	2	15	8	5	30
National and international patents requested and/or granted	0	0	0	3	3
Ph.D. and Master's theses underway with the support of the Center*	1	2	3	4	5
Undergraduate theses underway with the support of the Center*	0	6	7	8	16

* As theses last more than a year, they are counted in each year of their development.



REGIONAL CONTEXT ¹

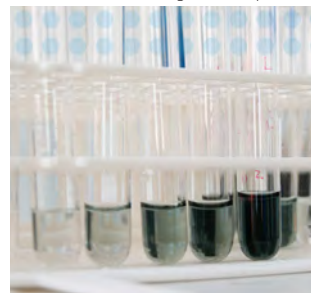
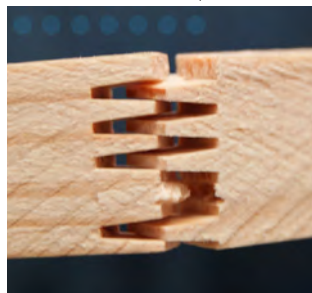
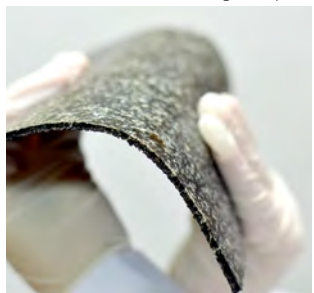
SOCIOECONOMIC PROFILE OF REGION

Regional GDP (2013)	MMCLP 7,892,234 (7.6% of the national total).
Main sectors by contribution to regional GDP (2012)	Manufacturing industry (24.1%), electricity, gas and water (13.3%), personal services (13.2%), construction (8.8%) and trade, restaurants and hotels (8.4%).
Business composition (2013)	There are 104,270 businesses in the region, which employ 579,749 dependent workers. 69% of these are microenterprises, which employ 8.4% of all workers. Manufacturing concentrates 10.1% of businesses and 14.2% of workers, while the agricultural and forestry sector concentrates 11.6% of businesses and 13.0% of workers.
Exports (2013)	MMUSD 5,226 (6.8% of the national total). Manufacturing generates 95.4% of the value of regional exports, including 39.3% from the wood pulp, paper and cardboard industry, 35.7% from the primary forestry industry, and 12% from the food industry.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 17 universities in the region, including Universidad de Concepción, Universidad del BíoBío, and Universidad Católica de la Santísima Concepción. In 2014, graduate degrees available in the region included 36 Ph.D. and 169 Master's programs, mainly in the fields of social sciences, business and law (43 programs), education (36), sciences (35) and engineering, manufacturing and construction (32).
Regional competitiveness index (ICORE) 2012	The region ranks 10 th in the country (index of 0.328). It ranks 6 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 15.8% (compared to a national rate of 23.7%). Both the technological (11.5%) and the non-technological (10.7%) innovation rates are below the national averages (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 7,887 articles (12.4% of the national total). During this period, the annual number of articles increased at a rate of 2.6%. The rate of international collaboration was 52.7% (compared to a national average of 52.4%). The normalized impact of regional production is 0.82, which falls to 0.61 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Biobío 2008-2015* proposes an image of Biobío as a region that is, among other characteristics, economically dynamic, equitable and sustainable. The seven strategic guidelines for regional development include: economic growth, diversification and improvement of regional competitiveness, generating quality jobs that promote development and social equity; and science, technology and innovation for a dynamic and competitive regional economy, for social development and for the prevention and mitigation of natural and anthropic risks.

The *Regional Innovation Strategy, Region of Biobío*, meanwhile, is based on a vision of the Biobío as an intelligent region that develops sustainable, innovation-based businesses. The gaps detected are used to define five pillars that the strategy is based on, associating each one to the result it seeks to accomplish: human capital: to transform human capital into a competitive advantage for the region; associativity and cooperation: to increase cooperation to enhance innovation; interconnection and technological transfer: to transfer science and technology to the market; information and dissemination: to create a more innovative society; and support for innovation: to develop new R&D&I activities.

RESEARCH CENTER FOR ADVANCED POLYMERS (CIPA)

CIPA was created in 2003 and established as a private non-profit corporation in 2009. Its founding partners are Universidad del Biobío (UBB), Universidad de Concepción (UdeC) and CONICYT. Its executive director is Claudio Toro.

The Center's mission is to contribute to the development and competitiveness of the Biobío Region and the country, through the generation and transfer of cutting-edge scientific and technological knowledge in the field of polymers². In this framework, it aims to become recognized as a technological center for R&D&I that is capable of contributing to regional and national development.

GOALS

CIPA seeks to contribute to the technological, economic and social development of the Region of Biobío, through the formation of human capital, the development and transfer of technology and the provision of differentiated R&D&I services that are aligned with the needs of diverse productive sectors related to synthetic and natural polymers. For this purpose, it conducts activities through their management and relationships, interconnection and technological transfer, and research areas.

In the area of research, the goal is to develop technologies that help create solutions that may be implemented at the industrial level. The work focuses on obtaining new polymer formulas with properties that have been improved by mixing or adding synthetic polymers, developing biopolymers and/or adding ingredients capable of developing specific functions in different materials, natural and engineered fibers, nanoparticles, inorganic molecules and beneficial microorganisms. This activity is organized into three lines: the development of polymers with agroindustrial and medical applications, the procurement of polymers for removing contaminant species, and the technological valuation of waste.



² Polymers are materials, of natural or synthetic origin, formed by large molecules that are constituted by the repetition of a molecular unit called a monomer.

RESEARCH LINES³

DEVELOPMENT OF POLYMERS WITH AGROINDUSTRIAL AND MEDICAL APPLICATIONS

Goal: this line works on the development of new packages and packaging, mainly using biopolymers to strengthen the competitiveness of the regional agrifood industry in foreign markets; new polymer materials are developed for the agricultural sector that may have a positive impact on local production (especially bioplastics for covering surfaces and the application of natural polymers with plant extracts for plague control and productive improvement); and they provide technological solutions for medical applications, based on natural polymers and plant extracts, to strengthen the production of local products comparable to those which exist on the market in terms of effectiveness.

Technical team: Claudio Toro (Dr., line coordinator, CIPA). Researchers employed by CIPA: Claudio Pozo (Dr.), Saddys Rodríguez (Dr.) and Cristian Gutiérrez (Dr.(c)). Researchers from partner institutions: Mónica Pérez (Dr., UdeC) and Carlos von Plessing (Dr., UdeC). Research support (CIPA): Francisca Saavedra (Bach.).

PROCUREMENT OF POLYMERS FOR THE REMOVAL OF CONTAMINANT SPECIES

Goal: this line works to obtain polymers capable of retaining metallic ions and organic matter from waste water from fishing and forestry activities, and from the metal and oil refining industry, helping to reduce the regulatory risks of regional businesses.

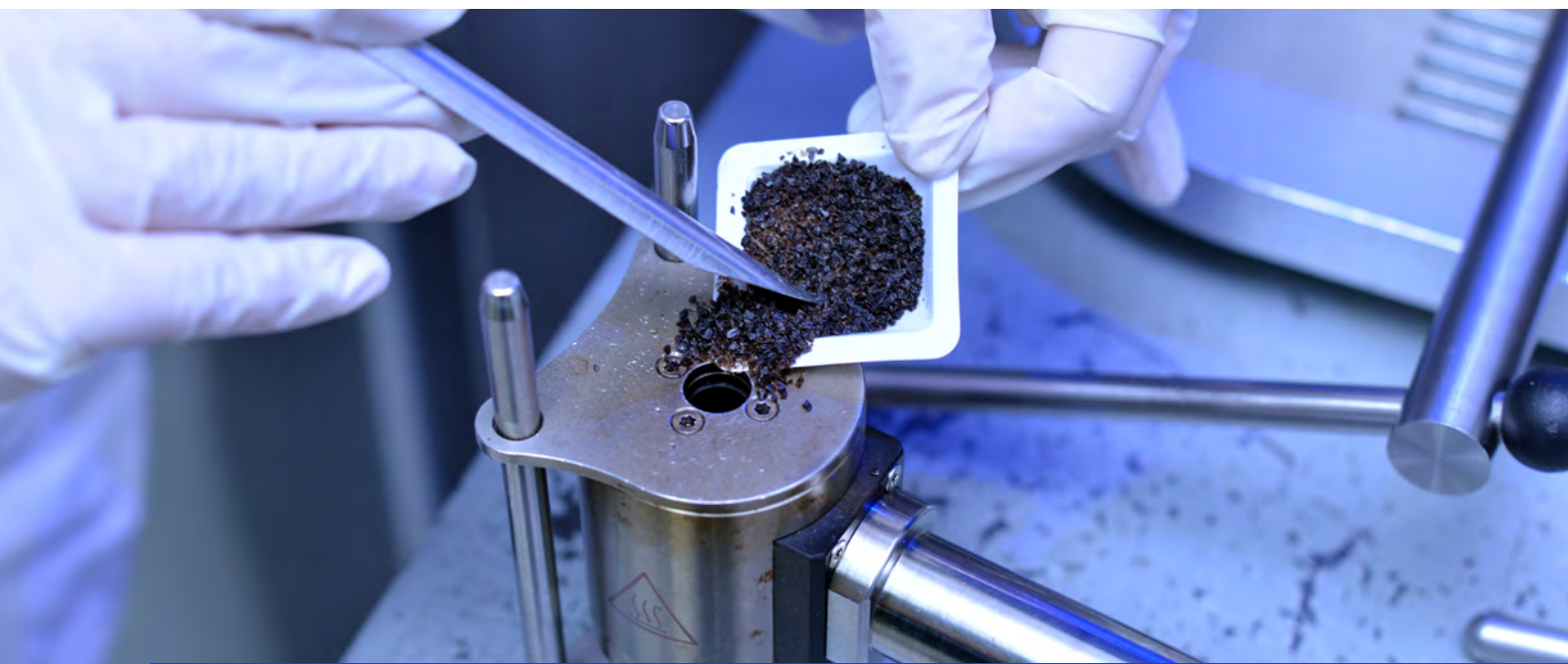
Technical team: Claudio Toro (Dr., line coordinator, CIPA). Researchers employed by CIPA: Elizabeth Elgueta (Dr.). Researchers from the partner institutions: Eduardo Pereira (Dr., UdeC), Julio Sánchez (Dr., UdeC) and Bruno Urbano (Dr., UdeC). Research support (CIPA): Lorena Leiton (Bach.).

TECHNOLOGICAL VALUATION OF WASTE

Goal: work in this line is designed to add value to agricultural and forestry activities, diversifying the matrix of available products, through the valuation of waste and the development of new materials with applications in construction and agroindustry; as well as adding value to high-volume polymer waste from the goods and services industries (materials based on polyethylene, polypropylene, Tetrapack, PET and used tires (NFU), among others), to improve the quality of life of the population.

Technical team: Claudio Toro (Dr., line coordinator, CIPA). Researchers employed by CIPA: Rodrigo Briones (Dr.) and Varaprasad Kokarachedu (Dr.). Researchers from partner institutions: Alex Berg (Dr., UdeC), Paulo Flores (Dr., UdeC), Justo Lisperguer (Dr., UBB), José Norambuena (Dr., UBB), Mario Solís (Dr., UBB), Alonso Rebolledo (M.Sc., UBB) and Emilio Vergara (Bach., UBB). Research support (CIPA): Miguel Araya (Bach.) and Cristina Donoso (Bach.).

³ Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.

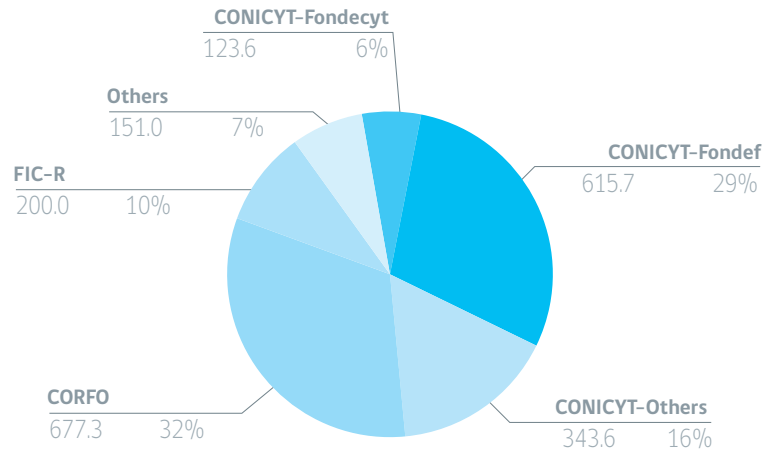


RESOURCES OF THE CENTER DURING THE 2011-2014 PERIOD ⁴

Core funding from CONICYT Regional Program*	MMCLP	720.0
Core funding from Regional Government of Biobío	MMCLP	900.0
Resources awarded through projects from different sources	MMCLP	2,111.2

* CONICYT has committed core funding for the Center until 2018.

CIPA: resources awarded through projects from different sources, 2011-2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CIPA and CONICYT Regional Program.

Note: CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CONICYT-Fondef: CONICYT's Fund for the Promotion of Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CIPA'S ACTIVITIES

CIPA's activities are designed to offer the region and country solutions based on research and development for industrial sectors that require polymer materials to manufacture their products, that require solutions based on polymers to increase their productivity or differentiate their products, or that generate a large volume of polymer waste products. For this purpose, CIPA works on the development of polymers with medical, agricultural and energy applications, the procurement of polymer materials with environmental applications, and the development of different types of materials (compound thermoplastics and thermoplastic biomaterials) from recycled polymers and subproducts of the agricultural and forestry industries.

Its work results in contributions to the chemical industry, agricultural and forestry activities, agroindustry,

construction and the health sector, mainly. This supports the development of local productive chains in these industries, providing businesses with technological solutions, interconnection, associativity and cooperation. At the same time, it develops technological alternatives for the valuation of waste generated by sectors dedicated to the exploitation of natural resources, with an emphasis on product diversification and adding value to traditional activities. It also offers technological solutions for the treatment of contaminated waters from effluents of the fishing, forestry and metal and oil refining industries.

In functional polymers, the Center works in the procurement of polymer materials with environmental applications, for example, polymers for the removal of undesirable elements and toxic species, generating environmentally-friendly solutions for the industry; in the development of polymers with diverse applications,

⁴ In current Chilean pesos of each year.

such as biodegradable films for food preservation; and in the field of medical products, creating compound antimicrobial materials, analgesic and anti-inflammatory bandages based on natural polymers and active substances of vegetable origin, all with great potential for applications in the region and the country.

In thermoplastic materials, its work focuses on the development of new polymer formulas with properties that have been improved by mixing or adding synthetic or natural polymers from filler materials (fibers, particles, inorganic molecules and active ingredients, among others). The work includes, on the

one hand, thermoplastic biomaterials, which seeks to replace thermoplastic materials of fossil origin with alternatives based on renewable raw materials, also evaluating processing alternatives and additives to achieve specific characteristics required by the industry (for example, stability over humidity, permeability over oxygen or resistance to pathogens); and, on the other hand, compound thermoplastics, based on virgin or recycled materials, with the inclusion of diverse fibers or additives processed using different techniques, studying the compatibility of the different combinations with the final properties required for the material.

RELATIONSHIP WITH REGIONAL POLICIES

CIPA's work is fully aligned with the guidelines of the regional development strategy, since it aims to strengthen the competitiveness of productive activities, creating novel solutions in the form of products and processes that respond to the final use requirements of different industries. With a strong emphasis on the use of waste and the creation of environmentally-friendly materials, their work contributes to a large degree to the sustainability of productive processes.

Incorporating science and technology to the development of new materials, CIPA's activity is contributing to the creation of sustainable, innovation-based businesses, as proposed in the regional innovation strategy. Thus, through work that is strongly tied to the productive sector, it is bringing science and technology closer to the needs of businesses and to the market, helping to build a more innovative society.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CIPA has a work team of 41 people (29 employed by the Center and 12 by the partner institutions), 7 of which work in the field of management and relationships, 11 in interconnection and technological transfer, and 23 in research. The research area includes researchers, project engineers and other professionals and technicians. These include 18 researchers and 5 professionals and technicians⁵.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	6	10	16
Researchers with a Master's degree	1	1	2
Professionals and technicians who support research	4	1	5
Total	11	12	23

From the total of researchers, professionals and technicians of the research area, 7 work in the line of polymer development with agroindustrial and medical applications (5 employed by the Center), 6 in the procurement of polymers for the removal of contaminant species (3 employed), and 12 in technological valuation of waste (5 employed)⁶. They are joined by undergraduate and graduate thesis students, who have developed 101 theses between 2011 and 2014.

CIPA's main offices are located in Concepción and its facilities are distributed in different spaces at Universidad del Bío-bío and Universidad de Concepción. It currently has a site (ceded by Universidad del Bío-bío) for the construction of its laboratories. It has laboratories (300 square meters) for the development and characterization of polymers, thermoplastic materials, thermal analyses and mechanical analysis, a microbiology laboratory for the work with functional polymers, and a pilot plant for processing polymers.

⁵ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

⁶ A researcher works in the three research lines.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS

Networks for scientific collaboration

CIPA has collaboration agreements with research centers and technical entities in Chile and abroad. Within the country, it has agreements with Fundación Chile, the technical private corporation Chilean Packing and Packaging Center (CENEM), the Mitiliculture Technological Institute (INTEMIT), the Agriculture & Aquaculture Nutritional Genomic Center (CGNA), the Effectivus Technological Research and Development Center, and Universidad San Sebastián.

At the international level, it has agreements with the Technological Institute of Plastics (AIMPLAS) in Spain, the Research Center in Applied Chemistry (CIQA) in Mexico, the Latin American Association of Compound Materials (ALMACO), the National Institute of Industrial Technology (INTI) in Argentina, the ASCAMM Technological Center in Spain, Leartiker (a center specialized in polymer and food technology) in Spain, Universidad Nacional Mayor de San Marcos (Peru), Universidad Nacional de Callao (Peru), Universidad de La Coruña (Spain) and Universidad de Alcalá (Spain).

Relationship with local organizations, industry-related and government agencies

CIPA develops its work in close collaboration with the regional and national productive sectors, and as a result of this work, more than 30 businesses use the knowledge produced by the Center, which is delivered mainly through technical consultancies and the development of analyses and essays. Similarly, the Center has interacted with young professionals in the field of chemical and biological sciences, supporting the development of undergraduate and graduate theses, which in some cases has led to new enterprises based on technology. It has also contributed to the formation of social capital in the region and the country, through its participation in multiple activities of technological dissemination and environmental education regarding the use and recycling of polymers and, in particular, plastic materials and new sustainable alternatives for their replacement, based on recycled products and biomaterials.

In the future, CIPA hopes to expand its regional collaboration, particularly by incorporating SMEs. Also, in the framework of new trends that require innovation (such as climate change and the scarcity of water resources) and regional productive development, the Center has advanced in the development of new technologies, particularly those which are potentially sustainable, in order to prepare the process of incorporating technology in sectors of regional interest.



With applications in the food sector, foam biopolymer production is one of the processes through which CIPA creates new materials for use in different industries.

RESULTS AND IMPACTS IN THE REGION

Seeking to offer solutions to the requirements of diverse productive sectors, CIPA is innovating in the creation of new materials and processes, for applications in the chemical, agricultural and forestry industries, agroindustry and construction. With a strong emphasis on the recycling of waste material and the production of biomaterials, it is helping to strengthen the competitiveness and sustainability of these productive activities.

CIPA's work has generated a series of raw materials, technologies and products that may be applied in different industries and productive processes, which are the foundation for commercial scaling, as well as technical and feasibility studies related to other potential technological developments of interest for the market.

The diverse ongoing technologies include, for applications in construction, constructive elements based on recycled rubber, Tetrapack and polyolefins

of recycled origin and a natural wood preservative for external use; for applications in the chemical industry, reinforced materials, an enamel for the treatment of onychomycosis (nail infections caused by fungus) and polymers for the metals removal; for applications in health care, bandages with vegetable extracts for the treatment of wounds; for applications in the agrifood sector, biodegradable polymers for food packing and packaging; and for applications in diverse sectors, additives and plasticizers with a renewable base for processing materials for construction and the agrifood sector, thermoplastic starch foam with uses in the agricultural, forestry and agrifood sectors, biodegradable polymers for agricultural and forestry applications, and wood-plastic alternatives for construction and the agricultural and forestry sectors.

The Center also provides different technological services, including more than 20 types of analyses, essays and services, including -for example- the determination of physical, thermal and mechanical, viscosity, humidity and antibacterial properties of



The liquefaction of biomass to obtain films is an alternative for producing materials using renewable raw materials.

different materials, thermogravimetry, calorimetry and infrared spectroscopy, among others.

Several of the materials developed are the result of taking advantage of the waste generated by different productive processes, and are also used as raw materials to create products with applications in different industries and sectors. For example, using waste from the baking industry, such as bread and dough whose usable lifetime has expired, the Center developed a process of biotransformation to obtain, purify and characterize lactic acid. This raw material was used in the polymerization of poly-lactic acid and its transformation into biodegradable packages for the plastic transformation industry, in particular, to create products used to package food within the country. There has also been a market study and a technical study, and technological partners have been identified.

In a development designed for the construction sector, based on rubber from used tires (NFU), constructive elements were developed to improve the energy efficiency of housing units in Chile, through the adherence of virgin and/or recycled polymers that may help obtain a high level of thermal-mechanical-acoustic performance, which is competitive in this market. A market study and a technical study were also conducted, and technological partners were identified.

In an initiative related to the food sector, the Center produced packages for use in the food packaging industry, based on nanotechnology, in response to technical, economic and market requirements which allow their manufacture and sale in Chile.

A project designed for this same sector has developed technological components for the production of non-dairy foods, using probiotic gastric strains with activity to counter to the *Helicobacter pylori* bacteria, microencapsulated in water-soluble polymers in order to ensure their viability during processing.

For the generation of environmentally sustainable products, CIPA's researchers created a natural wood preservative based on polyphenols from murtilla (*Ugni molinae*) stems and leaves, harmless to human health and environmentally-friendly, with mainly residential applications in outdoor exposure. A market study and technical study were also conducted, identifying technological partners. In this same field, formulas for biodegradable film were developed for their use in agriculture.

Also on the issue of environmental sustainability, CIPA's team generated a diagnosis of the current state of plastic waste in Chile to characterize, value, classify and

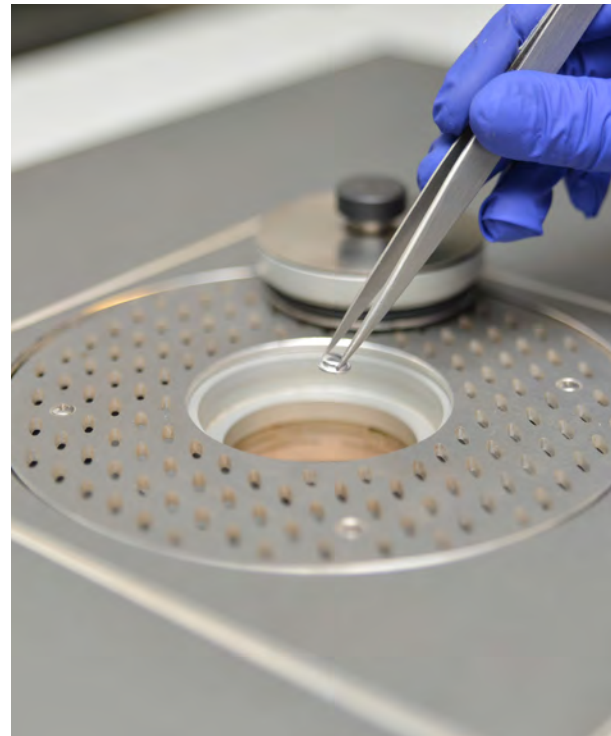
identify their origin, and created a plastics recycling guide and instructions for the municipal and industrial sectors and for the general community.

Researchers at the Center have also conducted technical and economic feasibility studies for the development of several products: biodegradable mesh from renewable thermoplastic sources, which reinforce the growth and proliferation of vegetation on slopes and in spills, including in its matrix active elements that help improve the quality of the eroded soil; bioactive packages from blueberry foliage discard; and biodegradable packages from waste products of tomato skin for the food packaging industry, considering the technical, economic and market requirements for their manufacture and sale in the country.

In terms of medical supplies, CIPA is advancing towards the development of bandages with vegetable extracts and an enamel designed for the chemical industry, for the treatment of onychomycosis (designed for diabetic persons), in order to generate lower-cost alternatives than those currently available, all imported. These products have had vegetable extracts from endemic species introduced into them, based on information from the Ministry of Health regarding native plants and their uses.

Between 2011 and 2014, CIPA developed a series of 67 projects⁷. Its researchers produced a total of 55 scientific articles (ISI), which were published in journals with an average impact index of 2.180, and a total of 115 works, which were presented at 45 scientific

congresses. During this period, the Center's work led to three patents, one of them granted in 2014: monolayer rigid container made by injection, useful for the preservation of fatty foods which includes homopolymer polypropylene, polypropylene grafted with maleic anhydride and modified clay. During these years, CIPA supported the development of 15 Ph.D., 7 Master's and 79 undergraduate theses on subjects related to its lines of work.



⁷ The list of the Center's projects is available at: www.conicyt.cl/regional/categoría/estudios-y-documentos/.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI Publications	13	13	9	20	55
Impact index	3.428	2.094	1.946	1.529	2.180
Non-ISI publications	0	1	1	0	2
Number of works presented at scientific congresses	12	18	50	35	115
Number of scientific congresses at which the Center presented works	6	7	19	13	45
National and international patents requested and/or granted	2	0	0	1	3
Ph.D. and Master's theses underway with the support of the Center*	4	11	14	13	22
Undergraduate theses underway with the support of the Center*	12	26	35	37	79

* As theses last more than a year, they are counted in each year of their development.

AGRICULTURE & AQUACULTURE NUTRITIONAL GENOMIC CENTER **CGNA**

REGION OF ARAUCANÍA

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REGIONAL CONTEXT ¹

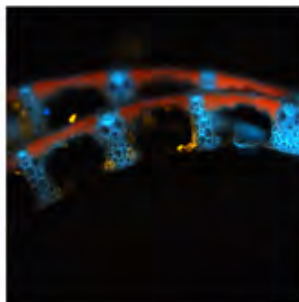
SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 2,380,066 (2.3% of the national total).
Main sectors by contribution to regional GDP (2012)	Personal services (20.1%), trade, restaurants and hotels (12%), transportation and communications (11%), agricultural and forestry sector (10.5%), and manufacturing (9.7%).
Business composition (2013)	There are 48,399 businesses in the region, which employ 250,886 dependent workers. Almost 70% are microenterprises, which employ 9.5% of all workers. The agricultural and forestry sectors account for 15.8% of all firms and employ 17.7% of all workers.
Exports (2013)	MMUSD 611 (0.8% of the national total). The food industry represents 21.1% of these exports (the industry in general represents 79.8%). The agricultural and forestry sector accounts 20.1%, and within this sector, fruit exports represent 13.8% of total exports.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 10 universities in the region, including Universidad Católica de Temuco and Universidad de la Frontera, which belong to the region itself. In 2014, available graduate degrees in the region included 8 Ph.D. programs and 78 Master's programs, mainly in the fields of social sciences, business and law (30), education (19), and health and social services (15).
Regional competitiveness index (ICORE) 2012	The region ranks 15 th in the country (index of 0.156). It is ranked 9 th in the area of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 9.9% (compared to a national rate of 23.7%). Both the technological innovation rate (6.8%) and the non-technological innovation rate (7.3%) are well below the national average (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 2,204 articles (3.5% of the national total). The annual number increased at an average rate of 5.2% during this period. The rate of international collaboration was 38.2% (compared to a national average of 52.4%). The normalized impact of production is 0.78, which falls to 0.44 in the case of production led by the region.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy for Araucanía 2010-2022* establishes a desired image of the region which –among other characteristics– includes the transformation of the current dominant growth model into one based on a competitive, innovative, associative and sustainable productive structure.

For this purpose, among the five guidelines included in the Strategy, the one that refers to economic growth has the following objectives: to develop and attract modern, rapid-growth sectors in order to increase their relative participation in the regional economic structure and improve regional competitiveness; to promote innovation among small businesses and the *mapuche* population (an ethnic group that represents 23% of the regional population, according to the 2002 census), fostering associativity, productive chains and links between universities, businesses and the government; and to strengthen human capital, educational levels and technical-professional qualification, so that the region may embark on the path towards a knowledge society.

AGRICULTURE & AQUACULTURE NUTRITIONAL GENOMIC CENTER (CGNA)

CGNA was created in 2005 and established as a private non-profit corporation in 2010. Its founding partners are Universidad de La Frontera (UFRO) and the Institute of Agricultural Research (INIA). Its director is Haroldo Salvo-Garrido.

The Center's mission is to develop basic and strategic research to add value to vegetable raw materials, using biotechnology to create products and processes with great economic potential for human and animal feeding, thus contributing to the development of the agrifood chain and each of its components.

GOALS

CGNA seeks to create know-how through research and development for the innovation required in the agroindustrial food sector; to establish itself as a center of excellence for the creation of knowledge, skills and the commercialization of technological vegetable products from the Region of Araucanía; and to articulate productive sectors with the food industry. For this purpose, CGNA develops work in two research lines: crop genomics, and technology and processes.

RESEARCH LINES ²

CROP GENOMICS

Goal: to use DNA and genetic research on crops to promote the development and production of premium vegetable raw materials, in order to create the innovation required by the agroindustrial sector.

Technical team: Iván Maureira (Ph.D., line coordinator, CGNA). Researchers employed by CGNA: Takahiro Ogura (Dr.), Claudia Osorio (Ph.D.), Braulio Soto (Ph.D.), Claudia Vilo (Dr.) and Traudy Wandersleben (Dr.). Researchers from the partner institutions: Millaray Curilem (Dr., UFRO), Haroldo Salvo (Ph.D., INIA) and Horacio Miranda (M.Sc., UFRO). Research support (CGNA): Paula Mora (M.Sc.), Jason Astudillo (Bach.), Gustavo Del Canto (Bach.), Humberto Gajardo (Bach.), Annally Rupayan (Bach.) and Fernando Westermeyer (Bach.).

TECHNOLOGY AND PROCESSES

Goals: to develop technologies and processes for obtaining functional ingredients; to develop nutritional complements; to identify and characterize bioactive and technofunctional compounds; and to improve the nutritional properties of materials of vegetable origin.

Technical team: Mónica Rubilar (Dr., line coordinator, UFRO). Researchers employed by CGNA: César Burgos (Dr.) and Yussef Esparza (M.Sc.). Researcher from partner institution: Edgar Uquiche (Dr., UFRO). Research support (CGNA): Eduardo Morales (Bach.) and José Piornos (Bach.).

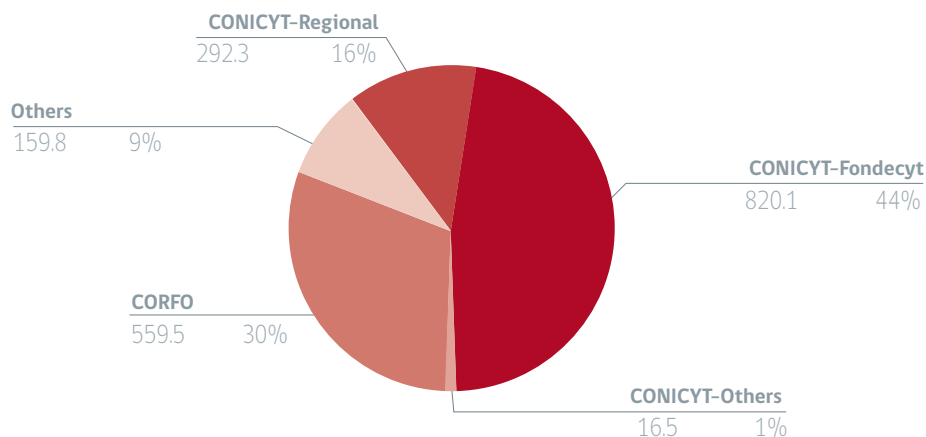
² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.

RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP	720.0
Core funding from Regional Government of Araucanía	MMCLP	1,200.0
Resources awarded through projects from different sources	MMCLP	1,848.2

* CONICYT has committed core funding for the Center until 2017.

CGNA: resources awarded through projects from different sources, 2011–2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CGNA and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CORFO: Chilean Economic Development Agency.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CGNA'S ACTIVITIES

CGNA's work focuses on creating high-level knowledge and skills for the development and commercial use of premium-quality technological vegetable products, destined to animal (salmon, pigs, poultry, pets and ruminants) and human nutrition. Its activity is based on research and development in the nutritional genomics of conventional crops, such as lupine, rapeseed canola and flax, and includes the stages of basic and applied research, technological development, transfer and promotion of results in the productive sector, particularly peasant family agriculture (PFA), and the articulation of business activities that help create value and develop the Region of Araucanía and the country.

The Center's work is based on the development of premium vegetable raw materials, that is, those with an outstanding quality and quantity of proteins, fatty acids, soluble fibers and antioxidants, among other elements, which present a low proportion of anti-nutritional elements (which affect the normal digestion of some components) and are well adapted

to and friendly with the environment in which they are produced. For this purpose, CGNA has developed a series of cutting-edge tools in the fields of genomics, bioinformatics, proteomics and genetic engineering, producing valuable results to help crops breeding with high-protein content (such as yellow lupine), high-oil content (such as rapeseed canola and flax), and soluble fibers and antioxidants (such as flax and lupine, respectively).

A fundamental aspect of CGNA's work is the creation of value for the industry, through the application and scaling of its developments in basic and applied science, as well as innovation through new products, in processes that involve the entire chain, agricultural production, industrial transformation and commercialization. Its strategy is based on participation in the productive chain with a clear market orientation, seeking to add value to the grain industry and move beyond the mere production of commodities. In this strategy, the process begins from the problem, from the final user, and even considers how much an innovation should cost on the market to make it pertinent and to favor its adoption by the food or agriculture industry.

³ In current Chilean pesos of each year.

The Center has already produced relevant results in the research and development of lupine-based products for animal and human feeding. Lupine is a legume that has traditionally been used in Chile for animal feed (especially salmon) and exports, but its planted surface has been quite variable, since it has depended on the evolution of salmon farming and its external demand, which is affected by the quality of the export product (basically, by the concentration of protein in the grain).

For flax, CGNA works to achieve a good profile of oils and soluble fibers, which are used as nutraceuticals (that is, elements which produce health benefits) and can be destined to human or animal (salmon) consumption. For rapeseed canola, the goals for breeding are focused on its properties as a source of oils that have a better balance of fatty acids (saturated and unsaturated), with a lower level of Omega 3 (but with more Omega 6 and 9), which are in great demand.

RELATIONSHIP WITH REGIONAL POLICIES

CGNA's work is clearly aligned with the strategic development guidelines for the Region of Araucanía, since it aims to strengthen the competitiveness of regional agriculture by developing premium technological products of high nutritional and economic value, by improving crops that are relevant to the region and thus satisfy the increasing demand for high-quality food for human and animal consumption, beyond commodities.

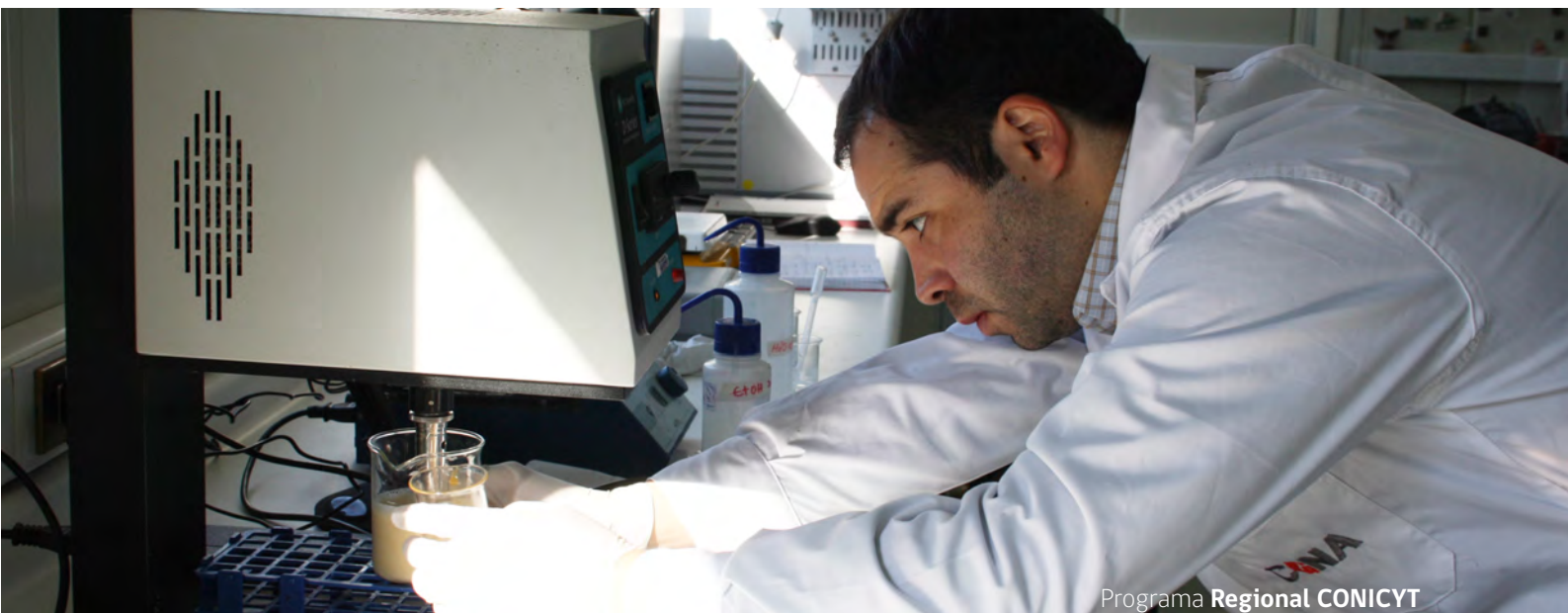
For this purpose, it has developed a working model for social innovation, based on a close relationship between research, the productive sector and the food industry, directing scientific and technological results towards the development of products with significant market perspectives from the very beginning. This model features as main actors a set of peasant family agriculture (PFA) cooperatives, with a great presence of *mapuche* producers, to whom CGNA has transferred results through the creation of a firm. Through training and certification of their lupine crops, producers have entered a business field with great possibilities, using a model of shared benefits, while the Center has made progress in the development of new products based on this same species, as well as rapeseed canola and flax. In this way, the PFA farmers are entering the market alongside other productive sectors.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CGNA has a technical team of 21 people, 16 of whom are employed by the Center and 5 of whom are from partner institutions⁴. Of this total, 15 specialists work in the crop genomics line (including 12 who are employed by the Center) and 6 in the technology and processes line (including 4 employed by the Center). This work is supported by a management team of 7 people.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	7	4	11
Researchers with a Master's degree	1	1	2
Professionals and technicians who support research	8	0	8
Total	16	5	21

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.



Besides attracting high-level researchers, CGNA has made a contribution to the formation of human capital in collaboration with universities. The students, hired through scholarships and for specific projects, come mainly from Universidad de Chile, Universidad de Santiago and Universidad Austral de Chile. CGNA is a center with a significant amount of movement, which possesses a stable critical mass and another group that fluctuates. At the end of 2014, for example, researchers from France, Japan and Argentina were collaborating with the Center.

CGNA's main office is in Temuco. Its facilities are located at INIA (laboratories) and Universidad de la Frontera. Although it does not have its own facilities, the Center has modern, efficient equipment that allows it to produce and analyze data massively and with great reproducibility, in order to ensure the precision of all inferences and results generated.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS

Networks for scientific collaboration

CGNA believes that a relationship with the scientific field, through joint work and effective collaboration, is essential to obtain a final product with added value that is useful for society.

In this sense, CGNA has agreements with renowned international consortiums. It is part of the International Consortium of SNP (Single Nucleotide Polymorphisms) for Brassicas, which has 17 member organizations, including John Innes Centre, Agriculture and Agri-Food Canada, Max Planck Institute, Oil Crops Research Institute, Chinese Academy of Agricultural Sciences, Illumina, Syngenta and Bayer BioScience. It has also joined networks with Canada for its work on flax; and with the United States, Australia, France and Japan for its work on lupine. In the country, it has scientific collaboration agreements with Universidad de Chile, Universidad de la Frontera, Universidad de Talca, Universidad Austral de Chile and Universidad de Concepción.

Relationship with local organizations, industry-related and government agencies

CGNA works in close collaboration with the productive sector in the Region of Araucanía, particularly with peasant family agriculture producers and cooperatives, to which it has transferred the technological results by creating a *spin off*, as well as with larger producers and agroindustries (both intermediate and final) in the food production chain. In the field of product development, it has formal agreements for the creation of prototypes and tests, with businesses in sectors that may potentially demand these products, such as the salmon industry or the food industry for human consumption. In terms of promotion, it participates in several activities, such as innovation forums, workshops, scientific fairs and field visits, among others. This has led to a network of approximately 500 farmers and more than 700,000 visits to CGNA's website, with a great number of visits from the United States, Poland, the United Kingdom, Spain, Canada, Indonesia, Israel, Colombia and Mexico, among others.

Also relevant for CGNA is the acknowledgment of the regional community, and for this purpose it maintains a permanent strategic communications effort, positioning issues and opinions in the regional media and disseminating information aimed at local authorities and the regional productive sector. Its formal relationship with CONICYT's Explora Program has also helped promote the Center in schools.

RESULTS AND IMPACTS IN THE REGION

CGNA works to add value to agricultural crops that are relevant to the region and to create products of vegetable origin that possess a high nutritional content, for the food industry for human and animal consumption. Its first product, *AluProt-CGNA*®, has already created a firm in which over 200 peasant family agriculture producers are cultivating certified lupine under a shared benefits scheme.

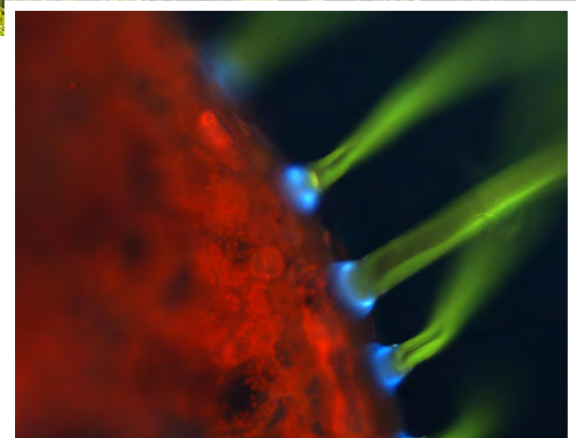


The Center's most important achievement is the development, registration and certification of its first technological product, *AluProt-CGNA*®. This is a premium product, the first lupine crop with 60% protein in dehusked grain, compared to conventional lupines, which have a maximum of 44% protein, and soybean, the worldwide reference point in high-protein grains, which has 43% and is less digestible. This is the only grain in the world with such a high protein level, which produces a great value for the food industry both for human and animal consumption. This protein also has great biological qualities, due to its high digestibility, the presence of the ten essential amino acids, and a high proportion of sulfur-containing arginine and lysine amino acids, which are key to the nutrition of salmon, poultry, human beings and monogastric animals in general. For example, it has twice as many sulfur-containing amino acids as conventional lupines and 30% more than soybean. It also has a very good glycemic index and a high level of antioxidants, due to the presence of lutein, zeaxanthin and B-carotene carotenoids. Since this protein is a vegetable, it has no lactose, which is an advantage for lactose-intolerant populations. It is a more efficient agroindustrial crop, since its production process has lower energy costs. To favor the development of this crop, a biofertilizer was also created using genomics and microencapsulation.

Based on this product, the Center is developing a series of prototypes for agroindustrial products that aim to position the Region of Araucanía in the vegetable protein market for animal and human consumption. These include vegetable milk and premix for different products for mass consumption, such as healthy bread and rice for gluten intolerants, among others.

For all these achievements, in 2014 CGNA won the National Innovation Award, Avonni, in the Natural Resources category.

As mentioned before, in the context of the Center's work, a first spin-off was also created, NG-Seeds S.A. owned by five regional cooperatives composed of peasant families, representing more than 200 small farmers who are producing certified lupine seeds for the first time. In 2014, these farmers had 1,200 hectares of *AluProt-CGNA*®, and, based on the current demand, genetic seed has been projected for 10,000 hectares in 2015. All properties were registered at the Agricultural and Livestock Service (SAG), since this production complies with certification standards. This also represents a great achievement for CGNA in terms of the technological transfer of its results, as well as the socioeconomic effect on participating families.



In this model, farmers may combine their production to meet a demand that is vastly superior to their individual capacities, as well as to negotiate prices and gain access to economies of scale for the purchase of agricultural inputs. But this is not all: for CGNA, this work method represents what can be called a "social innovation". The Center's role is research and development, not business. For this reason, the *AluProt-CGNA*® patent belongs to CGNA but is licensed to the small producers, through a licensing system which establishes that, since this development was funded with public resources, 100% of what is captured through this channel must be invested in research for the sector itself. NG-Seeds S.A. is a joint-stock corporation that has contracts with the farmers and seeks to participate in the market with good prices, setting aside only what is necessary for business operations, since the goal is that the small producers may reap the benefits of the business. The Center's vision is that this is proof of how science can be a motor for improving people's quality of life, as long as the producers are beneficiaries and protagonists of their own applications.



NG-Seeds has two business lines: the production of premium-quality lupine seed and the production of premium-quality protein. Already in 2014, medium and large farmers planted *AluProt-CGNA*® with seeds sold by NG-Seeds. Thus, along with the traditional model of liberation of varieties multiplied by large businesses, there is now a model for the participation of small farmers, who now share in this genetics market by selling their seeds to all types of users. For this purpose, all farmers were trained and accredited by SAG to perform seed multiplication. There are already requests being made by other countries to produce *AluProt-CGNA*®, and licensing agreements are being evaluated.

In economic terms, the industry has acknowledged and paid the quantity and quality of this protein, which is a very competitive alternative to imported protein and superior to conventional products. This has allowed more than 200 small producers to sell the product at a much higher value than they could have done previously.

In the field of process development, the Center already has a series of food prototypes based on *AluProt-CGNA*®, sausages, extrude⁵, pellets, protein isolates, healthy puddings and bread with a high protein and fiber content, among others. Through these prototypes, progress is being made towards the industrial scaling phase, using a series of projects presented together

⁵ Processed through rapid, continuous and homogenous high-pressure and high-temperature cooking.

with the private sector, which brings together and closes the circle that must be created. Another short-term goal is to develop vegetable milk, which may compete with different milks already available, and whose cost fluctuates between 2,000 and 3,000 Chilean pesos per liter. Besides offering consumers high-quality products with great nutritional content, these developments lead to a higher price for lupine and greater profits for farmers. In this field, alternatives are being developed which include greater value, so that this grain is not only a commodity and small producers may move on to become agroindustrial producers.

CGNA has also developed two other technological products for food use in dairies, together with agroindustrial processing and the final dairy industry, which are currently being adopted by the industry. To enter the dairy food chain, lupine must undergo an industrial process, which means it will create work throughout the entire year. Dairy plant testing has produced results equal or superior to those of the soybean vegetable protein, which is imported. In Chile, imported soybean currently represents over 90% of the vegetable protein used in dairy plants, which illustrates the strategic value of developing these products within the country.

Between 2011 and 2014, CGNA developed a total of 26 projects⁶. During this period, the Center's researchers

⁶ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

published 39 scientific articles (ISI) in journals with an average impact index of 2.767. They also presented a total of 63 works at 24 scientific congresses. Finally, 3 Ph.D. theses, 5 Master's theses and 33 undergraduate theses were developed, all related to the Center's work.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI publications	1	12	15	11	39
Impact index	0.656	2.678	3.634	2.855	2.767
Non-ISI publications	0	1	0	0	1
Number of works presented at scientific congresses	24	12	19	8	63
Number of scientific congresses at which the Center presented works	6	4	9	5	24
National and international patents requested and/or granted	0	0	1	0	1
Ph.D. and Master's theses underway with the support of the Center *	5	2	3	4	8
Undergraduate theses underway with the support of the Center *	9	15	17	14	33

* As theses last more than a year, they are counted in each year of their development.



In what represents a milestone for the Region of La Araucanía, small farmers are now genetic seed multipliers, and comply with all the necessary requirements (AluProt-CGNA® seed field belonging to the Huichahue cooperative).



In 2014, CGNA won the Avonni National Innovation Award in the natural resources category, for its technological product AluProt-CGNA® and the social innovation associated to NG-Seeds S.A., which included the participation of five *mapuche* cooperatives.



CENTER FOR RESEARCH ON PATAGONIA ECOSYSTEMS CIEP

REGION OF AYSÉN

www.ciep.cl - contacto@ciep.cl - (56-67) 2244506

REGIONAL CONTEXT ¹

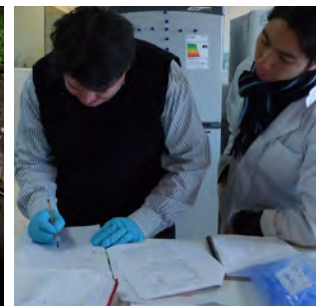
SOCIOECONOMIC PROFILE OF REGION

Regional GDP (2013)	MMCLP 514,666 (0.5% of the national total).
Main sectors by contribution to regional GDP (2012)	Public administration (20%), fishing (18.1%), construction (15.9%) and personal services (10.9%).
Business composition (2013)	There are 7,575 businesses in the region, which employ 29,095 dependent workers. 73.7% of these are microenterprises, which concentrate 13.9% of all workers. After sectors such as trade and construction, it is relevant to note the proportion of workers in firms of the fishing sector (9.2% of total) and, to a lesser extent, in manufacturing and the agroforestry sectors.
Exports (2013)	MMUSD 333.9 (0.4% of the national total). The food industry generates 52.5% of these exports, while metal mining generates 47.1%.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 3 universities in the region, which center their activities on teaching (without conducting any research), all of them with their main campus in other regions of the country. In 2014, there were no graduate degree programs available in the region. It is important to mention that, in mid-2015, there is a law being discussed to create a public university in the Region of Aysén.
Regional competitiveness index (ICORE) 2012	The region is ranked 6 th in the country (index of 0.419). It is ranked 13 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 17.6% (compared to the national rate of 23.7%). The technological innovation rate (17.1%) is slightly lower than the national rate (18.8%), while the non-technological innovation rate (4.4%) is much lower than the national rate (16.4%).
Articles published in indexed scientific journals (2003-2012)	172 articles (0.3% of the national total). The annual number increased at an average of 15% during this period. The rate of international collaboration is 58.7% (compared to a national average of 52.4%). The normalized impact of regional production is 0.99, which falls to 0.92 in the case of production in which the region is a leader.

¹ Data sources for this regional profile, as well as conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Region of Aysén (2009)* is based on an image of Aysén in the year 2030 as a region that, among other characteristics, has a platform of high-level scientific research activities on issues in which it has comparative advantages, such as glaciers, water, global warming and ecosystems, among others. In this image, the region has also achieved an economic growth sustained mainly on the development of sustainable, high-quality international tourism and the consolidation of a competitive aquacultural sector in harmony with other uses of the coastline, among other sectors; it is also a region with a real concern for its environmental problems, based on a sustainable development model in line with its natural vocation as a life reserve.

The *Regional Innovation Strategy 2014-2020 Region of Aysén - General Carlos Ibáñez del Campo*, proposes a vision of Aysén in the year 2030 as a region, among other characteristics, known worldwide for its natural resources and its development model that combines economic well-being, social equity and environmental sustainability, as well as internationally known as a part of Patagonia and valued as a destination for tourists and scientists. The goal of this strategy is to increase the competitiveness of Aysén in a context of environmental sustainability and social and economic well-being, through innovation and based on its natural, human and social capitals. The four goals proposed for this purpose include positioning Aysén as a recognized knowledge pole, promoting research and innovation for the sustainable use of natural resources. The areas with potential for innovation include natural resources, scientific knowledge and environmental innovation, particularly the enormous richness and purity of the region's natural resources in terms of its marine and terrestrial ecosystems and water reserves.

CENTER FOR RESEARCH ON PATAGONIA ECOSYSTEMS (CIEP)

CIEP was created in 2005 and established in 2010 as the Aysén Regional Corporation for Cooperative Research and Development "Center for Research on Patagonia Ecosystems". Its members are the Regional Government of Aysén, Universidad Austral de Chile (UACH), Universidad de Concepción (UdeC), the Institute of Agricultural Research (INIA), the University of Montana (USA), Universidad de Córdoba (Spain), Salmon Chile, Intesal (Technological Salmon Institute) and CONICYT. Its executive director is Giovanni Daneri.

The Center mission is to contribute to the development and sustainability of Western Patagonia through scientific research of excellence that is pertinent to the interests of the community and various economic sectors. It aspires to become a worldwide reference point as a platform for research related to development and sustainability of Patagonia's ecosystems, with an institutional framework that may ensure its independence and consolidate its strong ties to other research centers and academic, business and public stakeholders.

GOALS

CIEP's goals are to consolidate fundamental research on aquatic and terrestrial ecosystems, in order to determine the impact of climate change on regional ecosystems; to promote sustainable productive activities, particularly in the aquaculture, tourism and artisanal fishing sectors; to intensify applied research and promote the transfer of scientific knowledge towards regional society; and to extend international scientific networks to multiply research developed in the region and improve the quality of knowledge of its ecosystems, as well as the sustainable use of these resources. The Center concentrates its work on four lines: aquatic ecosystems, terrestrial ecosystems, fishing and aquaculture, and sustainable tourism.



RESEARCH LINES AND LINKS ²

AQUATIC ECOSYSTEMS (RESEARCH LINE)

Goal: to generate basic and applied knowledge of excellence on the processes which control productivity, the state of conservation and variability at different spatial and temporal scales, which are relevant to the water resources of the region.

Technical team: Rodrigo Torres (Ph.D., line coordinator, CIEP). Researchers employed by CIEP: Giovanni Daneri (Ph.D.), Pablo Mata (Ph.D.), Brian Reid (Ph.D.) and Paulina Montero (M.Sc.). Researchers from the partner institutions: Humberto González (Ph.D., UACH) and Óscar Parra (Ph.D., UdeC). Research support (CIEP): Soraya Villagrán (M.Sc.), Emilio Alarcón (Bach.), Rosa Torres (Bach.), Luis Uribe (Bach.) and Ángela Bahamondes.

TERRESTRIAL ECOSYSTEMS (RESEARCH LINE)

Goal: to generate basic and applied knowledge of excellence on the processes which control the state of conservation and the dynamics of natural land resources in the Region of Aysén, through strategic alliances with regional planning and productive institutions; and in particular, to study patterns and processes that affect land resources and which are current regional concerns.

Technical team: Alex Fajardo (Ph.D., line coordinator, CIEP). Researcher employed by CIEP: Frida Piper (Ph.D.). Research support (CIEP): Jonathan Riquelme (Bach.).

FISHING AND AQUACULTURE (RESEARCH LINE AND LINKS)

Goal: to generate knowledge in the fields of fishing and aquaculture in order to promote the sustainable use of marine ecosystems through productive diversification, environmental monitoring and the development of load capacity models for fjords and canals in Patagonia.

Technical team: Madeleine Hamamé (M.Sc., line coordinator, CIEP).

SUSTAINABLE TOURISM (RESEARCH LINE AND LINKS)

Goal: to support the sustainability of tourism development through social and economic studies and scientific research on the natural and archaeological patrimony, in order to produce added value and promote new products that may stimulate responsible tourism in the Region of Aysén.

Technical team: Anabel Reis (M.Sc., line coordinator, CIEP). Researchers employed by CIEP: Trace Gale (Ph.D.), Francisco Mena (Ph.D.), Fabien Bourlon (M.Sc.) and Rodrigo Merino (M.Sc.). Research support (CIEP): Ricardo Orellana (Bach.), Josefina Ruiz (Bach.), Dinelly Soto (Bach.) and Gabriela Igor.

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a BA. or B.Sc.

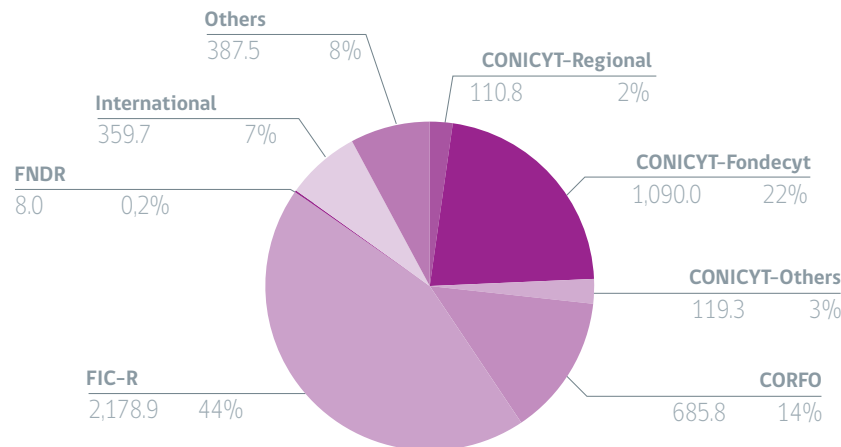


RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

Core funding from CONICYT Regional Program*	MMCLP	731.8
Core funding from the Regional Government of Aysén	MMCLP	799.8
Resources awarded through projects from different sources	MMCLP	4,939.9

* CONICYT has committed core funding for the Center until 2018.

CIEP: resources awarded through projects from different sources, 2011–2014
(Millions of Chilean pesos and percentage distribution by funding source)



Source: CIEP and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness; FNDR: National Regional Development Fund.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CIEP'S ACTIVITIES

In the aquatic ecosystems line, CIEP's activities are focused on understanding how these systems work, in order to predict their response to pressures (natural and manmade) on multiple scales, developing knowledge on global change, aquacultural activities and the impact of the acidification of the ocean and exotic species, to contribute to territorial planning and organization. It also seeks to support the development of models that may help comprehend the evolution of continental glacial masses and its impact on the dynamics of fjord and channel ecosystems, in order to favor the capacity to anticipate the effects of climate change on the availability of water resources for human use and the stability of ecosystems related to glaciers. It also aims to contribute knowledge for maximizing and maintaining ecosystemic services provided by the region, measuring the impact of fishing and aquaculture pressure on Patagonia's fjords and channels, and handling continental water resources.

In the terrestrial ecosystems line, its work is focused on developing research on general ecological processes (such as the carbon balance and the maintenance of biodiversity), using the forest formations of the Region of Aysén as systems to study. This has produced guidelines that have contributed to decision-making processes in the region, for example, the creation of planting protocols to restore burned lands based on the ecological requirements of native tree species, obtained as a result of its work.

In the fishing and aquaculture line, CIEP's work focuses mainly on fisheries of interest for artisanal fishermen, helping to deal with the deterioration of regional fisheries, highly vulnerable due to the concentration of the capture in few resources and its dependence on limited purchasing markets. At the same time, the Center seeks to contribute knowledge and biological-fishing management of the resources with the greatest

³ In current Chilean pesos of each year.

potential for extraction or cultivation, and to support the training of the human and social capital of artisanal fishing communities. In the field of aquaculture, it promotes baseline environmental studies that may support the creation of load capacity models, in order to strengthen the sustainability of the aquaculture industry in the region.

The sustainable tourism line seeks to support the development of new tourism proposals based on social, environmental resources and market research, contributing to the sustainability of tourist destinations, and safeguarding and placing value on the region's natural, cultural and (pre)historical patrimony.

RELATIONSHIP WITH REGIONAL POLICIES

CIEP's activities are clearly aligned with the region's strategic development and innovation guidelines, thus contributing to create within the region a high-level scientific research platform, precisely on subjects related to the environment and climate change, in which –as the development strategy indicates– the region has comparative advantages. Its work also focuses on creating knowledge and practices that strengthen the sustainable and competitive development of high-quality tourism and aquacultural and fishing activities, sectors that are priorities within these regional strategies. For this purpose, CIEP has the strength of its specialized human capabilities, the convergence within its structure of the productive and research sectors, its collaboration with Chilean and foreign entities, and its resolute vocation for collaboration with regional public entities and productive organizations.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CIEP has a research team of 25 people (23 employed by the Center), including 10 researchers with a Ph.D. (8 employed and 2 from partner institutions) and 5 with a Master's degree (all employed by the Center)⁴. This has helped attract high-level specialists who conduct research and transfers in the region's priority productive sectors, in a zone where there was formerly only one resident Ph.D.

From the 25 specialists, 12 work in the water ecosystems line (10 employed by the Center), 3 in terrestrial ecosystems (all employed) and 9 in sustainable tourism (all employed), while the fishing and aquaculture line employs 1 full-time researcher, with another to join the team during the second semester of 2015. This work is supported by a laboratory team, and a management team of 6 people.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	8	2	10
Researchers with a Master's degree	5	0	5
Professionals and technicians who support research	10	0	10
Total	23	2	25

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.



The Center also receives thesis students, especially from UACH and UdeC, and from foreign universities. In any case, the absence of a university based in the region itself, is a limitation, since it makes it difficult to generate critical mass, as well as the permanence of the students being trained at CIEP in the region. Even so, the Center's researchers teach in the Bachelor's program and the Technical Tourism Program at UACH's Patagonia campus (Coyhaique), besides being professors in the Master's and Ph.D. programs in Oceanography at UdeC and the Ph.D. in Marine Biology at UACH, among others.

The Center's greatest strength in terms of infrastructure are its high-level laboratories and the quality of the equipments (for an estimated amount of 1 billion Chilean pesos). There, researchers may study carbon chemistry in its organic and inorganic phases, work with sweet water ions (calcium and others) and inorganic



In response to the needs of the region's fishing communities, CIEP is seeking productive diversification ways, such as the cultivation of new hydrobiological species (crustaceans and algae).

nutrients (nitrates and phosphates), quantify the age of forests, and obtain information on toxic microalgae in the region, among others.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS **Networks for scientific collaboration**

At the national level, CIEP works closely with the Center's partner universities (UdeC and UACH) and with centers of excellence in all its research fields. Highlights its participation as a member of the interdisciplinary network of the Fondap⁵ Center for Oceanographic Research in the eastern South Pacific (COPAS) and its base program, COPAS Sur Austral; its close collaboration with the Interdisciplinary Center for Aquaculture Research (INCAR, also Fondap center), and the collaboration with other regional centers such as CEQUA and CEAZA. CIEP's researchers are part of the Ecology and Biodiversity Institute (IEB) and the IDI Center in Special Interest Tourism of UACH, and it has cooperation agreements with UACH's Fishing Research Program.

At the international level, CIEP has multiple scientific collaboration agreements. The collaboration with the Alpine Ecology Laboratory of U. Joseph Fourier-Grenoble (France) has allowed for researcher exchanges, the presentation and execution of joint projects and publications. In sustainable tourism, the solid collaboration with several U.S. universities (Penn State, Montana, Utah, West Virginia and Florida) is expressed in the availability to give master classes, the presentation of associative projects, and publications in international journals.

⁵ CONICYT's Fund for Research Centers in Priority Areas.

The participation of CIEP's researchers in international networks involved in climate change issues, such as the International Monitoring Group for Oceanic Acidification, the Global Lake Ecological Observatory Network, and the Inter-American Institute for Global Change Research, is also expressed in the execution of international research projects. The Center also collaborates with the universities of Stanford (USA) and Dortmund (Germany), in ecosystem dynamics, and with the Universidad Complutense de Madrid (Spain) in the field of artisanal fishing. CIEP also participates with the universities of Paris, Concepción and Austral de Chile, in the International Laboratory Center LIA-MOFUN of the ECOS-CONICYT program.

Relationship with local organizations, industry-related and government agencies

CIEP's work focuses on the creation of knowledge and the connection between its goals and the development expected from the most relevant sectors of the region, more than in the technological development for one particular productive sector.

The Center has worked actively, along with professionals of the National Fishing and Aquaculture Service and the Subsecretariat of Fishing and Aquaculture, in the creation of the regulations that may implement the environmental monitoring system for productive neighborhoods.

In the forestry sector, the Center develops services that are required by forestry firms, for example to obtain international certification, and maintains ties with the National Forestry Corporation (CONAF).

In the work in the artisanal fishing line, the fishers are the final beneficiaries of its actions, such as, for example,

the Nucleus project for artisanal fishing. Meanwhile, as a way to diversify the fishermen's sources of income, and after close collaboration with the region's fishing communities, a project is currently being executed in Puerto Aguirre for the cultivation of the *luga* algae, which is to be replicated in Puerto Gaviota. It must also be noted that CIEP participates actively in the Fishing Board, the Coastline Organization Roundtable, and the Red Tide Committee, advising the different stakeholders from a scientific and technological perspective, and maintains close collaboration with the National Statistical Institute (INE) of the Region of Aysén.

The sustainable tourism team collaborates on planning with the various public services (it participates in the public-private tourism board of the Region of Aysén and the Cultural Tourism Roundtable, and supports the creation of the guidelines for the Regional Tourism Observatory). Through its relationship with the private sector, it promotes the creation of local capabilities through various research and transfer activities in each place it intervenes. It must be mentioned that it also works with recreational fishing operators (such as the river monitoring and oversight program), with entrepreneurs from very isolated rural sectors within the region (binational tourism initiative and island communities) and also with larger firms (scientific tourism project).

RESULTS AND IMPACTS IN THE REGION

With scientific research capabilities installed for the first time within the region, CIEP's team is generating valuable information on the aquatic and terrestrial ecosystems of Aysén, thus contributing to regional decision-making, environmental protection and more competitive tourism, fishing and aquaculture sectors. At the same time, it helps develop the region's potential as a place to conduct science related to natural resources.

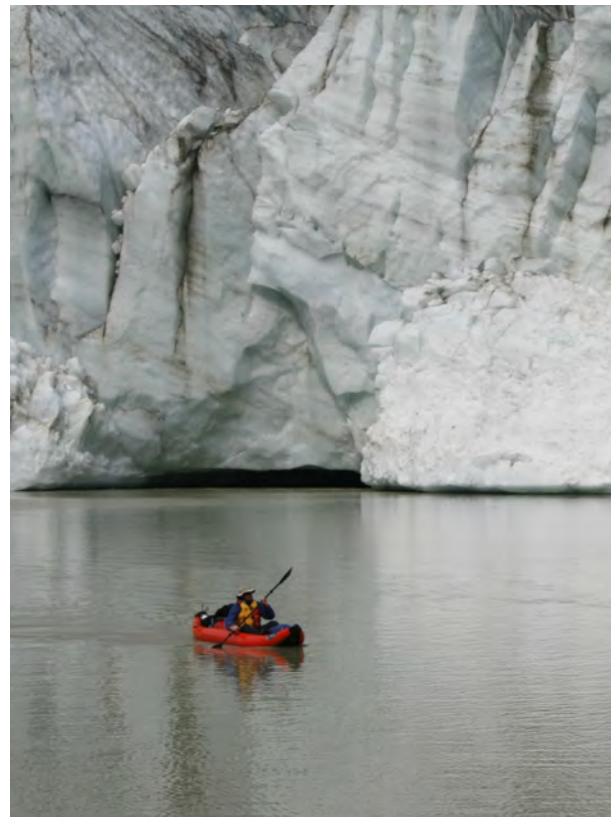
CIEP's installation has led to the attraction of high-level human capital and an increase in the region's scientific productivity, expressed in the production of ISI publications, the execution of projects and the inclusion on international research teams.

Research on fjords and channels contribute basic information for projecting productive investments: today they are studying physical, chemical and biological components that improve our understanding of the complex marine ecosystem. CIEP conducts research in some of the region's main fjords, generating

baselines with relevant data on the operation and structure of fjords and channels. In the case of the Puyuhuapi-Jacaf fjord system, a study has begun with the goal of assessing its load capacity and biodiversity. There have also been initial studies published on the impact of ocean acidification in economically-important mollusks (Chilean *loco* and mussel).

On the other hand, CIEP was the first to react to the plague of the invasive exotic algae known as *didymo* (*Didymosphenia geminata*), which disturbs the landscape, affects the development of fish, and reduces the quality of fishing: a project executed by the sustainable tourism line provided an action framework for the promotion of knowledge in biosecurity and the implementation of measures to prevent, monitor and control the dissemination of this plague in the region's rivers and lakes. The Center also articulated public-private alliances to expand this effort, provided information for public agencies in the fishing and environmental sectors, and supported initiatives in the regions of Magallanes, Los Lagos and Los Ríos, as well as in Argentina.

In terrestrial ecosystems, a line with a clear identity and goals has been strengthened, and the results of its



By developing specialized research and studies, CIEP aims to contribute to the knowledge, sustainable use and enjoyment of the natural resources of the Region of Aysén.

research have helped generate a better understanding of the dynamics and physiological requirements of forests, which has produced knowledge that is useful for decisions to be made based on information of the region itself, as in the case of the responses of plants to climate change at the regional level. Lenga beech studies, for example, are helping identify the pattern that should be followed to plant forest species in the region, since, to this point, the pine model has been followed unsuccessfully.

In the fishing and aquaculture line, it is important to note the support to the Subsecretariat of Fishing and Aquaculture in the promotion of management, and the results obtained in the evaluation of natural banks. The monitoring of 27 management areas with the Subsecretariat helped generate a socioeconomic characterization of the management areas of the Region of Aysén. This generated a significant proximity with the beneficiaries (artisanal fishermen), who have increased their technical knowledge and understanding of the regulations that govern its work.

In the framework of the Regional Government's program for the productive diversification of artisanal fishing, the Center generated knowledge of the main regional fisheries and proposed a research plan for each type of fishery in the short and long term. In response to the need for productive diversification, CIEP has begun works that seek to promote the cultivation of species not affected by red tide, and which are of great interest to artisanal fishermen.

In the sustainable tourism line, CIEP has followed the concept of science tourism and has made interesting regional proposals that combine the production of knowledge with recreational activities, creating new regional opportunities to reinforce the international interest for the regional laboratory that is Aysén. It has also combined knowledge of its natural and cultural patrimony, both historical and prehistorical, with the development of visitor experiences, positioning its own brand: "A Patagonia to discover." Through strengths identified in the entire regional territory, it has made new proposals linked to the coast and gastronomy that include microenterprises, small businesses and entrepreneurs.

Between 2011 and 2014, CIEP developed 60 projects⁶, and its researchers produced 79 scientific articles (ISI), which were published in journals with an average impact index of 2.864. To disseminate the results of their activity, they also produced 72 scientific works, which were presented at 48 congresses. During this period, CIEP supported the development of 10 Ph.D. and postdoctoral theses, 13 Master's theses and 17 undergraduate theses on topics related to its work.

⁶ The list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/.

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI publications	29	15	20	15	79
Impact index	2.601	2.804	2.980	2.832	2.864
Non-ISI publications	14	11	3	8	36
Number of works presented at scientific congresses	18	23	17	14	72
Number of scientific congresses at which the Center presented works	13	17	8	10	48
Ph.D. and Master's theses underway with the support of the Center*	0	4	8	13	23
Undergraduate theses underway with the support of the Center*	1	4	11	7	17

* As theses last more than a year, they are counted in each year of their development.



CEQUA
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CEQUA

REGION OF MAGALLANES
AND THE CHILEAN ANTARCTIC

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REGIONAL CONTEXT ¹

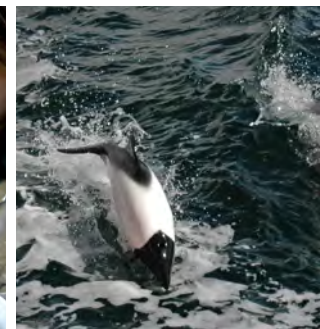
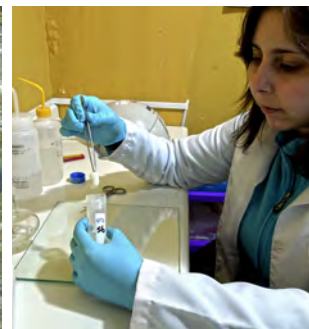
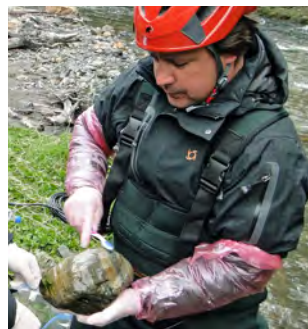
SOCIOECONOMIC PROFILE OF THE REGION

Regional GDP (2013)	MMCLP 853,366 (0.8% of the national total).
Main sectors by contribution to regional GDP (2012)	Mining (17.9%), public administration (14.6%), construction (12.5%) and trade, restaurants and hotels (11.3%).
Business composition (2013)	There are 11,392 businesses and 67,424 dependent workers in the region. 67% of these are microenterprises, which employ 10.7% of all workers. The trade sector concentrates the largest percentage of both businesses (32.1%) and workers (20.9%). The manufacturing industry represents 8.8% of all businesses, the agricultural and forestry sector represents 5.3%, while fishing represents 4.2%.
Exports (2013)	MMUSD 604 (0.8% of the national total). Manufacturing generates 90.6%, including 55.6% of the food industry and 9.1% of the basic chemical products industry.

PROFILE OF THE REGION IN SCIENCE, TECHNOLOGY AND INNOVATION

Higher education entities (2015)	There are 3 universities in the region, including Universidad de Magallanes. In 2014, the available graduate degrees included 7 Master's programs, mainly in scientific fields (3).
Regional competitiveness index (ICORE) 2012	The region ranks 3 rd in the country (index of 0.571). It also ranks 7 th in the field of "innovation, science and technology".
Business innovation (2011-2012)	The business innovation rate is 17.9% (compared to a national average of 23.7%). The technological and non-technological innovation rates are similar, around 13.5%, and both are below the national rates (18.8% and 16.4%, respectively).
Articles published in indexed scientific journals (2003-2012)	A total of 520 articles (0.8% of the national total). The annual number increased at an average rate of 6% during this period. The rate of international collaboration is 67.1% (compared to a national average of 52.4%). The normalized impact of regional production is 1.04, which falls to 0.97 in the case of production in which the region is the leader.

¹ Data sources for this regional profile, as well as some conceptual clarifications common to all regions, are presented on page 10.



REGIONAL STRATEGIES

The *Regional Development Strategy, Magallanes and the Chilean Antarctic, 2012-2020* proposes an image of the region that includes, among other characteristics, the goal of inserting Magallanes in the international scientific and technological field. In terms of productive development, the priority sectors include the promotion of competitive tourism through the positioning of the Antarctic and Sub-Antarctic brand by developing world-class touristic destinations and products and the sustainable and competitive development of fishing (both artisanal and industrial) and aquacultural activities, in both cases emphasizing the strengthening of innovation and entrepreneurship of the business and public sectors.

In terms of science, technology and innovation, the strategy aims to strengthen human capital as a fundamental pillar for developing STI within the region; to create relationships between science, technology and innovation; and to maximize the scientific and economic potential of STI areas through the sustainability and conservation of biodiversity.

The *Regional Policy for Science, Technology and Innovation, 2010-2020* adds to the aforementioned guidelines the development of public institutions capable of catalyzing STI. As part of its future vision, it aims to position the region as a social and economically attractive territory, with a development based on its natural surroundings and its biodiversity, which is its fundamental patrimony and a main source of its scientific, technological and innovative capacities.

CENTER FOR QUATERNARY STUDIES IN FUEGO-PATAGONIA AND ANTARCTICA (CEQUA)

CEQUA was created in 2001 and established as a private non-profit corporation in 2005. Its founding institutions are Universidad de Magallanes, the Fisheries Development Institute (IFOP), the Regional Government of Magallanes and the Chilean Antarctic and CONICYT. Its executive director is Paola Acuña Gómez.

CEQUA's mission is to conduct scientific research that may have a positive impact on the comprehensive and multi-sectorial development of the Region of Magallanes and the Chilean Antarctic through the creation, dissemination and technological transference of the knowledge generated by the Center. Its vision is to become a sustainable center that is a reference point for science, innovation and technology in the region and the entire country, conducting local science with a global impact.

GOALS

CEQUA's work aims to contribute knowledge on the health, management and conservation of natural resources and southern ecosystems, territorial organization and the relationship between science and the community. Its efforts focus on the patrimony of the southernmost region in the world, by generating knowledge, value, care, protection, management and a good use of ecosystems and natural resources in a region known for its conditions as a natural laboratory.

For this purpose, the Center works in three research lines: aquatic ecosystem ecology, climate change and recent variations, and territorial studies.



By installing a time lapse camera, which records the formation of ocean ice, it is possible to assess the detachment and mobility of ice in a fjord. The goal is to establish the relationship between glacier dynamics and the formation of ocean ice in Patagonia, recent variations that help measure the impact of climate change (Glacier fjord at Gran Campo Nevado).

RESEARCH LINES²

AQUATIC ECOSYSTEM ECOLOGY

Goal: to generate and transfer high-level scientific and technological knowledge on the subject of aquatic ecosystem ecology in the Region of Magallanes and the Chilean Antarctic, in order to contribute with high-level interdisciplinary knowledge for the conservation of biodiversity and the sustainable management of resources (both ocean and sweet water) present in the region's southern water ecosystems.

Technical team: Fabiola Arcos (Dr., line coordinator, CEQUA). Researchers employed by CEQUA: Paola Acuña (Dr.), Rocío Canche (Dr.), Máximo Frangópulos (Dr.) and Jorge Acevedo (M.Sc.). Research support (CEQUA): María José González (Bach.), Carla Mora (Bach.), Marco Pinto (Bach.), Diana Schofield (Bach.), Sebastián Ruiz (Bach.), Guillermo Alvarado, Juan Carlos Unión and Óscar Mancilla.

CLIMATE CHANGE AND RECENT VARIATIONS

Goals: to identify the potential impacts of global climate change scenarios on southern ecosystems and the socio-productive activities of the Region of Magallanes and the Chilean Antarctic, in order to produce scientific information that may help public and private agencies plan their actions and make early decisions to mitigate the negative impacts caused by environmental modifications due to regional climate changes.

Technical team: Researchers employed by CEQUA: Inti González (Bach.). Research support (CEQUA): Rodrigo Gómez (Bach.).

TERRITORIAL STUDIES

Goals: to contribute to the sustainable development of the Region of Magallanes and the Chilean Antarctic through the study and planning of ecosystems and productive activities, considering environmental issues, in order to contribute to the social and economic well-being of the region. For this purpose, it conducts studies that apply to territorial development, searching for solutions to regional problems, oriented towards the comprehensive development of the territory, as a transversal line that collaborates closely with the Center different areas.

Technical team: Carlos Olave (M.Sc., line coordinator, CEQUA). Researchers employed by CEQUA: Ernesto Davis (M.Sc.), Juliana Torres (M.Sc.) and Germaynee Vela-Ruiz (M.Sc.). Research support (CEQUA): Francisca Quezada (Bach.) and Manuel Sánchez.

² Information on technical teams is updated until June 2015. The abbreviation "Bach." indicates that the professional has earned a Bachelor's Degree, such as a B.A. or B.Sc.



RESOURCES OF THE CENTER DURING THE 2011–2014 PERIOD³

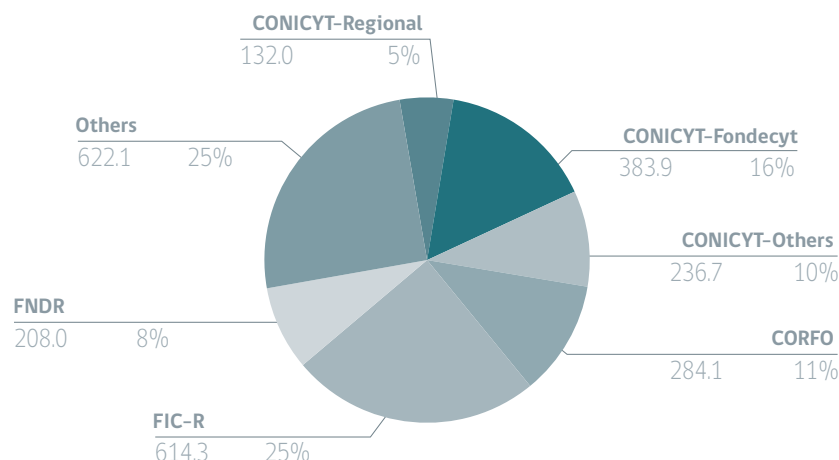
Core funding from CONICYT Regional Program*	MMCLP	590.0
Core funding from Regional Government of Magallanes and the Chilean Antarctic**	MMCLP	390.0
Resources awarded through projects from different sources	MMCLP	2,481.0

* CONICYT has committed core funding for the Center until 2016.

** The Regional Government has approved increased multi-annual funding for the coming years.

CEQUA: resources awarded through projects from different sources, 2011–2014

(Millions of Chilean pesos and percentage distribution by funding source)



Source: CEQUA and CONICYT Regional Program.

Note: CONICYT-Regional: CONICYT Regional Program; CONICYT-Fondecyt: CONICYT's National Fund for Scientific and Technological Development; CORFO: Chilean Economic Development Agency; FIC-R: Regionally-Allocated Innovation Fund for Competitiveness; FNDR: National Regional Development Fund.

PROGRESS, RESULTS AND IMPACTS

FOCUS OF CEQUA'S ACTIVITIES

The Center work focuses on two main pillars: the relationship between scientific activity and the community, and particularly the educational system, seeking to create regional pertinence in the contents of study plans and promoting among children and adults a sense of belonging to the valuable territory they inhabit (taking advantage of the fact of living in a region that is particularly rich in natural resources and natural history); and the relationship between science and business in two fields that are priorities in the regional development strategy: tourism and fisheries.

CEQUA's activities are implemented through the work of specialized laboratories in each research line. In the line of aquatic ecosystem ecology, the biological oceanography laboratory studies coastal environments (fjords and canals), with an emphasis on oceanographic processes that affect the creation of harmful algae

afflorations (known as "red tide") and their impact on the components of the marine food chain. Studies on regional phytoplankton and zooplankton seek to identify signs of changes in its distribution and abundance, and the eventual impact of climate change on these in terms of one of its main environmental stress factors, ocean acidification. There is also work being done in limnology, in order to establish a baseline of physical-chemical and biological parameters of the continental bodies of water (rivers and lakes) and to provide public agencies with the necessary information to support decision-making on issues such as the invasive microalgae *didymo* (*Didymosphenia geminata*).

The research laboratory on top predators conducts studies on marine mammals and birds in Sub-Antarctic and Antarctic ecosystems, on issues related to conservation, ecology and life histories, nature

³ In current Chilean pesos of each year.

tourism, and stable isotopes to determine the status of populations and food chains.

The genetics and genomics laboratory studies the phylogenetic relationships between species and the genetic structure and diversity of the populations of flagship regional species and fish species with commercial potential. It has also begun to implement genomic technologies and genic expression, knowledge that is key to the conservation and sustainable management of natural resources and highly important in aquaculture.

The geographic information systems (GIS) and remote sensing laboratory aims to contribute capabilities and

skills in the use of GIS and the processing of satellite images, as applied tools in the study of spatial events and phenomena that directly affect the region. It also aims to strengthen a technological nucleus capable of diagnosing the conditions present in physical-oceanographical variables, in order to help evaluate the situation of marine biodiversity and the monitoring of climate change events.

The line of climate change and recent variations has been successful in implementing activities to study ocean ice, a relevant activity that had not been developed previously in Chile.

RELATIONSHIP WITH REGIONAL POLICIES

CEQUA's work is clearly aligned with regional strategic goals, since, in productive issues, it aims to promote the sustainable and competitive development of the region, particularly the tourism sector and fishing and aquacultural activities. The Center also represents a top-rate scientific activity pole which helps create and strengthen specialized human capital, increase regional scientific productivity and establish national and international collaboration networks on the issues of most interest for the region, such as knowledge and the preservation of the natural environment, biodiversity and studies related to climate change.

Along with providing a permanent source of information for making regional decisions, the Center participates actively in several of the issues included in the Regional Strategic Plan 2010–2020, which also underscores the pertinence of its work and its vision as a contribution to regional development.

CONTRIBUTION TO HUMAN CAPITAL AND REGIONAL INFRASTRUCTURE

CEQUA's research team consists exclusively of researchers employed by the Center, with no researchers associated from other entities. Since it lacks associate researchers with a high degree of productivity and professional experience, the Center has hired external consultants in all three research lines. It also implements a program for researcher specialization and training of administrative professionals, which has achieved promising results.

2015 technical team	Employed	Associated	Total
Researchers with a Ph.D.	4	0	4
Researchers with a Master's degree	5	0	5
Professionals and technicians who support research	12	0	12
Total	21	0	21

The team consists of 21 people, including 4 researchers with a Ph.D. and 5 with a Master's degree⁴. 13 of these researchers, professionals and research support technicians work in the line of aquatic ecosystem ecology, 2 in climate change and 6 in territorial studies. They are joined by a management team of 10 people.

CEQUA also welcomes young professionals from the region who are just beginning their careers, as well as students from different regions of the country and from other countries, through internships and research theses with the specialists.

The Center is located in the city of Punta Arenas. It is planning the construction of a corporate building with a surface of 750 square meters, using resources committed by the Regional Government. It already possesses the equipment necessary to establish seven specialized laboratories, which will be implemented in its corporate facilities.

⁴ The list of the Center's researchers is available at: www.conicyt.cl/regional/category/estudios-y-documentos/.

RELATIONSHIP WITH RELEVANT STAKEHOLDERS

Networks for scientific collaboration

At the international level, CEQUA collaborates with the Center for Biological Studies of the Mexican Northwest (CIBNOR), Universidade de Sao Paulo (Brazil), the National Institute of Science and Technology of the Cryosphere, the Polar and Climate Center of Brazil, Universidad de Córdoba (Spain), Universidade de Algarve (Portugal), University of Copenhagen (Denmark) and Fundación Marcuáticos (Colombia).

Within the country, it has established relationships with the Chilean Navy, Universidad Austral de Chile, the Center for Research on Patagonia Ecosystems (CIEP), the Fisheries Development Institute (IFOP) and the Andean Geothermal Center for Excellence (CEGA), among others. Within the region, it has relationships with the regional IFOP, the National Forestry Corporation (CONAF), the General Directorate of Waters (DGA) and, in the private sector, with Turismo Comapa, Turismo Fitz Roy, Global Fishing and the Torres del Paine Association of Tourist Hotels and Services (HYST), among others.

Relationship with local organizations, industry-related and government agencies

CEQUA has strong ties to the tourism sector, due to its contributions to the management plans for the Bernardo O'Higgins and Francisco Coloane parks, the sustainable tourism management system project in protected areas of the Torres del Paine National Park, and the study of sustainable penguin sightseeing tourism on Contramaestre Island, among others. It also has an agreement through which the Ministry of National Goods authorized the Center to use this island, transforming it into a space to develop scientific activities and sustainable tourism.

Since 2011, the Center has supported the recreational fishing sector through several projects, one of these focused on creating work roundtables in order to promote this activity in the most relevant municipalities, and three projects related to the monitoring, study and dissemination of knowledge on the invasive microalgae *didymo* in the region's continental bodies of water, which has been explored in its entirety to avoid the propagation of this plague and to raise awareness within the recreational fishing sector regarding the threat it represents for sweet water ecosystems.

The Center has also worked with the municipalities of Punta Arenas, Puerto Natales, Porvenir and Primavera on environmental certification, clean energies, ecotourism, fishing and aquaculture and education; and on initiatives with artisanal fishermen, studying different fish resources, such as king crab (*Lithodes*



santolla) and hake (*Merluccius australis*). It has also subscribed agreements with the Kawésqar Community in Puerto Edén and the General Directorate of the Marine Territory and the Merchant Marine, among others.

CEQUA participates in different regional working groups, on issues such as energy, tourism, water resources and benthic resources, as well as on the Environmental Advisory Council. In the action framework of the Regional Government, it also participates as a permanent member on different roundtables involved in the development of the Regional Strategic Plan, 2010-2020, such as Science, Technology and Innovation, the Environment, Tourism, and Food Safety, among others.

RESULTS AND IMPACTS IN THE REGION

In a region with a great biodiversity and potential for climate change studies, CEQUA produces essential scientific knowledge on ocean, coastal and continental water ecosystems, while also supporting municipalities on productive and environmental issues, contributing valuable information for decision-making, promoting the sustainable development of tourism and the fisheries and aquaculture sectors, and promoting interest in science among children and young people.

CEQUA's team has achieved results and progress in several areas related to its main goals. In its efforts to control the marine plague *Didymosphenia geminata*, or "rock snot", it has achieved an acknowledged national leadership in terms of its monitoring, studies, mitigation measures, identification of propagation vectors, and dissemination of information in the community. The

projects with the greatest regional impact include two initiatives that have led to the creation of a regional program for monitoring and dissemination of information on the algae, as well as a regional working group with the participation of seven public services.

In collaboration with specialists from IFOP, CEQUA's researchers are also working to detect new species of microalgae that produce "red tide" in the region, as well as to implement *in situ* devices to detect and quantify their presence.

The line of aquatic ecosystem ecology implemented the first molecular ecology laboratory and consolidated the region's first biological oceanography group. Its work produces knowledge that helps determine the health of southern ecosystems. The Center also conducts research in the field of ocean acidification caused by climate change, which represents a contribution to the international study of this issue and the knowledge of its effects on fisheries.

It also studies the environmental impact produced due to the implementation of non-conventional renewable energies, such as the tidal or wave energy. It also deals with the implementation of geothermal and hydrokinetic energy for productive development in isolated municipalities.

In another field, CEQUA works to lay the biological foundations for the cultivation of marine crops, conducting basic biological studies (in genetics,

genomics, physiology, reproduction, histology and GIS) applied to the conservation and productive sustainability of emerging and potential fisheries. In this area, it has been able to sequence the entire mitochondrial genome of the king crab (*Lithodes santolla*) and the transcriptome genome of three genes of the species, which represents the first national result of this type for fisheries.

The Center's researchers also work to add value to the production of the artisanal fishing, through efforts that aim to achieve geographic identification, denomination of origin, and quality and clean production seals. In this field, two projects that implement molecular tools to contribute to a sustainable management plan for the king crab resource and its commercial value-added have helped support CEQUA's application to the National Seal of Origin program through the National Industrial Property Institute (INAPI), which seeks to grant geographic denomination and/or denomination of origin for products that are characteristic of each region.

The territorial planning work through geographic information systems (GIS) and remote sensing represents a basic input for the National Forestry Corporation (CONAF) and has helped provide the results this entity requires to implement management plans for natural parks, reserves and protected areas within the region. The result was the creation of the first protected marine area in Chile, Francisco Coloane Park,



CEQUA implements several projects involving the invasive microalgae *didymo*, which includes monitoring and studying this plague and disseminating information on the threat it represents for sweet water ecosystems (sampling of planktonic microalgae in the area of the Las Mellizas lagoon, Torres del Paine National Park).

and the development of the first baseline study of the Bernardo O'Higgins National Park, as well as the fine cartography of the Torres del Paine National Park and the pilot study on this park's tourist capacity.

CEQUA's researchers are responsible for updating the marine biodiversity databases for the region in national statistics, which determine the status of national fauna. This also contributes to the biological knowledge on populations of Antarctic and Sub-Antarctic marine mammals, for their conservation and sustainable management, for example for purposes of ecotourism. The Center has established international relationships to guarantee continuity for the study of the migration of the humpback whale, as an ecotourism alternative.

In the community, the Center's work has helped strengthen the development of ten municipalities within the region in issues such as energy alternatives for isolated zones, sustainable tourism, fishing and aquaculture, the patrimonial value of each municipality, and environmental certification. In this last aspect, the Center has acknowledged experience at the national level. CEQUA's team also does valuable work to recover the patrimony of indigenous peoples, particularly by introducing the Kawésqar and Yagan ethnic cultures in the educational system.

In terms of information transfer, the Center developed an online platform, the Biodiversity Information System (SIB) (www.sibmagallanes.cl), by compiling, classifying and organizing biological and ecological information on the species that are present in the region, especially those with economic, cultural or scientific potential, in order to help improve economic and social decision-making processes.

CEQUA is also committed to the transfer of knowledge to the regional educational system, through the publication

of didactical and attractive books (such as activity workbooks and observational guides), created following the participation of students in the implementation of the Center's projects. It also publishes the biweekly magazine *Cequarito* (a supplement that comes in a local newspaper), the "Mini-Scientists" website, and a series of activities designed for children, young people and the general community, such as science fairs, contests, the celebration of important environmental dates, and science cafés, among others.

Between 2011 and 2014, CEQUA implemented 73 projects⁵. Its researchers produced 45 scientific articles (ISI), in magazines with an average impact index of 2.319, and a total of 107 scientific works, which were presented at 50 congresses. During this period, the Center supported the development of 8 Master's theses and 8 undergraduate theses, on subjects related to its research lines.



⁵ A list of the Center's projects is available at: www.conicyt.cl/regional/categoria/estudios-y-documentos/

Main indicators	2011	2012	2013	2014	2011-2014 period
ISI Publications	20	13	8	4	45
Impact index	2.253	1.976	1.627	2.375	2.319
Non-ISI publications	16	15	4	8	43
Number of works presented at scientific congresses	18	41	31	17	107
Number of scientific congresses at which the Center presented works	7	16	19	8	50
Ph.D. and Master's theses underway with the support of the Center*	2	4	8	3	8
Undergraduate theses underway with the support of the Center*	3	5	3	3	8

* As theses last more than a year, they are counted in each year of their development.



With the goal of supporting scientific and technological research in the different regions, as a motor for its economic and human development, the CONICYT Regional Program, along with regional governments, has promoted the creation and strengthening of Scientific and Technological Research Centers throughout the country. Through its working model, it seeks to respond to needs and issues that are relevant to each local reality, in order to satisfy the aspiration of doing science in and for Chile's regions.

The 13 regional research centers currently operating in the country –with the natural diversity arising from the characteristics of each regional environment and the respective stage of development of each center– have achieved interesting progress and results in basic research, technological development, and the creation of processes and products for various productive sectors. They have also contributed to debates and decision-making processes on issues of regional importance and have supported higher education and schools, while also helping bring science closer to the community.

This document, 15 years after the creation of the CONICYT Regional Program, seeks to explain this progress, as well as the impact and potential of the work of each regional center.

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