Asia-Pacific
Economic Cooperation

Advancing Free Trade
for Asia-Pacific Prosperity

Efficient and Sustainable Use of Water for Agriculture under the New Climate Scenarios as a Contribution to Food Security

APEC Policy Partnership on Food Security

December 2020

APEC Project: PPFS 04 2018

Produced by
National Commissión of Irrigation (CNR in Spanish)
Av. Libertador Bernardo O´Higgins #1449, 4th floor, Santiago, Chile
http://www.cnr.gob.cl

For
Asia-Pacific Economic Cooperation Secretariat
35 Hong Mui Keng Terrace
Singapure 119616
Tel: (65) 68919600
Fax: (65) 68919690
Email: info@apec.org
Website: www.apec.rog

APEC#220-PP-01.4

TABLE OF CONTENTS

Introduction

This document is part of the Final report of the APEC Project called “Efficient and Sustainable Use of Water for Agriculture under the New Climate Scenarios as a Contribution to Food Security”. Title and number of the project: PPFS 04 2018.

Its content presents consolidated information of the products such as Preliminary Report, Brochure, Seminar, Field Days and the results of a consultation process on successful cases carried out to all the economies that are part of APEC.

Regarding the Preliminary Report, it consists of a review of experiences in the efficient use of water for agriculture in APEC economies. The cases presented correspond to a selection of the best projects to improve the efficient use of water and energy for agriculture, in accordance with the criteria established by the National Commissión of Irrigation (CNR), which is an institution belonging to the Chilean economy.

For the search of information of successful cases, initially it was necessary to define the topics of interest to be addressed, which was in charge of CNR.

Relevant and contingents issues were defined as large search groups, which were called “dimensions”. From the foregoing, it was agreed that the issues that should be included in these dimensions are the following: Watershed management; Pressurized water conduction systems; Renewable Energy; Irrigation canal networks; Accumulation systems, Recharge of aquifers; and others.

After this stage, the search itself was executed, supporting this activity through different digital media, websites, publications, news, magazines, among others that could yield results according to what you want to find out, and the methodology for search is carried out by economy and by dimension in each of them.

Based on the results of cases prioritized the consultant for the Preliminary Report document, the cases presented in the seminar and the visits on field days that took place during the Workshop program for APEC 2019 were incorporated, to which a second prioritization was made through the application of the criteria compliance score. These criteria were related to innovative merit, background availability, replicability potential and others that are presented in detail in this report.

As it was mentioned before, between the 24th and 26th of July, 2019, a Workshop with APEC resources was organized by the National Commission of Irrigation of the Chilean Ministry of Agriculture. This initiative was supported (co-sponsoring economies) of Australia, Canada, New Zealand, Peru and Papua New Guinea economies.

The Workshop had an extension of three days. The first day consisted of a seminar and the following days were held in different fields visiting innovative experiences in the efficient use of water and energy resources.

Consolidated summary of the results obtained

Below is a consolidated summary of the contents and methodologies used to obtain the products of the APEC project called "Efficient and sustainable use of water for agriculture under the new climate scenarios as a contribution to food security" Title and number of the project: PPFS 04 2018. The aforementioned products consist of:

- A Preliminary Report about the search of successful cases on the efficient use of water and energy in the APEC economies, as well as consultation results for representatives of each economy.
- A Brochure that incorporates successful cases with the highest replicability potential of the economies that are part of APEC.
- A seminar, where experiences on the efficient use of water and energy were presented by the representatives and experts of the APEC economies.
- Two Field Days, where visits were made to the different successful projects on extra and intrapredial water management, aquifer recharge and energetic efficiency in the Chilean economy.

Preliminary Report

This preliminary report consists of a review of experiences on the efficient use of water for agriculture in the APEC member economies. The cases presented correspond to a selection of the best projects to improve the efficient use of water for agriculture, according the criteria established by CNR and the results of a consultation process on successful cases carried out to all the economies that are part of APEC.

For the search of information, initially the main issues had to be defined to address on the basis of what is required by the counterpart. The task of defining the research theme was carried out together with the professionals of the National Commission of Irrigation (CNR) in order to be able to include and cover the main topics that have to do, transversally, with the efficient use of water and energy for agriculture. All this, in the framework of food security in successful experiences that have a high potential to be replicated by APEC economies.

Relevant and contingents topics were defined as large search groups, which were called "dimensions". From the foregoing, it was agreed that the issues that should be included in these dimensions are the following: Watershed management; Pressurized water conduction systems; Renewable Energy; Irrigation canal networks; Accumulation systems, Recharge of aquifers; and others.

After this stage, the search itself was executed, supporting this activity through different digital media, websites, publications, news, magazines, among others that could yield results according to what you want to find out, and the methodology for search is carried out by economy and in it, for each of the defined dimensions.

As a first approach the collection of successful experiences, all the results that meet the search criteria are classified by importance and compliance of the initially established criteria. The procedures to prioritize the results were organized according to their relevance; the results that for some reason could not be replicated or that lacked research information; and finally, the results that for some reason had vague and/or ambiguous information or did not fully meet the search criteria.

Moreover, some private institutions (global and local) both of equipment, management or other topic framed in the search dimensions were contacted by e-mail and by phone. These contacts were asked for their collaboration to share their experiences.

The format and the content of the information in the cases of successful experiences were defined with the responsible actors of the local economy (Chile).

The Preliminary Report document was structured as follows: Introduction; The most relevant cases identified in the APEC economies; Results of cases obtained from the online consultation process to the representatives of each of the APEC economies; and a final conclusion. The cases were presented by each of the economies where relevant results were obtained from being incorporated in the document, having a total of 82 cases.

Brochure of successful cases

From the results of the 82 cases prioritized by the consultant for the Preliminary Report document, the cases presented in the seminar and the visits in the field days that took place in the Workshop program for APEC 2019 were incorporated, to which a second prioritization was performed through the application of the criteria compliance score, using a scale from 0 to 10. For each case, these scores were added to prioritize those with higher value. The criteria used were the following:

- It has minimal information to evaluate its replicability
- It has access to complementary information sources
- It has high quality images and / or contact information to manage images
- It has information on investment and / or operation costs
- There are clear and quantified results
- It contributes to water / energy efficiency in agriculture
- It is an Innovative Project
- The case contributes to food security
- It has replicability in APEC economies
- The case was presented in the Seminar / field days of APEC 2019

For the elaboration of the Brochure document entitled **SUCCESSFUL CASES AND EXPERIENCES ON THE EFFICIENT USE OF WATER IN AGRICULTURE IN APEC ECONOMIES**, the consultant carried out a background search to complement the information of each prioritized case through secondary information and communication with each of the participants or executors of the initiatives.

The Brochure information on the successful cases and experiences on the efficient use of water in agriculture in APEC economies was grouped and presented by dimensions, considering the following:

- Efficient Intrapredial Use
- Efficient Extrapredial Use
- Aquifer recharge
- Water storage systems
- Water reuse
- Renewable energy

For each of these cases, the following information was presented:

- Name of the case
- Localization
- Case description
- Benefits
- Type of investment
- Contact information
    - Type of contact
    - Name of the contact
    - Institution / Organization
    - Email / website
    - Phone number
    - Other sources of information

To finalize the Brochure document, a space for recommendations was included, rescuing the most relevant aspects of the different experiences of the identified successful cases.

Seminar

The seminar framed in the Workshop activities was celebrated on July 24th, 2019, in the conference room of the Cumbres of Lastarria Hotel in Santiago, Metropolitan Region.

For the preparation of the seminar, a selection of topics to be presented was made, including new sources of water, aquifer infiltration, efficient use of water and energy resources projects, and experiences in the APEC economies, of which the pertinent contacts were made with experts of the APEC economies on the topics indicated above.

Figure 1 shows the program of the seminar and a background summary of the specialists that participated as speakers, grouped by thematic areas:

Figure 1. Seminar Program.

Water efficiency experiences

Water efficiency is understood as the optimization of the use of water in productive systems, which implies extra and intrapredial level actions. These actions can be referred to conduction and distribution infrastructure, incorporation of technologies for monitoring and / or control of water use, as well as knowledge generation for the establishment of rules in decisions on the efficient use of water in crops during the different growing stages. In this context, it was possible to have the participation of two experts in these topics, who presented their experiences.

Mr. Jordon Navarrot
Theme: Telemetry Systems in Channels
Delegate of Claim District No. 108 of California, United States.

He has extensive experience in telemetry systems, flow measurement with acoustic, mechanical methods and knowledge in the use of automated gates. As a delegate, he is responsible for carrying out the annual water balance and crop analysis.

Navarrot holds a degree in accounting sciences from California State University (CSU, Chico), United States and he is a Minor in Sustainability Studies.

Dr. Rose Brodrick
Theme: Water irrigation efficiency
Scientific researcher at the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia.

Her experience focuses on the development of new technologies and integrated digital systems for the agricultural industry focused on improving agricultural productivity. She has 17 years of work with cotton growers to develop management solutions in irrigated agriculture. Her research in crop physiology and agronomy has led to changes in production practices within the Australian cotton industry.

Brodrick has a PhD in Philosophy from the School of Earth and Food Sciences at the University of Queensland, Saint Lucia, and has a degree in Applied Science (Ecology) from the Queensland University of Technology, Brisbane, and a degree in Environmental Biology University of Technology, Sydney.

Agricultural experiences

Regarding agricultural experiences, we find different initiatives which address the creation of laws and public policies that can contribute to the order and regulation of the actions to be implemented in terms of efficient use of water, as well as, investment strategies in accumulation, distribution infrastructure and control of watershed level, early warning alert systems for extreme events. Other lines of actions are found in the strengthening of water users through different financing programs or instruments. In addition, there are research and development experiences of irrigation technologies with a high impact on the optimization of the use of water resources at an intrapredial scale. In this segment, three experts on these issues participated representing their economies.

Dr. Wu Jingwei

Theme: Chinese experience in irrigation and drainage

Associate Professor of the Department of Irrigation and Drainage at Wuhan University, China.

He has a Master's degree in hydraulic and electrical engineering from the University of Wuhan and a PhD from the École Nationale du Génie Rural des Eaux et des Forêts in France, together with the University of Wuhan, China.

He has developed several investigations related to demand determination in crops, pollution and water management with emphasis on salinity.

Ms. Pajaree Singto

Theme: Thai experience in hydrology associated with agriculture

Hydrologist of the Royal Irrigation Department of the Ministry of Agriculture and Cooperatives of Thailand.

Hydrologist of the Royal Irrigation Department of the Ministry of Agriculture and Cooperatives of Thailand.

Bachelor of Physical Sciences and Master of Science in Applied Statistics from Naresuan University Phitsanulok Thailand.

She has studies in the strategic use of technologies of observation of hydro meteorological data and knowledge of water management in cases of flood and drought.

Dr. Abel Quevedo
Theme: Sustainable irrigation system with porous emitters
Agronomist, irrigation specialist at the Autonomous University of Chapingo, Mexico.

Master of Science in Agrometeorology (1994) with honorable mention and Doctor of Science in Edaphology (2005) by the Graduate College. He made updates at the University of Tottori, Japan and the United States Forest Service. He has published several scientific articles, and participated in the training of undergraduate, master and doctoral students. He has also been a professor of Hydrology at the Metropolitan Autonomous University. He is currently a research professor in the Postgraduate Program of Hydro-Sciences.

His areas of professional development are: Agrometeorology, Agroclimatology, Irrigation (control and management of irrigation water) and software design.

Renewable energies in agriculture

The growth of world population implies the need to increase the food production rates, which leads to an increase in the requirement of water and energy consumption. In addition, the search of reduction in water consumption through the implementation of technified irrigation implies an increase in energy consumption in agriculture. Against this, renewable energies become a significant contribution to reducing the dependence of agriculture to fossil fuels. To understand the evolution of renewable energies in agriculture and the implementation of strategies of investment support, two experts in the area were involved.

Mr. Bastián Celis Huaiquilaf
Theme: Renewable Energies in the agriculture of Chile
Professional collaboration agreement for the development of renewable energy in irrigation (National Commission of Irrigation - Ministry of Energy)

Professional collaboration agreement for the development of renewable energy in irrigation (National Commission of Irrigation - Ministry of Energy)

Celis is part of the Policy Unit of the National Commission of Irrigation of the Ministry of Agriculture of Chile and he is a Master in Energy Economics from the Technical University Federico Santa María.

Since 2015, he has promoted the incorporation of renewable energies in the agricultural sector for the benefit of small and medium farmers, increasing the competitiveness of their crops.

Mr. Agustín Cáceres
Theme: Floating Photovoltaic systems in agriculture
Member of the Akila SpA Group – Spain

Law degree with more than 15 years of experience in international organizations. Expert in opening new markets, location, development and negotiation of new projects oriented in the field of photovoltaic energy in the agricultural, industrial and mining sectors.

Non-traditional water sources in agriculture

The sustained decrease in water resources availability in a considerable number of the APEC economies, forces to evaluate, investigate and stablish strategies, policies and regulations that allow the use of non-traditional water sources in agriculture. In this matter, the recharge of aquifers, as well as the reuse of treated water, offer a great opportunity to reduce the gap between the supply and demand of water in agriculture. In order to have a background of international experiences, two experts in the area were involved.

Mr. Jacobo Homsi
Theme: Wastewater treatment and reuse
Chemical civil engineer from the Federico Santa María University, Chile

He has more than 40 years of experience in the areas of Wastewater Treatment and Liquid Industrial Waste (RILES), sewage and drinking water. Today he is a professor in the postgraduate program of the University of Chile on environmental pollution issues.

Homsi is a Master in Sanitary Engineering from the International Institute for Hydraulic and Environmental Engineering, IHDE, Delft. Holland.

Dr. Carlos Flores

Theme: Artificial recharge of aquifers in Agriculture

Scientist of the General Water Directorate, Ministry of Public Works of Chile

Scientist of the General Water Directorate, Ministry of Public Works of Chile.

Flores has a PhD in Hydrological Sciences at the University of California, Davis, focused on integrated hydrological modeling for water management. He obtained a master's degree in agricultural engineering from the Universidad de Concepción and a degree in agronomy from the Universidad Mayor de Chile.

Field Days

Depending on the topics to be debated in the seminar, replicable and / or innovative experiences on the efficient use of water and energy resources for agriculture were searched, at an intrapredial level as in organizations of water users. Figure 2 shows the visit program during the field days:

Efficient and Sustainable Use of Water for Agriculture under the New Climate Scenarios

July 25th - Day 2 - Field day - Valparaíso region
Activities

08:00-10:00	Transfer Hotel - Viña Concha y Toro (Close to San Felipe City)
10:00-11:30	Visit to a floating photovoltaic project over an irrigation dam
11:30-12:00	Transfer Viña Concha y Toro - Aconcagua River First Section
12:00-13:30	Visit to a telemetry system project - Aconcagua River First Section Surveillance Board
13:30-15:00	Lunch
15:00-15:20	Transfer San Felipe City - Agrícola Altaramira Fundo Capellania
15:20-17:00	Visit to a Water and energy efficient irrigation project for vineyards
17:00-18:30	Back to Santiago City

July 26th - Day 3 Field day - O'Higgins region
Activities

08:30-09:30	Transfer Hotel - Campus Antumapu - Universidad de Chile
09:30-11:00	Visit to the Canalistas Association "Sociedad del Canal del Maipo" Infiltration project
11:00-13:00	Transfer Campus Antumapu - Viña Cono Sur
13:00-14:00	Lunch
14:00-15:30	Visit to a efficiency energy irrigation project with a photovoltaic system
15:30-17:30	Back to Santiago City

Figure 2: Field days program.

Below, the summary information of the projects visited is presented:

Floating photovoltaic in San Felipe (Viña Cono Sur), Valparaiso Region

Description:

The project installed less than a year ago, corresponds to a floating solar plant of 230 kWp, installed inside the irrigation water storage tank for the cultivation of wine grapes from the Concha y Toro Company.

For the irrigation of 100 hectares of wine grapes (different varieties for red wine), an underground water source is used located behind the hills where the crop is located. In addition, the well is 130 meters deep and is more than 7 kilometers away. The main reason for the implementation of solar panels was to reduce the costs associated with the energy required to bring water from the source to the storage tank.

The company that builds the project structure is Jinko Solar (China), and for this field it had a total cost of USD $ 230,000 with a return period of 7 years, regarding energy costs, and only 2 years if water costs are included.

Photographs:

Contact Information:	
Type of Contact	**Developer**
Name	Juan Carlos Hernández Úbeda
Institution /Organization	Isigenere
Email / Web site	https://www.isifloating.com/isigenere/
Phone number	(+34) 645783190

Installation of automated gates and telemetry in irrigation channels, Manager of the first section of the Aconcagua River, Valparaíso Region

Description:

This project is subsided by the National Commission of Irrigation, where the main goal is to improve the management of water resources through technology, in this case technology related to distribution and delivery of water to the channels of the First Section of Aconcagua River.

The Surveillance Board of the First Section of Aconcagua River has this project involving all its distribution points: there are 25 channels to which water is delivered directly from Aconcagua River. At these points, radial gates with telemetry communication systems are being implemented, where RUBICO WATER Company provides technology and technical advice in its operation. These gate systems allow a more accurate control of water distribution in irrigation canals, and in turn, it allows to incorporate all gate information in an online management platform, facilitating the monitoring and joint operation of all the points or gates that are part of the distribution network. At the end of 2019, there will be 18 operational gates and by 2020 it is expect to finish with the remaining gates.

In the first section of Aconcagua River, there are about 6,000 users that irrigate 27,000 ha. There is no upstream regulation, therefore they depend on thaws, which have high variation flows, where the peak is reached at midnight going to a minimum at noon. Moreover, there are other factors, such as infiltration, hydroelectric power plants, which causes a greatly alteration to the flow and creates difficulty for water users.

Photographs:

Contact Information:	
Type of Contact	**Developer**
Name	Gastón Sagredo
Institution /Organization	Rubicon Water
Email / Web site	enquiry@rubiconwater.com https://www.rubiconwater.com
Phone number	(+56) 9 98725957

Intrapredial telemetry in farm Capellanía, Valparaiso Region

Description:

This Project consisted of the implementation of an irrigation monitoring and control system with a focus in water and energetic efficiency, for a 25 hectare field called “La Capellanía”, property of the Altamira Agricultural Company, in 2016.

For the design of the optimal irrigation of the field, the specific requirements and needs of soil, cultivation and technologies were taken into consideration. The project used the technology provided by DropControl (DP) of the Wiseconn Company.

This field has valves handled wirelessly, they are not cabled to the irrigation hut, they are controlled by nodes, and connected one by one, all the irrigation blocks can be resectioned, from the web platform that uploads the data every 15 minutes and store them in the cloud. Frequency inverters were installed and DP technology communicates with these drives and sets the specific work point in the specific irrigation block.

In terms of investment, in 2016 was USD$5,000 per ha; the materials, installation and telemetry represented only 5%, being able to recover the investment from four to five years.

Photographs:

Contact Information:	
Type of Contact	**Developer**
Name	Tomás Vicente
Institution /Organization	Ingeniería Wiseconn S.A.
Email / Web site	info@wiseconn.cl http://www.wiseconn.cl
Phone number	(+56) 2 29078586

Artificial water infiltration of Channel of Maipo Society, Metropolitan Region

Description:

This project corresponds to an Aquifer Recharge plant developed by the Canal Association "Sociedad del Canal de Maipo", which operates on the Antumapu Campus of the University of Chile. The project contemplates a zone of solid depletion and two recharge experiences both superficial (swimming pools, rafts or lagoons of recharge) and injection (two recharge wells). The design considered a refill flow of 50 l/ s.

The project began operating in February 29, 2016. The first two years were worked measuring every hour 24/7: pH, temperature, NTU, turbidity, water quality, etc., through mobile instruments and fixed sensors which kept an online record. The information was checked to see what was manually measured with the online meters.

The main issues faced in this project are the clogging in the infiltration pools and dwells, as well as water pollution.

So far, more than USD $ 3 million have been invested in studies, geophysics, guards, implementation, equipment, tests, among others.

Photographs:

Contact Information:	
Type of Contact	**Developer**
Name	José Fuentes
Institution /Organization	Sociedad Canal del Maipo
Email / Web site	https://www.scmaipo.cl
Phone number	(+56) 9 93094054 ; (+56) 225922300

Implementation of renewable energy and energy efficiency, O'Higgins Region

Description:

Cono Sur vineyard was founded on 1993. Due to their quality work, they have won a variety of acknowledgements, among those it is worth to mention: Irrigation Energy Management, ISO 50001, Certification 2014, ESCO.

The percentage of clean energy of the enterprise is 48%, which corresponds to the use of solar panels in their different fields and vines.

The project consists of the installment of a photovoltaic power plant of 100kW, connected to the electric network, along with the implementation of two frequency converters for the efficient use of energy from 2 electric pumps.

Photographs:

Contact Information:	
Type of Contact	**Owner**
Name	Claudia Pfau
Institution /Organization	Viña Cono Sur
Email / Web site	https://www.conosur.com
Phone number	(+56) 22476509011

APEC Evaluation Survey

At the end of the second field day, on Friday, July 26, 2019, the participants answered a survey, especially the delegates and speakers of the invited economies to this event. The survey mainly sought to identify the applicability in APEC economies of the experiences that were presented in the seminar and in the field days.

The purpose of this survey was to know the level of satisfaction of the addressed topics in the seminar and on field days, as well as, that respondents analyzed the applicability of the issues addressed in their economies, for example in public policies, training, technology research, among others.

Consolidated summary and analysis of the results obtained

Preliminary Report

Based on the search of successful and replicable cases of the APEC economies, with a main focus on food security and wcater use efficiency, it can be concluded that the results were satisfactory and of great interest. This can be observed in the summaries and files filled by the consultant, in addition to the primary-source information received from companies, organizations and the economies themselves.

The preliminary report filed 82 experiences in the APEC economies on the efficient use of water and energy resources, together with the experiences sent by the delegates and speakers that participated in the seminar.

Regarding the experiences of each economy, the largest number of cases are concentrated in Chile, the United States and China. Table 1 shows the results of number of cases per economy.

Table 1. Number of experiences per economy in APEC on the efficient use of water and energy resources.

Economy	No
Australia	3
Chile	17
China	9
Philippines	3
Hong Kong, China	1
Indonesia	4
Japan	5
Korea	1
Malaysia	1
Mexico	8
New Zealand	5
Peru	4
Russia	1
Singapore	4
Thailand	2
United States	10
Viet Nam	4
Grand total	**82**

Figure 3 shows the percentage distribution of cases considering the preliminary report by APEC economies.

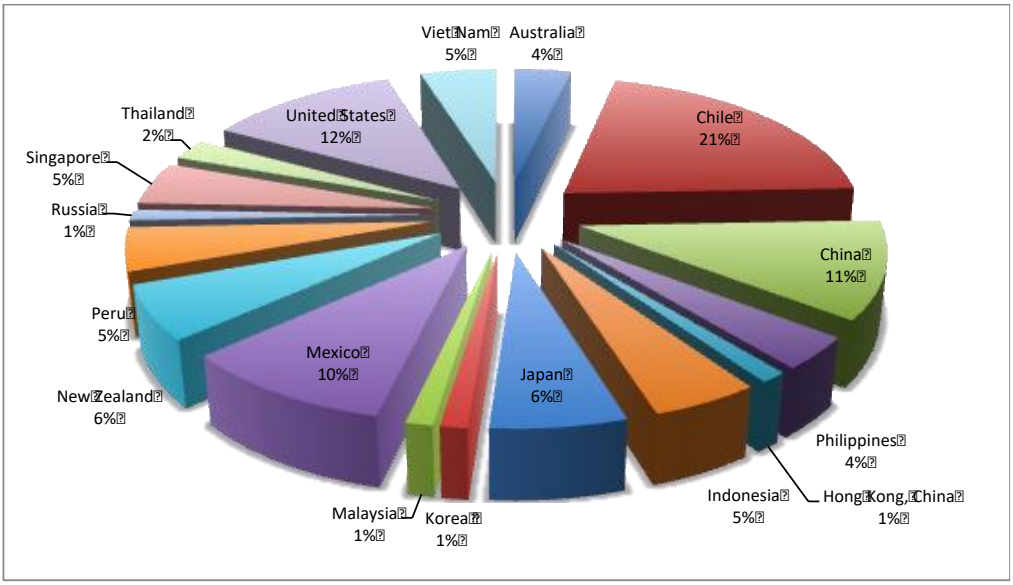


Figure 3. Percentage distribution of cases considered in the Preliminary Report**.**

Eight dimensions of water and energy efficiency were identified in the projects, with the highest concentration in terms of irrigation efficiency at the predial level (farm) and extrapredial level (irrigation systems) with 41% and 17% of the initiative:

Table 2. Number of cases per dimension.

Dimensions	**N°**	**%**
Extrapredial water efficiency	14	17%
Intrapredial water efficiency	34	41%
Renewable energies	3	4%
Watershed management	8	10%
New water sources	1	1%
Others	3	4%
Recharge of aquifers	6	7%
Water reuse	3	4%
Accumulation systems	10	12%
Grand total	**82**	**100%**

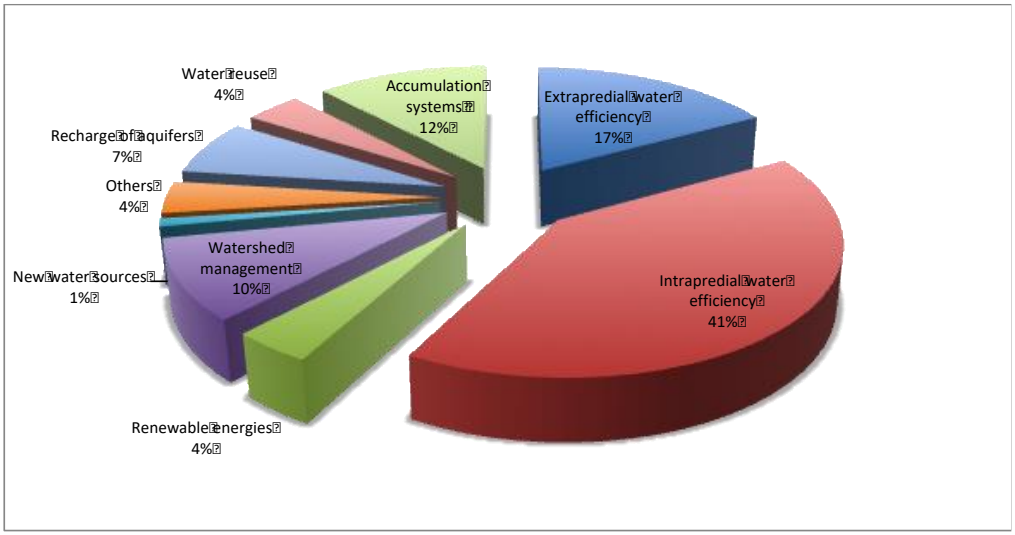


Figure 4. Percentage distribution of cases per dimension.

Below, the next tables provide a summary of each experience or case considered in the Preliminary Report, grouped by dimension:

Table 3. Number of cases per dimension and sub classified on extrapredial water efficiency.

Subclassification	**N° of Cases**
Tubing of irrigation canals	3
Maintenance of extrapredial irrigation systems	3
Gate measurement / automation	3
Pressured and automated network	2
Canal lining	1
Area irrigation improvement systems (basins)	2
Grand total	**14**

Table 4. Number of cases per dimension and Subclasification on intrapredial water efficiency.

Subclassification	**N° of Cases**
Precision Agriculture (Application)	5
Precision Agriculture (Use of sensors)	7
Greenhouses innovation	7
Improvement / innovation of irrigation systems	6
New products for irrigation / accumulation	4
Irrigation improvement projects in large areas	5
Grand total	**34**

Table 5. Number of cases per dimension and subclassification on renewable energies.

Subclassification	N° of Cases
Hydraulic wheel in rivers or canals	1
Photovoltaic system	2
Total general	**3**

Table 6. Number of cases per dimension and subclassification on watershed management.

Subclassification	N° of Cases
Aquifer Management Model	1
Watershed Management Platform	1
Irrigation efficiency program at the farm level and return of surpluses to the basin	2
Program for integrated planning and monitoring of Water Resources	3
Program to improve irrigation efficiency and productivity	1
Grand total	**8**

Table 7. Number of cases per dimension and subclassification on new water sources.

Subclassification	N° of Cases
Implementation of fog-catching systems for irrigation of olive trees and vines	1
Grand total	**1**

Table 8. Number of cases per dimension and subclassification on aquifer recharge.

Subclassification	N° of Cases
Private infiltration initiative	1
Infiltration pools / basins	4
Infiltration pools for aquifer recharge and flood mitigation	1
Grand total	**6**

Table 9. Number of cases per dimension and subclassification on water accumulation systems.

Subclassification	N° of Cases
Reservoir coverage	3
Reservoir construction	1
Underground reservoir construction	1
Platform for optimization of mobile dams	1
SCALL (Rainwater Collection System)	2
Reservoir system	2
Grand total	**10**

Table 10. Number of cases per dimension and subclassification on water reuse.

Subclassification	N° of Cases
Rural drinking water treatment plant	1
Treatment plant for domestic / industrial use	1
Large-scale wastewater treatment (Singapore)	1
Grand total	**3**

Table 11. Number of cases of other typologies.

Subclassification	N° of Cases
Water pump for flood control	1
Cultivation in isolated and controlled rooms	1
FARM App Application	1
Grand total	**3**

It is important to mention that the biggest challenge was the search for relevant information. When it comes to public interest initiatives and mainly with large-scale government financial contributions, some information about the projects is available in websites, media and / or academic publications. Nonetheless, when these initiatives involve individuals and private companies on a small, medium or large scale, the information is not widely disseminated or available to be quantified and referred.

Overall, the Preliminary Report information is based on the work of the consulting firm team, which compiled the as much data as possible to disseminate the attractive initiatives to be replicated and that met the criteria stablished in this background compilation. The Preliminary Report is attached in **Annex 1**.

Brochure of successful cases

In the second prioritization process of successful cases, the criteria compliance score was applied, using a scale from 0 to 10. For each of the 82 cases of the Preliminary Report, these scores were added in order to prioritize those cases that presented the highest total values. The criteria used were the following:

- It has minimal information to evaluate its replicability
- It has access to complementary information sources
- It has high quality images and / or contact information to manage images
- It has information on investment and / or operation costs
- There are clear and quantified results
- It contributes to water / energy efficiency in agriculture
- It is an Innovative Project
- The case contributes to food security
- It has replicability in APEC economies
- The case was presented in the Seminar / field days of APEC 2019

Table 12 shows the result of the number of initiatives prioritized per dimension for the Brochure:

Table 12. Number of cases selected per dimension for the Brochure.

Dimension	**N° of Cases**
Intrapredial water efficiency	12
Extrapredial water efficiency	4
Aquifer Recharge	3
Water accumulation systems	3
Water reuse	2
Renewable energies	3
Grand total	**29**

Below, Table 13 presents a summary of the 29 selected experiences according to the obtained scores per stablished criteria and the prioritized cases by CNR, which were grouped by dimension.

Table 13. Summary of the 29 selected experiences and their corresponding scores obtained from the prioritization process.

Dimension	Cases	Economy	Total Score
Extrapredial water efficiency	Case Nº1: Vertical farm for vegetable growing – Sky Greens.	Singapore	77
	Case Nº2: Hydroponics + education.	Singapore	67
	Case Nº3: Application for monitoring and irrigation, FieldNET ®.	United States	73
	Case Nº4: Precision agriculture experience with sensor use.	New Zealand	68
	Case Nº5: Water Conservation Project II.	China	70
	Case Nº6: Solid Rain / Water Silos.	Mexico	79
	Case Nº7: Imec ® Polymer Film.	Japan	66
	Case Nº8: Water monitoring system - SenSprout Inc.	Japan	70
	Case Nº9: Viet Nam Irrigated Agriculture Improvement Project.	Viet Nam	67
	Case Nº10: Telemetry for table grape orchard.	Peru	72
	Case Nº11: Technification of Surface irrigation.	Mexico	73
	Case Nº12: Intrapredial Telemetry with energy efficiency equipment.	Chile	79
Intrapredial water efficiency	Case Nº13: Small-scale irrigation management Project.	Indonesia	65
	Case Nº14: Pressurized distribution network for irrigation in Los Caleos water community.	Chile	72
	Case Nº15: Flow measurement program of the Reclamation District 108.	United States	76
	Case Nº16: RUBICON Gates, First Section of Aconcagua River.	Chile	CNR
Renewable energies	Case Nº17: Ponds and basins recharge of aquifers.	United States	67
	Case Nº18: Recharge of aquifers in the Ica Valley.	Peru	66
	Case Nº19: Artificial Aquifer Recharge.	Chile	CNR
Water accumulation systems	Case Nº20: Rangitata South Irrigation Scheme (RSIS).	New Zealand	80
	Case Nº21: Barrier Ball Floating Coverage.	Chile	80
	Case Nº22: Water collection system or Small Water Impounding System (SWIS).	Philippines	68
Water reuse	Case Nº23: NEWater.	Singapore	65
	Case Nº24: Reuse of Wastewater Treatment for Irrigation.	Chile	80

Continuation of Table 13….

Dimension	Cases	Economy	Total Score
Renewable energies	Case Nº25: Barsha Pump.	Indonesia	73
	Case Nº26: Samaca Ecological Park.	Peru	69
	Case Nº27: Photovoltaic Solar Power Generation Plant to Supply a Drainage Water Reuse Plant.	United States	78
	Case Nº28: Floating Photovoltaic Panels.	Chile	CNR
	Case Nº29: Photovoltaic Irrigation.	Chile	CNR

The Brochure document was diagrammed in two styles of visualization styles in PDF format, which are presented below. These are attached in **Annex 2**.

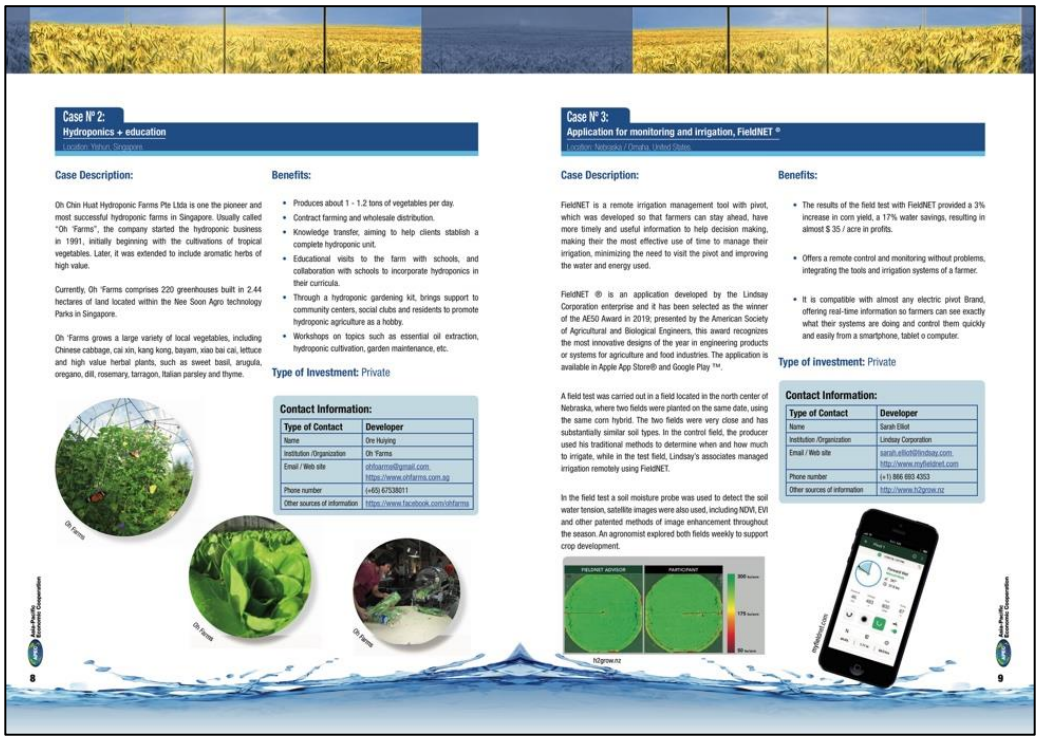


Figure 5. Design sample No 1.

Case Nº 2:
Hydroponics + education
Location: Yishun, Singapore

Case Description:

Oh Chin Huat Hydroponic Farms Pte Ltda is one the pioneer and most successful hydroponic farms in Singapore. Usually called "Oh 'Farms", the company started the hydroponic business in 1991, initially beginning with the cultivations of tropical vegetables. Later, it was extended to include aromatic herbs of high value.

Currently, Oh 'Farms comprises 220 greenhouses built in 2.44 hectares of land located within the Nee Soon Agro technology Parks in Singapore.

Oh 'Farms grows a large variety of local vegetables, including Chinese cabbage, cai xin, kang kong, bayam, xiao bai cai, lettuce and high value herbal plants, such as sweet basil, arugula, oregano, dill, rosemary, tarragon, Italian parsley and thyme.

Benefits:

- Produces about 1 - 1.2 tons of vegetables per day.
- Contract farming and wholesale distribution.
- Knowledge transfer, aiming to help clients stablish a complete hydroponic unit.
- Educational visits to the farm with schools, and collaboration with schools to incorporate hydroponics in their curricula.
- Through a hydroponic gardening kit, brings support to community centers, social clubs and residents to promote hydroponic agriculture as a hobby.
- Workshops on topics such as essential oil extraction, hydroponic cultivation, garden maintenance, etc.

Type of Investment: Private

Contact Information:

Type of Contact	Developer
Name	Ore Huiying
Institution /Organization	Oh 'Farms
Email / Web site	ohfoarms@gmail.com https://www.ohfarms.com.sg
Phone number	(+65) 67538011
Other sources of information	https://www.facebook.com/ohfarms

Oh 'Farms

Asia-Pacific Economic Cooperation

8

Figure 6. Design sample No 2.

Seminar

Delegates from 13 economies (including Chile) attended the event: Australia, Chile, Chinese Taipei, China, Indonesia, Malaysia, Mexico, New Zealand, Peru, Thailand, the Philippines, the United States and Viet Nam.

The seminar celebrated on 24th July concentrated the highest participation with a total of 88 attendees. Among them, there were high authorities of the Chilean Ministry of Agriculture, researchers, members of water users' organizations, international organizations and professionals related to the treated subject.

See below some pictures of the seminar carried out in Cumbres of Lastarria Hotel in Santiago.

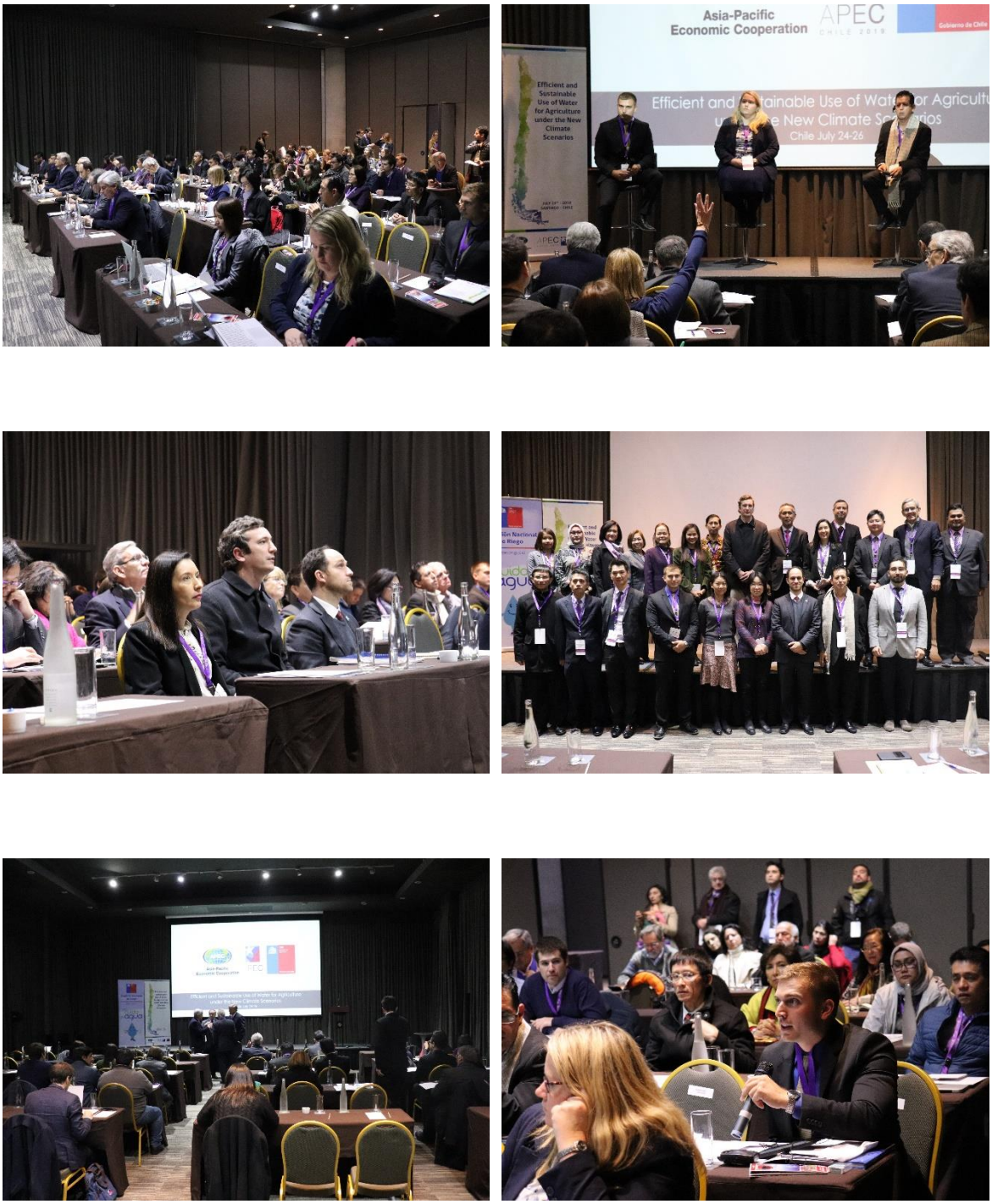


Figure 7. Seminar pictures 24th July, 2019.

As a summary of the information of the presentations that took place during the seminar, we can highlight the following:

Water efficiency experiencies

Mr. Jordon Navarrot
Theme: Telemetry Systems in Channels
Delegate of Claim District No. 108 of California, United States.

The Reclamation District N° 108 (RD 108) was formed in 1870 with the purpose of creating a district to build dikes and recover lands subject to periodic overflow of neighboring rivers and water bodies.

The RD 108 is located on the edge of the Sacramento River in northern California (figure 8), and it is one of the main water suppliers for agricultural uses along the river, since it distributes irrigation water for 20,000 ha and the main crop is rice that uses 12,000 ha, followed by tomatoes, sunflowers, nuts and other crops.

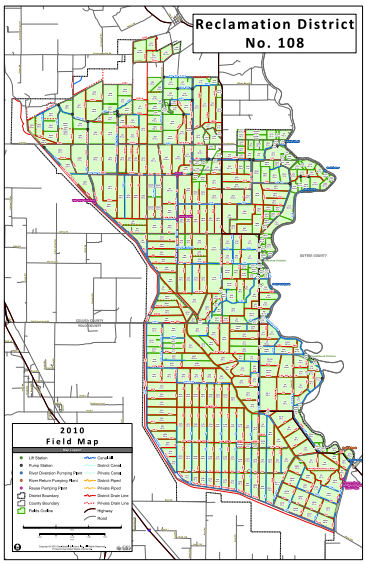


Figure 8. Reclamation District 108.

Water can enter the distribution network through four points, but the level is lower than the level of the channels, thus, water has to be pumped into the system. There is a pumping plant with five pumps of 200 horsepower, which can take from the rive300 cubic feet per second. This plant was built in 2008 in conjunction with a telemetric system (figure 9).

Figure 9. Poundstone Pumping Plant.

After water passes through the pumping plant, water gets into the concrete-lined channels, where the Rubicon “flumgates” are installed (figure 10). These are control automated flow control structures based on solar energy and operated by battery. There is no need for manal operation.

Figure 10. Rubicon Flumegate.

The concrete channels allow little loss or filtration and the Rubicon management platform shows every point of the system, in real time.

Finally, water passes through a delivery gate (usually a rice field), a portable speed meter is placed in the end point of the delivery line where the measured flow data is obtained and transmitted througha cell signal to a control center (figure 11).

Figure 11. Water flow portable speed meter.

The difference between the applied water to the rice fields and the consumed water is collected through a drainage network and taken to a reuse center (figure 12). This resued water reacher 1/3 of the total water in the system. The reuse center, water is pumped back to the channel system. Each drop of water that enters 108 is used to get its greatest advantage.

Figure 12.13 Pumping plant of water reuse, Sycamor.

When the reuse water re-enters the system, its quality is monitored by salinity measurements to ensure that the water, once mixed with the river fresh water, it does not exceed the limits to be used in agriculture.

Figure 13 presents the remote tracker software. It was incorporated due to legal requirements, since the district was required to measure flows to clients with a certain presicion, and a meter in eac field would be certainly expensive, taking into account that the district has about 500 delivery points in the fields. For measurements, a portable acoustic sensor is used which is installed in concrete boxes previously located in each point to be measured; these boxes deliver precise measurements. To use them, a support is placed to position the sensor in the right place, then the measurement sensor is connected via Bluetooth to the operator's computer and it is programmed with the diameter of the delivery pipe to determine the flow. Through a cell signal, the measurements are sent to a central database.

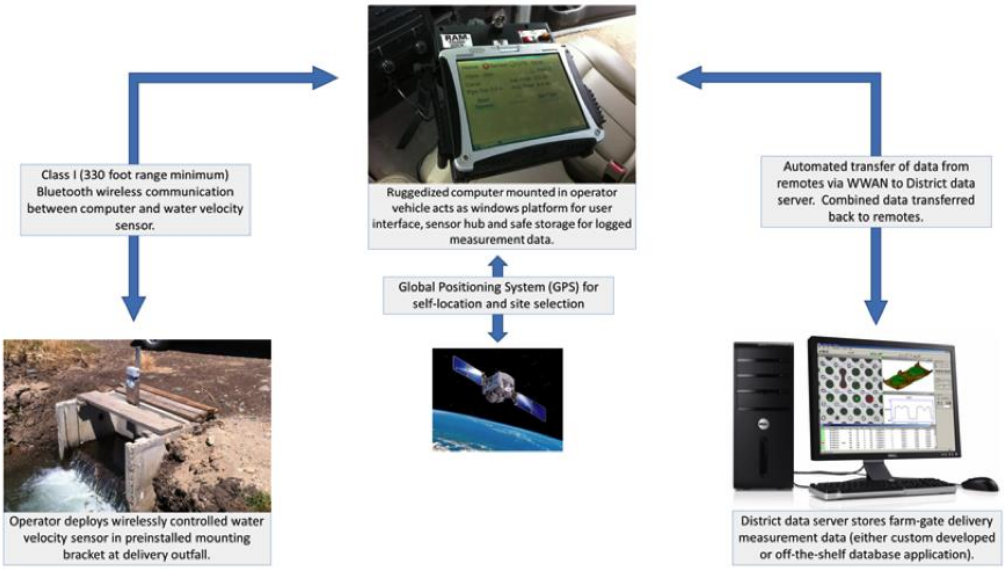


Figure 13. Software remote tracker.

The district aims to collect new measurements every four days to capture any flow change, in addition to measuring other conditions. The software used delivers this data to its clients online, allowing farmers to know, even from their homes, the exact flow that is entering their fields.

After gaining everyone's trust at the end of the second trial year, the district began charging based on remote measurements in 2016.

Dr. Rose Brodrick

Theme: Water irrigation efficiency

Scientific researcher at the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia.

The presentation was centered on the efficient use of water resources at a field level, through the development of tools that allow farmers to make decisions opportunely and based on reliable information.

In Australia, agriculture uses a significant proportion of the available water. 70% of water resources are used in agriculture, which is similar to the global average.

The project presented is called ***Waterwise*** and the idea is to show the challenge in crop irrigation, using sensors and data models to develop an app/tool that can help farmers. Currently, the work is concentrated in tomatoes and sugar, but with each new crop they work with farmers to see what changes are necessary to make. The main objective is to deliver a simple, integrated, and useful decision tool for the farmer.

To do this, a strong multidisciplinary team is necessary. CSIRO has invested in specialists such as agronomists, data analysts, social scientists, weather scientists, software engineers, user experience, hardware, uncertainty analytics and technical support. The professional team are part of a program called ***Digiscape*** that seeks digital solutions for decision making in the land sector.

The ***Waterwise*** project uses plant based sensors measuring the temperature of the plants, as well as current and future weather. This information is sent to a cloud-based platform, then analytical tools are used to predict when the next irrigation should occur. It is important to tailor this decision with knowledge of the specific crop and the experience and expertise of the user. Hence, it is important to work together with the farmer and the industry.

Figure 14 shows a schematic summary of the Waterwise Project.

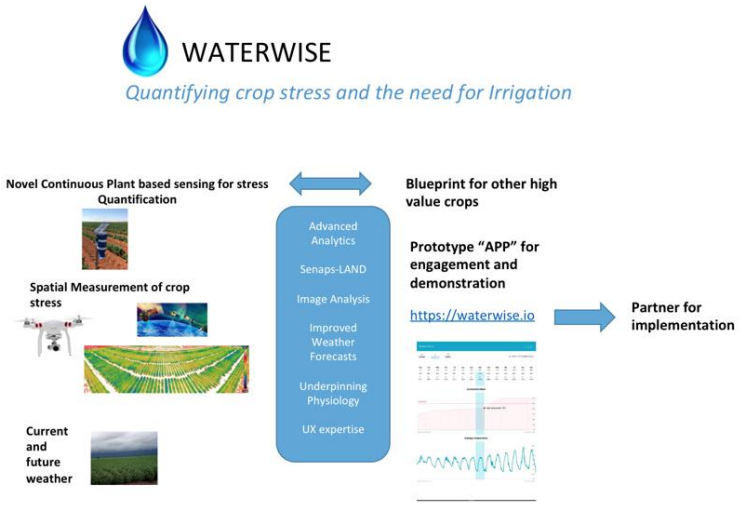
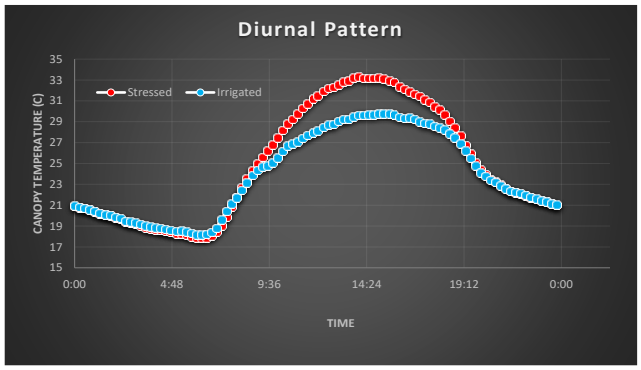


Figure 14. Schematic summary of Waterwise.

Part of the developed products is the ability to predict the plant stress using canopy temperature to accurately measure the crop. This prediction algorithm makes it possible to predict when the plant is going to need to be irrigated, or to use the system to identify that the measurement is not what is expected e.g. the irrigation may not be working, there may be disease present or some other problem that the farmer needs to check (figure 15).



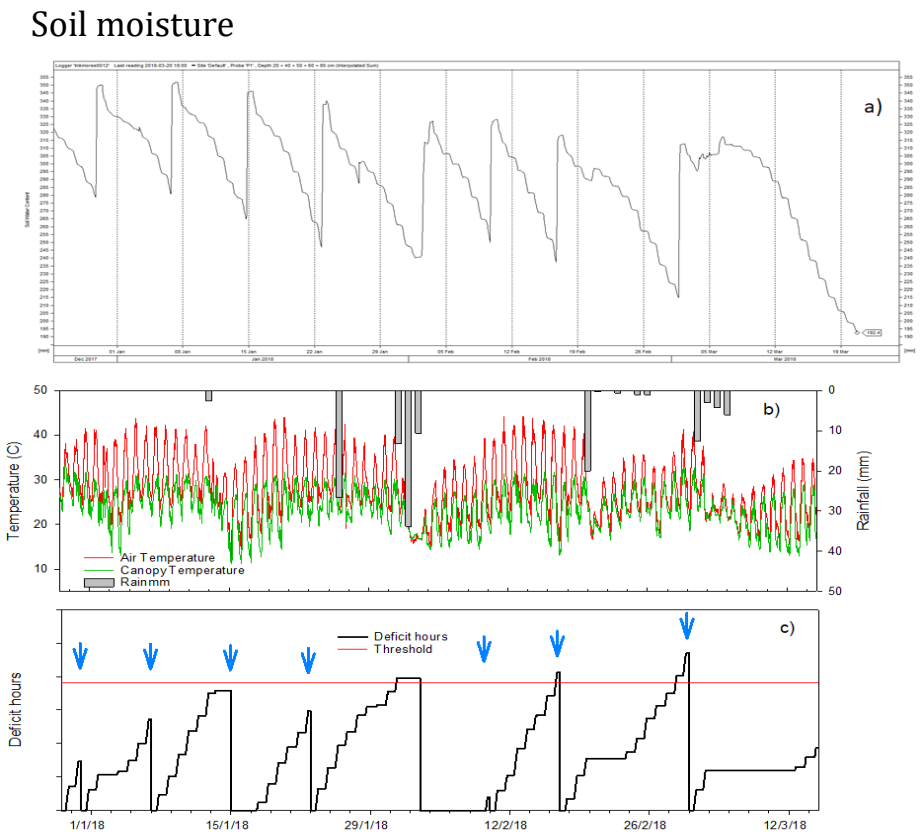


Figure 15. Temperature and soil water measurement results.

Experiences from other technologies and economies are presented, where the main objective is to respond to information requirement in a timely manner for the decision making of when and how much to irrigate, as well as to identify problems in the crop development. It is worth mentioning that one of the main barriers is technological adoption. Therefore, including the farmer in this process is really important.

Agricultural experiences

Dr. Wu Jingwei

Theme: Chinese experience in irrigation and drainage

Associate Professor of the Department of Irrigation and Drainage at Wuhan University, China.

The presentation is structured addressing four main points: Importance of irrigation in China; Water saving in 20 years; The effect of water saving practices; and Future perspectives.

China is the most populated economy in the world, total population reached 1,4 billion people. Thus, it is necessary food production and in that situation irrigation is key to get food security.

Currently, China has the largest irrigated surface in the world, about 65.8 million ha in 2018 (figure 16) and the irrigated land produces 75% cereals, in other words, 7% of arable land is used to feed 20% of the world population. In China, irrigation es vital for social development.

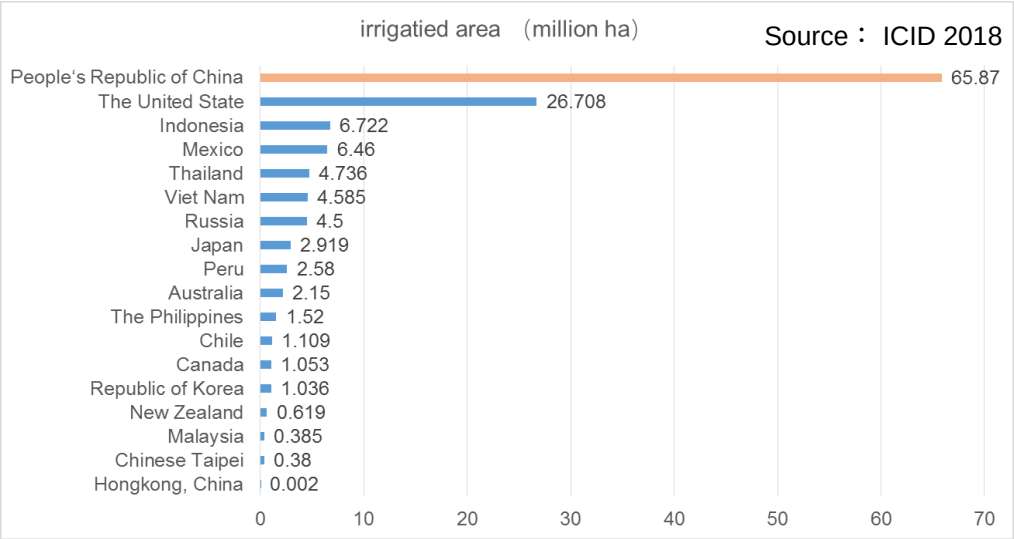


Figure 16. Irrigated surface of economies of the world in 2018.

The economy has a large rural population, around 60%, allowing irrigation to ensure fast rural development.

Irrigation is of the utmost importance to protect the environment, given that 20% of the surface can be affected by climate change. This surface suffers from desertification due to droughts, so irrigation helps mitigate this condition.

In 1983, the government indicated the need to protect and save water as a basic policy. After 1998, the government signaled the need of promoting irrigation and water saving as a revolutionary measure. In 2000, the Government asked to build a society that would save water not only in agriculture, but also on industrial and domestic use. Since then, a central document with water savings has been prepared every year, indicating what should be done.

In 2011, the government applied a more strict water resources system, known as the three red lines. It is a standard that stablishes limits, including the total use of water, water efficiencies and a red line to control pollution. In 2020, the water use cannot exceed the limit of 670 billion m^3 and in 2030, it cannot surpass 700 billion m^3 on irrigation. In the case of water use efficiency, in 2020 it has to exceed 55% efficiency, and in 2030 it must surpass 60%. For pollution control, in 2020 there hast to be more than 80% of the water function areas that meet quality standards and by 2030 about 95%.

Policies have been developed to support irrigation, as well as water laws, agriculture laws and the promotion of agricultural technology. Moreover, every five years China has a work plan and an irrigation investment plan. In China, the investment is made by two parties, one by the central government, and the other by the local governments. Figure 17 shows the investment made through the irrigation investment plans.

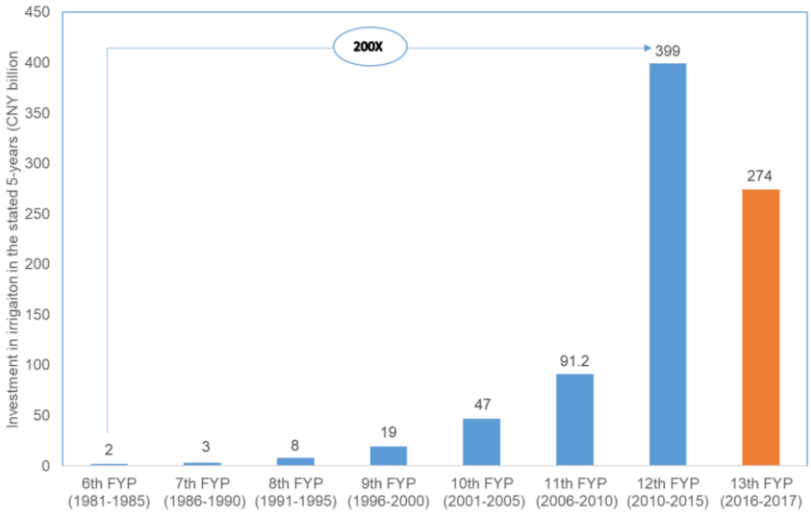


Figure 17. Irrigation investments of five-year plans in China (1981 to 2020).

In 1996, the water saving demonstration project was developed, where it was tested which type of irrigation is most appropriate. Another project that is still being carried out are large and medium-scale irrigation plants, with the objective of increasing irrigation efficiency and productivity. The project will end in 2020 with a coverage of 30 million ha of irrigation

The south of China is a humid area, so water scarcity is not a problem. The most important there is pollution caused by drainage in agriculture. Thus, saving irrigation water is reducing the drainage in this place.

In the northern area there are many cities, where water consumption is certainly high, and superficial water is overexploited. Here, the goal is to save irrigation water and reduce groundwater extraction.

Comprehensive water saving measures have been adopted, as engineering and agronomic works, irrigation management and policy and economic measures, first including an improvement of water delivery and distribution efficiency. The work was directed to coating the canls, then chaning the pipes, moving from canals to pipes to reduce losses. Control works have also been built to reduce losses during operation (figure 18).

Figure 18. Engineering works to save water during conduction and control.

Efficiency improvements have also been made on field or land, such as land leveling, ground cover (figure 19) and improving irrigation efficiency (figure 20).

Figure 19. Actions to improve efficiency in surface irrigation.

Figure 20. Actions to improve irrigation efficiency .

Regarding social and economic measures, there are water users associations (WUA). The WUAs are in charge irrigation management and the amount of WUAs has increased greatly, administering 35% of irrigation water in China.

One governemt policy is the reform of water rates. Looking back at 30 years ago, water was free for everyone, but today the prices are rising. Farmers are not owners of the land, but they have the rights to operate on it and the government now says that farmers have to pay for only 30% of the price of water.

A water rights exchange market was also built. It began its operation in 2016.

To increase water saving through technical-scientific support, more than 100 experiments have been developed, in order to define water saving standards in irrigation.

Among the effects on water savings in irrigation, it is possible to find an increase in irrigated areas and water saving in these total areas from 30% to 52%. Productivity per ha (kg/ha) has increased 32% and water use rate per hectare has been reduced 24%, increasing productivity per irrigated unit (kg/m^3) in 45%. A positive impact in water quality has been generated, reducing salinity in water.

Among the different perspectives, food security is certainly important, just as water quality. Hence, it is unquestionably importanta modernization on irrigation systems not only automating but also with Smart.

Ms. Pajaree Singto

Theme: Thai experience in hydrology associated with agriculture

Hydrologist of the Royal Irrigation Department of the Ministry of Agriculture and Cooperatives of Thailand.

Thailand is located in the southeast region of Asia, with and area of 51,312,000 hectares and a population over 68 million people.

Thailand's main income comes from agriculture, which is why it has a land use that represents 46.5% of the economy's area and 37% of the agricultural area is used for growing rice.

The weather in Thailand has winter, summer and rainy seasons, with a marked presence of Monsoon. The first monsoon starts in May and lasts until October, continuing a monsoon that starts in November until February.

At the institution level, Thailand has the Royal Irrigation Development (RID), which envisions to be a leading organization in water resources development and integrated water management with the present irrigated area in the world top ten.

RID has four missions: Develop water resources and increase irrigated area; Manage water allocation; Prevent and mitigate water hazards; and Encourage people's participation.

The pumping and storage works have a capacity of about 80,000 million m^3 and irrigated areas over 4,9 million hectares.

Climate change in Thailand tends to drive severe disasters, mainly storms, floods and droughts. Average temperature has increased 0,56°C during the last years. In 2000, Thailand suffered the effects of climate change with five events of tropical storms, generating large money losses due to damage. Between 2015-2016, Thailand has suffered extreme droughts, because there has been less rain than usual.

Thailand has a Climate Change Master Plan 2015-2050, where the main components are: Climate change adaptation; Mitigation and carbon-low development; and development of abilities / favorable environment.

Complementary to the above, there exists The Strategic Plan on Water Resources Management in Thailand, whose objectives are: Accelerating the provision of a flood and drought risk map, and to develop an efficient early warning system; Developing resilience to answer and mitigate the flood and drought effects; Dissimenating appropiate information and news effectively.

A case example of water management in the Chao Phraya basin is presented, which is 372 km long, 160,400 m^2 in size. Figure 21 shows a water distribution scheme and a map of the area included in the distribution network.

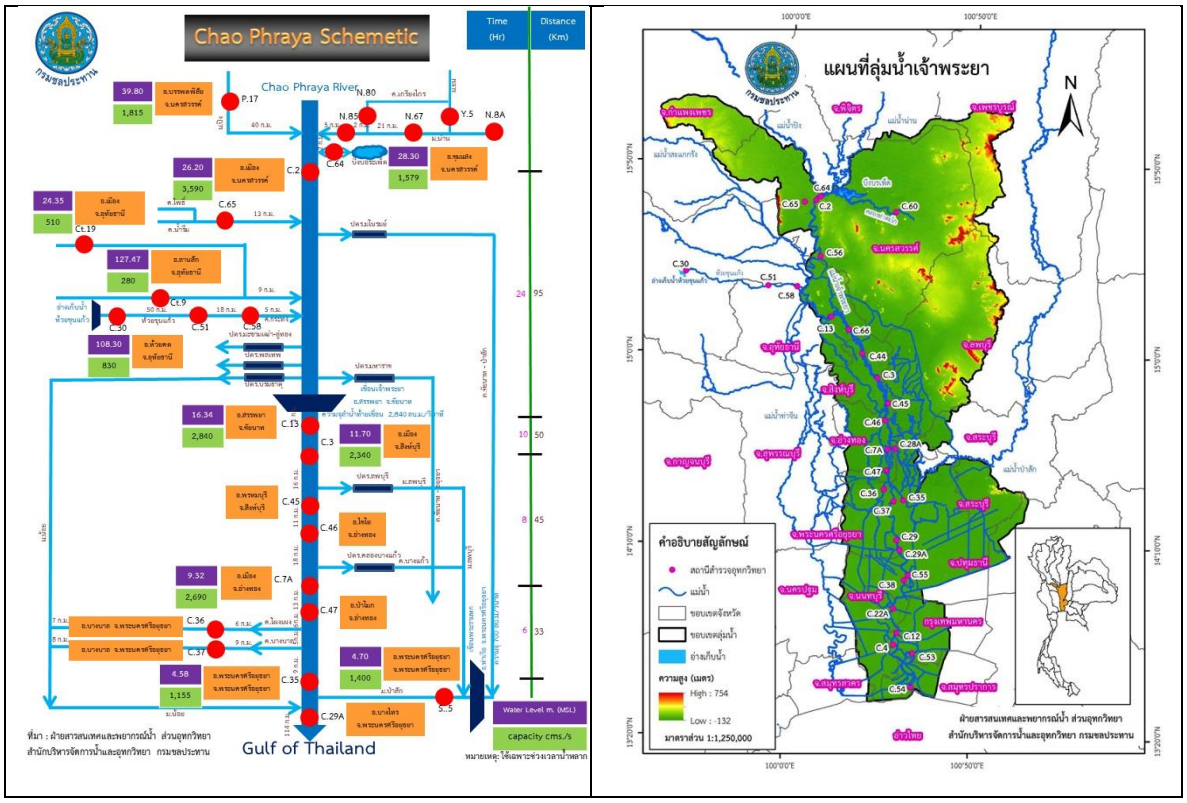


Figure 17 Distribution network scheme and Chao Phraya basin map.

Water management in Thailand aims to solve two main risks: droughts and floods. This management during drought season is based on available water at the beginning of the season. Water assignation priorities are applied as follow: Allocation of water for consumption (in dry season); Allocation of water for the ecosystem (in dry season); Water reservoir for the beginning of the rainy season; Allocation of water for agriculture; and Allocation of water for industries.

The challenges for water management consider maximizing benefits by providing enough quantity and quality of water, more efficient irrigation, and appropriate allocation by each interest group. Minimizing losses is also considered through flow control, drougt mititgation and by reducing the impact of disasters.

The distribution of annual precipitations records in the Chao Phraya basin is shown in figure 22, where the variability of the annual rainfall behavior can be appreciated.

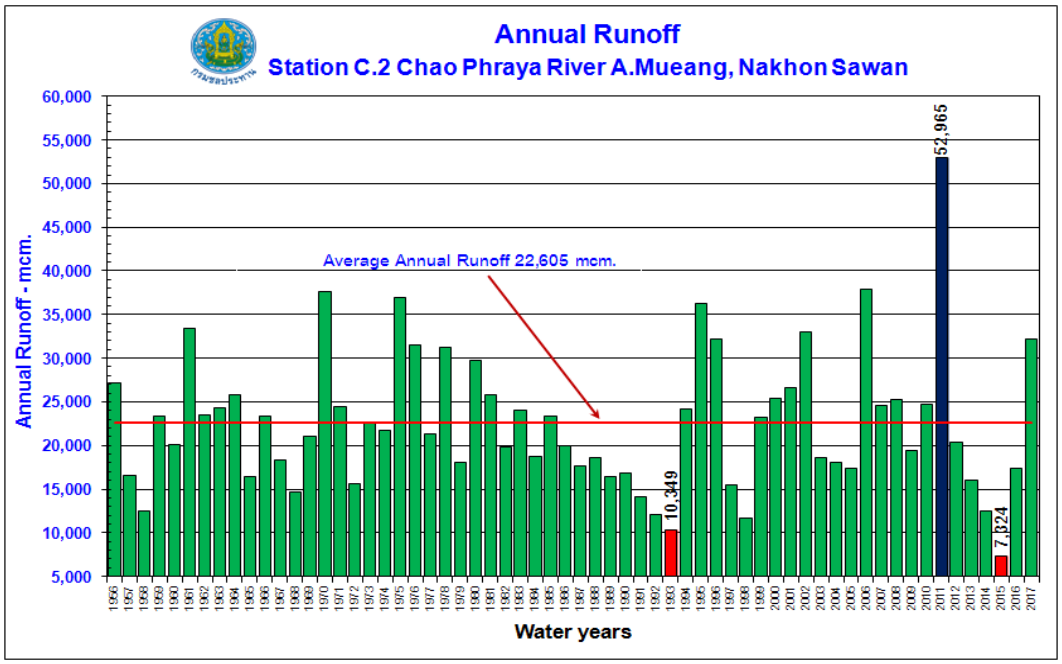


Figure 18. Historical record of precipitation in the Chao Phraya river basin .

As shown in figure 22, many years are recorded with accumulated values that exceed the historical average (red line), which requires the implementation of flood prevention strategies, considering structural and / or non-structural prevention. The first considers: dams, reservoirs and delay areas, bypass, flooding tract, canal dredging or widening, river embankment and dikes. The second considers: water management, flood monitoring and warning.

Dr. Abel Quevedo

Theme: Sustainable irrigation system with porous emitters

Agronomist, irrigation specialist at the Autonomous University of Chapingo, Mexico.

The presentation showed the experience in an irrigation system through porous emitters, for localized irrigation. The speaker presented a conceptual analysis of localized irrigation and raises the idea of using porous vessels as irrigation emitters. A scheme of the irrigation system components is presented in figure 23, where the water source, crop, porous capsules and the installation configuration can be identif

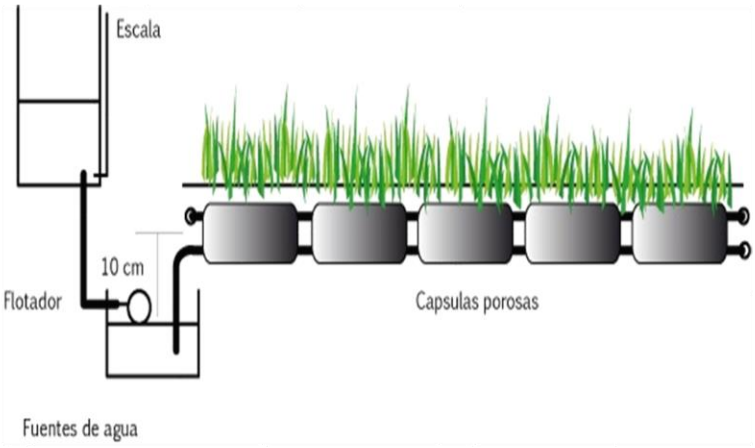


Figure 23. Scheme of the porous capsule irrigation system.

The background information of several research on the use of porous irrigation emitters is presented, where the following comments can be highlighted.

- Water application is more efficient and the irrigation system operation is easier.
- It does not require an external source to supply the water needs of the plant.
  Water is supplied locally, efficiently and continuously, which translates in higher yields per unit of water used.
- Some problems encountered were plugging (the pores can be sealed with salts), low uniformities and small hydraulic conductivities are the main disadvantages of suction irrigation with porous capsules.
- In trials with three geometric figures of porous capsules (**conical, cylindrical and saucer**), in a Lettuce crop the highest production yield was obtained for suction irrigation with conical capsules.

In a Tioga strawberry crop, water efficiency and yield was tested with a suction irrigation system, with three levels of fertilization and two plants densities. The results obtained are the following:

- At higher plant density there was higher yield.
- The suction irrigation method is able of supplying water demand of a crop as demanding as strawberry.
- The water used was eigh times less in volume compared to water used at commercially (surface irrigation methods).

- An unusual lush development was observed in the plants due to the doses of fertilizers used, which went directly to the root through the suction irrigation system.

In a test in greenhouses with Wheat, Tomato and bean crops, considered as tolerant, semi-tolerant and susceptible to exits respectively. The feasibility of using the porous capsule irrigation method when using salt water was determined. As a result, higher yields of dry matter, g reater leaf area, lower water consumption and higher plant height were obtained compare to those obtained by the method of surface irrigation.

In 2012, the hydraulic operation of spherical porous capsules of commercial ceramic paste, in substrate (tezontle) with different particle sizes, was evaluated with irrigation purposes (figure 24 and 25).

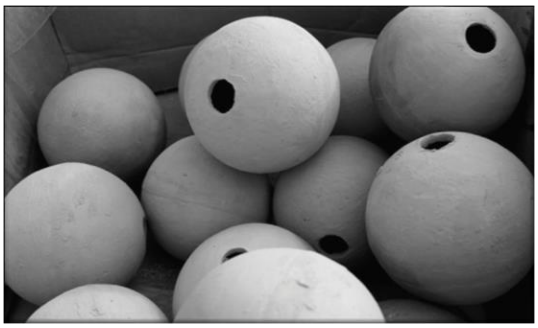


Figure 24. Spherical porous capsules of commercial ceramic paste.

Figure 25. Test with a spherical capsule.

It is proposed that irrigation with porous vessels as irrigation emmiters eliminates high pressurization requirements of the system, as well as having a system that delivers water to the plant constantly according to the crop's real demand.

Renewable energies in agriculture

Mr. Bastián Celis Huaiquilaf

Theme: Renewable Energies in the agriculture of Chile

Professional collaboration agreement for the development of renewable energies in irrigation (National Commission of Irrigation - Ministry of Energy)

To understand the importance of renewable energy in agricultura necessary to know what is currently happening in the economy and in the world. Agriculture consumes 2% of the world's energy, which is produced from fossil fuels and / or electricity. But electricity comes from generators, mainly thermoelectric plants that burn fossil fuels.

During the last 20 years, there has been an energy transformation in the world and some of the key points of this period are the increasing capacity or use of renewables, especially in the global photovoltaic generation capacity, increasing from 15 GW of capacity to 400GW of capacity in 10 years. In the case of wind power, its global generation capacity increased 10 times. Another important aspect, last year in Peru, electricity reached the lowest price in history, that is 20 dollars per megawatt hour, thanks to photovoltaic generation, with wind projects also close to those numbers. In addition, decarbonization plans have been established.

Renewable energy appears as an opportunity for irrigation projects. Some advantages are to improve competitivity of products in agriculture due to low prices in agriculture; more resilient products contribute to energy descentralization that refuses a dependency on fossil fuels, along with less water use. Figure 26 shows water consumption among the different electricity generators in the cases of Europe, highlighting the low water use in the case of renewable energies.

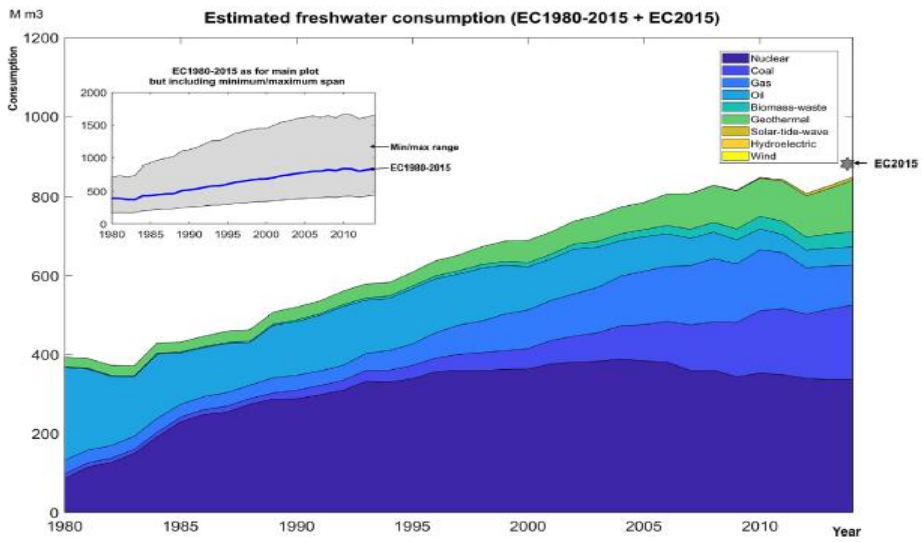


Figure 26. Water consumption of different electricity generators in the case of Europe.

If we are looking for renewable energies, these have to accessible, affordable and user-friendly for farmers. In this context, we can see two options: First, photovoltaic systems, which have an immense potential in Chile, low costs, flexibles and developed market. Second, we have minihydro plants, which are for under 200 kw capacity and have low environmental impact.

The National Commission of Irrigation (CNR) seeks to increase and develop the irrigated area in Chile, along with promoting efficient irrigation. For this, there is law 18,450, an instrument that works through competitive projects. Figure 27 presents the total financing amounts per year in projects related to civil works, drainage works and technification works.

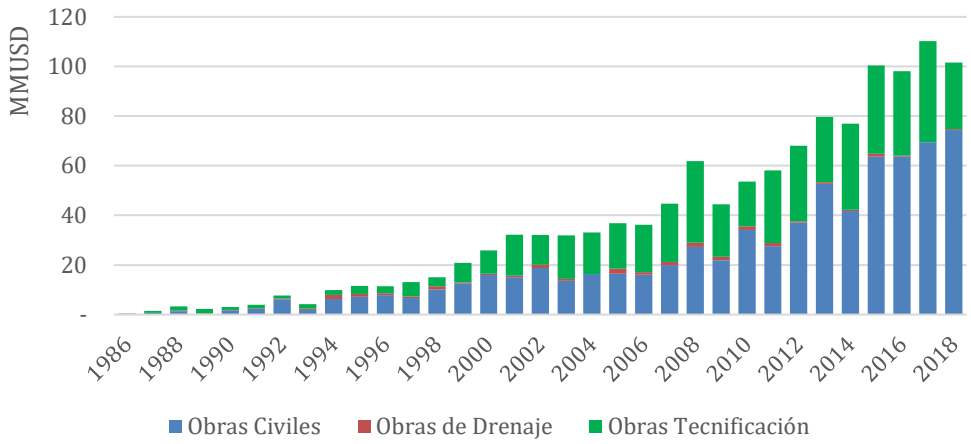


Figure 27. Total financing per year according to the type of project (CNR, 2018).

During the period 1985 to 2018, through law 18,450, more than USD 1,2 million in 26,000 projects, with a total of 600,000 beneficiaries and technification of 336,000 hectares.

In the case of specific projects with renewable energies, there are currently 770 projects with these characteristics throughout the whole territory. These have a capacity between 0.5 to 300 kW with a total of 6 MW. This supplies 6,000 ha of irrigated area, the investment exceeds USD 31 million and 98 of these projects have photovoltaic systems.

Since 2015, work is being carried out on promotion and training, delivering information on these areas. It is certainly important to consider training all actors constantly and with updated information, which has been carried out in different places (figure 28).


Figure 28. Dissemination and training activities in ERNC.

Another important aspect is to develop information and materials that can be available on the CNR website for free so it is transparent to the market and performances are better in projects that have been excecuted to promote the development of these irrigation projects. Apparently, this practice is working, since last year, more farmers have been applying their projects in CNR.

Renewable energies help modernize irrigation projects in the economy and these are a powerful tool to encounter climate change for water and energy reasons.

Mr. Agustín Cáceres
Theme: Floating Photovoltaic systems in agriculture
Member of the Akila SpA Group – Spain

The presentation begins with the background of the origin of the Isigenere Company in 2008, which was born in southern Spain. A Spanish company and the founders received a problem, which was related to the loss of water for evaporation in the reservoirs. The biggest problem faced was how to solve this and propose a solution. They realized that another problem that existed was that pumping water to the fields was very difficult because they were using a diesel generator, and then the perfect solution was found. On the deck used to cover the reservoir, solar pannels could be mounted, thus preventing evaporation and, at the same time, generating energy.

What is a floating solar plant?

In short, it is a normal solar plant that is placed on a body of water. The solar panels that absorb the sun's energy are mounted on the floating deck (figure 29). The energy generated by the panels is taken to a central inverter to transform it from direct current to alternating current and then be injected into the conventional network or consumed directly by the irrigation systems (figure 30).

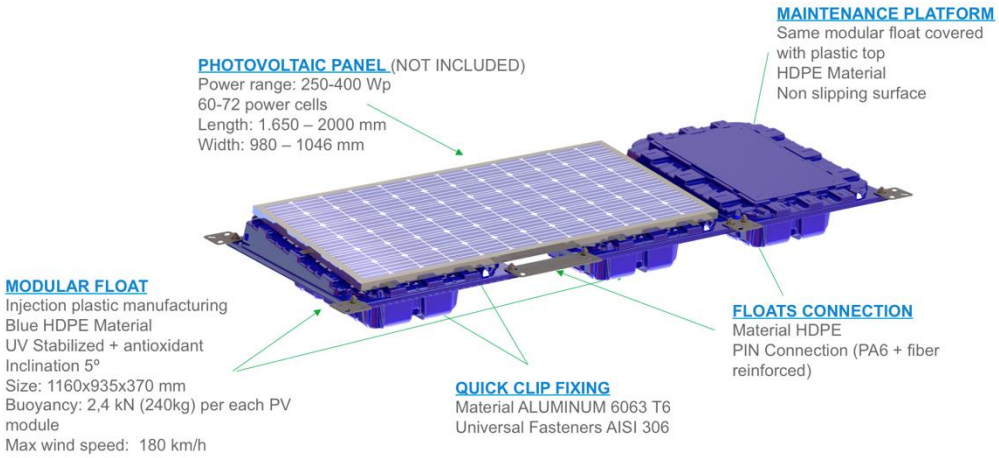
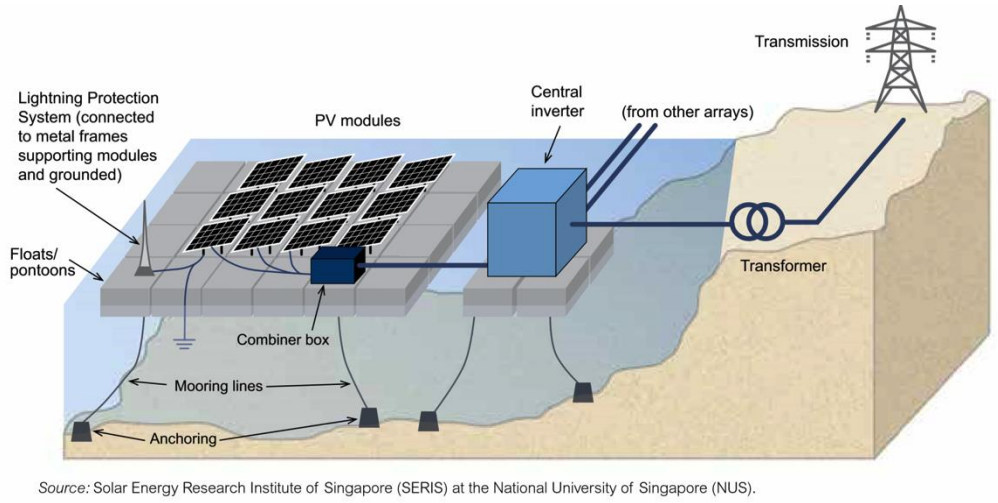


Figure 29: Key components of Isifloating 4.0.



Source: Solar Energy Research Institute of Singapore (SERIS) at the National University of Singapore (NUS).

Figure 30. Schematic representation of a typical large-scale floating PV.

What are the benefits of using a floating solar plant?

At first, the interest is the use solar energy to generate electricity. The performance peak of solar panels is at 25 degrees Celcius, anything above generates a performance loss of 0.4%. Thus, when using water as a cooling system, the photovoltaic panel stays close to 25 degrees. Another aspect to consider is the point of energy consumption, which is close to the generation point. In terms of water evaporation, the system reduces 80% evaporation and improves water quality, since reducing

the incidence of solar radiation to the body of water, the appearance and growth of algae and other microorganisms is also reduced, loweing water maintenance costs.

The rafts are designed to be used in water reservoirs and their design depends on the types of reservoirs, in which there are square and rectangles shapes. They also depend on the slope of the gradient. It is possible to install rafts on slopes and threre is no risk in the lining system of a reservoir: drilling and anchoring are not necessary for these rafts (figure 31).

Figure 31. Floating system installed in different conditions of water reservoirs.

The speaker presents the background of some of the developed projects, highlighting that the floiting plants are not only to be used in agriculture, forests or vineyards, since there are other fields or industries where these can be used.

Non-traditional water sources in agriculture

Mr. Jacobo Homsi
Theme: Wastewater treatment and reuse
Chemical civil engineer from the Federico Santa María University, Chile.

Currently, the reuse of water is a global trend in developed and developing economies, determined by three factors. First, a growing demand where there is less water availability; second an increasing increase in the source of sewage water; and third, the economic reconciliation associated with the partial return of the benefit when one invests in the treatment of dirty water.

With regard to global warming in the world, we will have serious problems related to water consumption as well as industrial consumption in 30 years.

The global availability of treated wastewater has appeared as a resource in recent decades, as a result of the change in climatic conditions (increase in average temperature, change in precipitation standards and extreme weather events). The reuse referred to treated wastewater must be

incorporated into the integral and sustainable management of water, applicable with direct benefits (reducing energy consumption and costs) allowing the use of treated wastewater in local economic activities.

This can be difficult to understand because our culture is not used to this kind of changes, but this issue must be discussed. This point is important, today there are many economies that are already researching and applying this mechanism. But in Chile, 80% of sources goes to irrigation and agriculture, the other 20% is divided into domestic and industrial use, so irrigation in agriculture is a relevant element to take into account.

The most common uses are assigned to agricultural irrigation, park irrigation, industrial use, groundwater recharge, power generation, etc. The main aspects associated with irrigation in agriculture are salinity, toxicity and microbiological quality due to pathogenic organisms present in wastewater.

When discussing irrigation, the type of irrigation must be taken into account, because there are globally two types of irrigation: ***restrictive irrigation***, which has to do with some products that are eaten raw, when taken from the ground; and ***irrigation without restriction,*** these are the conditions that have no significant effects on agriculture, animals or humans and are suitable for the preservation of life.

What is the institutional behavior?

The World Health Organization (WHO) has summarized the epidemiological and transmission studies of infectious diseases related to health risks associated with the use of dirty water in irrigation, due to pathogenic organisms that could survive in the environment (sewage, soils, agricultural products) that could eventually infect people. A relevant aspect, especially in agriculture, is the combination of different sanitary protection measures throughout the entire process chain, from the production of water intended for irrigation to the final consumer of the product. There are many control measures, all associated with the reduction of the concentration of pathogens.

Regarding international experiences in the reuse of dirty water, we have the case of Israel, which in 1959 parliament adopted the first water law, which defines the reuse of water as a resource to be used. In 1970, water scarcity was already a domestic issue issue and incentives are given to enhance water reuse. In 1984 created the first large-scale water reuse system is created. In 2005, water reuse reaches 75% of all dirty water produced, with more than 200 reserves for storing reuse water. In 2011, the water authority developed a Long-Term Master Plan for the National Water Sector; and in 2015 the reuse of treated dirty water reaches 85%.

Another example is Singapore, that has implemented this dirty water reuse issue, because Singapore does not have enough water and they have to enter the issue of dirty water treatment until they reach the requirements throughout the economy. In 1972, the first Water Master Plan was developed and, in 1974, the first pilot plant for reuse by the National Water Agency was built. In 1998 they developed the Singapore Water Recovery Study (NEWater) as a public initiative.

The first NEWater plant for water reuse was built in Singapore in 2000. Currently, NEWater (reused water) supplies more than 30% of Singapore's total water demand. ***Newater***'s public acceptance is the most important one developed in Singapore. Through intensive public education and the permanent search for public acceptance, especially industries, NEWater grew steadily.

In the case of Chile, there are some barriers that have to be faced. First, the standards: there are no standards related to the use of treated wastewater, there is no legal or administrative framework (public policy, institutional leadership) associated with the reuse of treated wastewater , it is necessary to adapt the associated laws (Water Code, Sanitation Services Law, Environmental Law, etc.). Second, cultural rejection of the community: in Chile, when the issue of treated wastewater to be reused is approached, there is a rejection by the community. Third, the costs: conditioned by the production points and where the treatment plant is located, as well as the wastewater disposal points.

Dr. Carlos Flores
Theme: Artificial recharge of aquifers in Agriculture
Scientist of the General Water Directorate, Ministry of Public Works of Chile

The content of the presentation addresses: Interactions between surface and groundwater; Groundwater recharge mechanisms (natural and management); Experiences Abroad; Experiences in Chile; and Vision of development of recharge works by management in Chile (taking technical, legal and financial aspects).

Regarding interactions, we know that all the waters in the world are connected, especially in a basin, we also know that surface waters are connected through currents or reservoirs of surface waters or bodies of groundwater (figure 32).

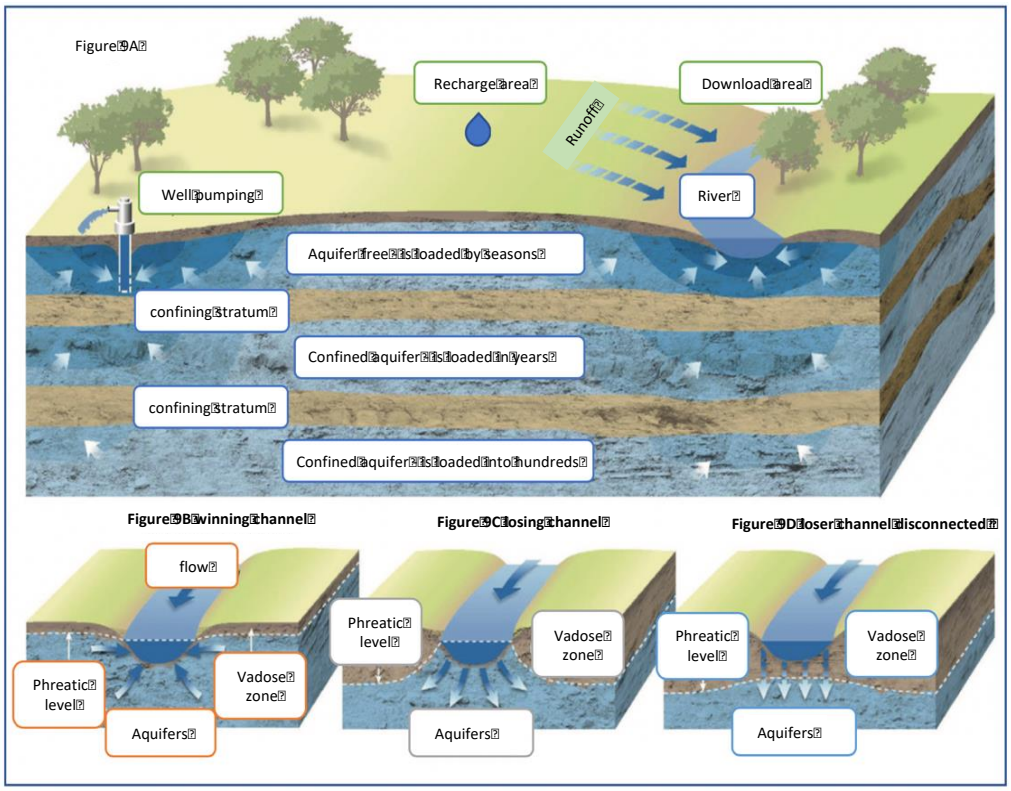


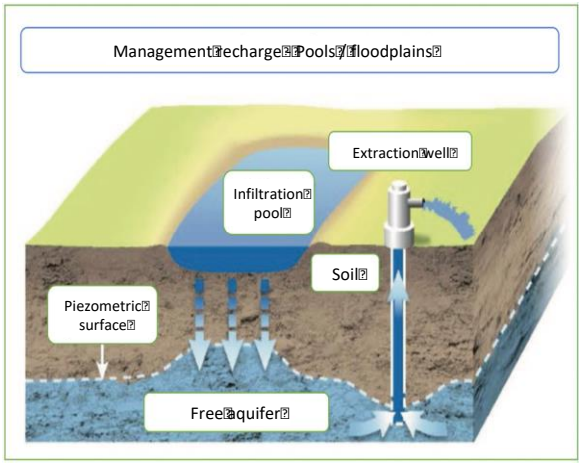
Figure 32. Interactions between surface and groundwater.

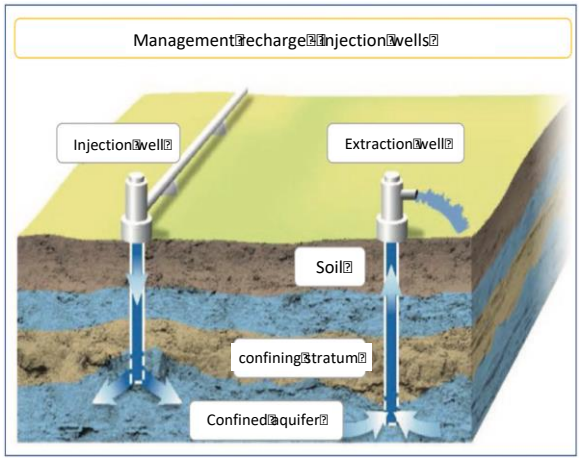
The aquifers are connected directly with lakes, streams and waters in low areas will be discharged in a stream, we also have extractions through wells and pumping wells. We can also create infrastructure that will drive the water from the aquifer and finally be able to transport water of streams or any open body of water. We can obtain streams that deliver water to the aquifer, also that draw water from the aquifer and we can also have streams that are disconnected from the aquifer, these mechanisms occur naturally. But they could be influenced by groundwater pumping if we reduce the level of water around a stream.

A surface water stream is going to deliver water to an aquifer, therefore, if we want to recharge through a stream we need space. We also need to know the groundwater levels, storage and storage changes. If we put this in a model we can better understand what are the dynamics of a groundwater recharge in a hydrological cycle.

When we talk about the natural mechanisms of groundwater recharge, we can identify: The contributions of underground water channels through infiltration; Recharge on foot of mountains due to precipitation and thawing; Infiltration by agricultural irrigation / precipitation (15%), the variable according to basin, can reach more than 90% in basins with high irrigation rates; Flow from nearby basins (10%); and Base flow, i.e. mobile flows in the unsaturated area that discharge to the aquifers.

In the case of management recharge mechanisms, most of the water recharge techniques are delivered by infiltration pools, injection wells which inject water directly into the aquifer and infiltrator riverbeds (figure 33).





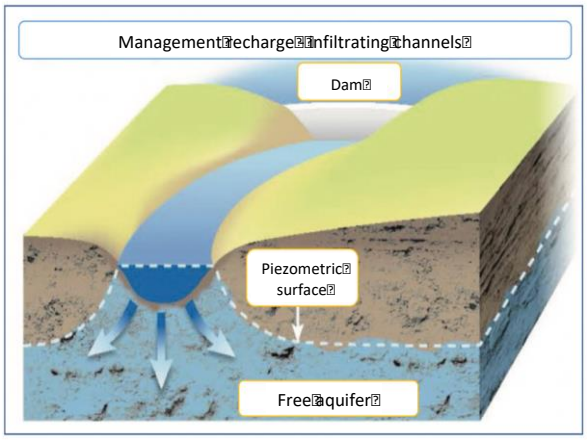


Figure 33. Groundwater recharge mechanisms by management.

In Chile we have four research pilots, which are presented in Table 14.

Table 14. Active prototypes of groundwater recharge in Chile.

Recharge method	Basin	Sector	Developer	Recharge rate (lt/s)	Storage (Millions m^3 per year)	Value of water (CLP$/$m^3$)
Infiltration pool	Copiapó	Piedra Colgada	Groundwater Community CASUB	200	6,3	15
	Aconcagua	Curimón	Dirección de Obras Hidráulicas	1000	31,5	48
Infiltration channels	Aconcagua	Catemu	Irrrigators of irrigation canals high and below Catemu	120	3,8	8
Injection wells	Maipo	La Pintana	Sociedad del Canal de Maipo	50	1,5	450

The General Water Directorate (DGA) has conducted many studies to understand the aquifers of Chile, with main efforts from the O'Higgins region to the north of the economy. A small research was carried out, based on all the available background information of some basins, with the aim of feeding simulation models and obtaining results on the capacities or spaces available for a potential groundwater recharge.

Regarding the vision of the development of management recharge works in Chile, we must consider technical, legal and financial aspects for each project.

In the technical aspects of aquifer recharge, we must analyze aspects of joint water use management, development components and project feasibility. In the case of legal aspects, the Chilean water code regulates groundwater recharge initiatives (Article 66 and 67). There is also Supreme Decree No. 203/2013 that "Establishes the Exploration and Exploitation Standards for Groundwater."

From a financial point of view, public-private investment is necessary. This is a framework that can be developed to build a business model; if you are an investor and want to invest in recharging, you need to know that the DGA will give you information about legal and technical certainty. Nonetheless, the most important thing is the payment capacity of the water end-user, because not everyone is able to pay.

Field days

In the field days for the visit of water and energy efficient projects, it was carried out with the delegates of the APEC economies, with 36 people participating in the visit to the Valparaíso region, of which 19 corresponded to delegates from the economies APEC, regarding the visit to the O'Higgins region, had the participation of 30 people, 18 of whom were delegates or speakers from the invited economies.

Below are some photographs of the field days taken between July 25 and 26, 2019.


Figure 34. Field days Pictures.

APEC Evaluation Survey

The survey was answered for 20 delegates / speakers, with 18 of APEC economies. Below, the results and the process analysis is presented:

Question 1

The consultations made in question 1 are aimed at identifying if the delegates found that the topics of the seminar and field days were relevant, that if the content of the seminar was well organized and easy to follow, the quality of the exhibitors and times used in visits.

Delegates had to choose one of the options presented, which were totally in agreement, agree or disagree.

Most of the responses of the members of the participating economies fully agreed or agreed according to the following breakdown:

Table 15. Overall results of Question 1.

Question	Strongly Agree	Agree	Disagree	Comments
The topics covered in the seminar were relevant	17	3	0	
The topics covered in the field trips were relevant	19	1	0	
The content of seminar was well organized and easy to follow	15	5	0	
The trainers/experts or facilitators were well prepared and knowledgeable about the topic	17	3	0	
The time allotted for field visits was appropriate	11	9	0	

Next, each of the questions presented in the previous table is broken down, also indicating the main comments of the respondents.

Question 1.1 *The topics covered in the seminar were relevant*

Of the 20 responses, 17 of the respondents replied that they completely agreed that the topics discussed were relevant, corresponding to 85%, the difference, that is 3 delegates, were that the topics discussed are of a relevant nature. The following figure shows the results more illustratively.

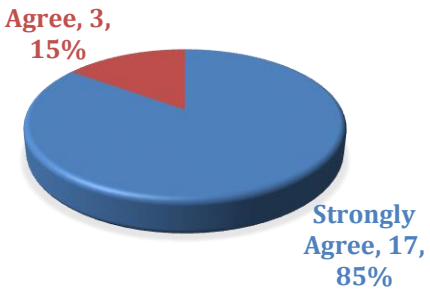


Figure 35. Results Question 1.1.

Among the comments made by delegates and speakers, it is highlighted that the topics discussed were useful and relevant.

Question 1.2 *The topics covered in the field trips were relevant*

The following figure illustrates the results obtained in question 1.2 of a universe of 20 respondents. According to the results of the following figure, 100% of the respondents were totally in agreement or agreement, not showing negative opinions.

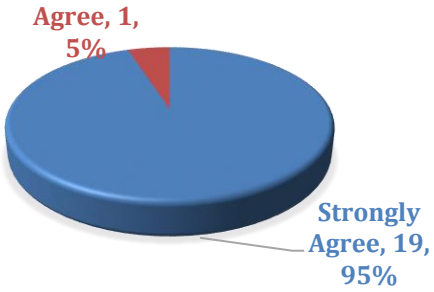


Figure 36 Results Question 1.2.

Among the comments made by the respondents, only one was made, which indicated that the topics addressed in the field days helped to better understand the issues addressed in the seminar.

Question 1.3 *The content of seminar was well organized and easy to follow*

The following Figure illustrates the results of the question indicated above in detail.

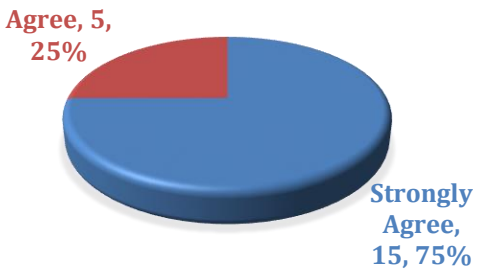


Figure 37. Results Question 1.3.

According to the results seen in the previous figure, it is highlighted that 100% of the respondents were either totally or agree or agree, there is no negative reception. Among the main comments, it was indicated that the content of the seminar was According to time schedule represented by different economies also.

Question 1.4 *The trainers / experts or facilitators were well prepared and knowledgeable about the topic*

100% of the respondents agreed or completely agreed that the experts and facilitators were well prepared knew the topics discussed, with 85% (17 of 20 respondents) of the delegates fully agreeing. The following figure shows the detail of the answers indicated by the respondents.

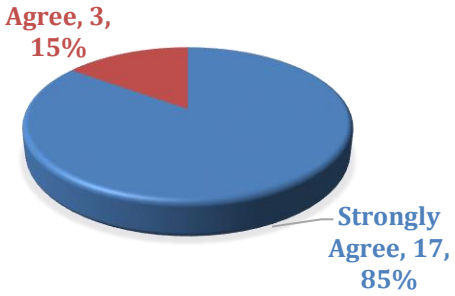


Figure 3819. Results Question 1.4.

Among the comments made by respondents, the following aspects stand out:

- Some speakers should improve.
- Effective translator helps a lot in understand the topic being discussed.

Question 1.5 *The time allotted for field visits was appropriate*

In this consultation there was a greater dispersion among the delegates who completely agreed and agreed (55% vs. 45%), the above was mainly due to the fact that the field visits extended more than planned. The following figure shows the detail of the answers made by the respondents.

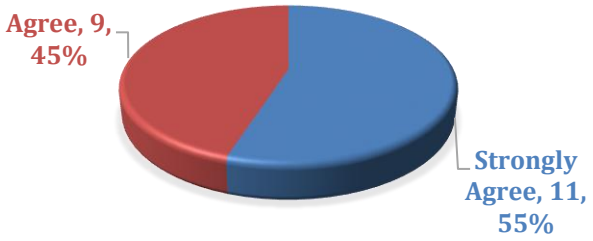


Figure 39. Results Question 1.5.

From the comments one is rescued who mentions that the time back to Santiago was too late and should not have been extended beyond 5:30 p.m. It should be noted that the time was extended due to delayed travel problems, which was caused by heavy traffic due to an accident on the road.

Question 2

How relevant were the issues addressed in seminary for you and your economy?

This question qualified the answers in which the topics discussed were very important (5), important (4), moderately important (3), slightly important (2), unimportant (1).

The following figure shows the detail of the answers obtained in this question.

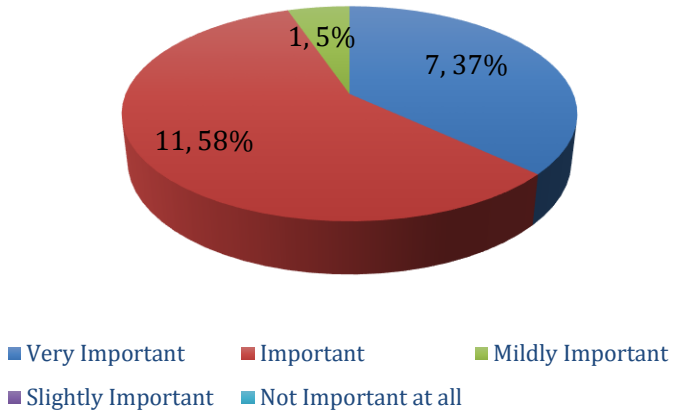


Figure 40. Results Question 2.

From the comments made by the respondents, it is visualized that the central ideas of their comments focus on topics such as:

- The management and efficient use of water is relevant because water scarcity caused by climate change occurs in large part of the economies.
- Unlike what happens in Chile, some economies such as Indonesia have flood problems, so the problem must be addressed differently.
- The application of technologies for management, the use of non-conventional renewable energies and artificial recharge of aquifers would be useful and replicable in the economies. However, considering these alternatives implies a high cost of implementation.

Question 3

How relevant were the issues addressed in field trips for you and your economy?

In the same way as the previous question, this question qualified the answers in which the topics discussed were very important (5), important (4), moderately important (3), slightly important (2), unimportant (1). The fact that one of the respondents responded that the topics discussed in the field days were unimportant is highlighted. The following figure illustrates the overall results of this question. However, there is a certain inconsistency in this answer because, according to what the same person answered in question number 1.2, he considered that he was very in agreement with the topics discussed in the field days and the relevance of them.

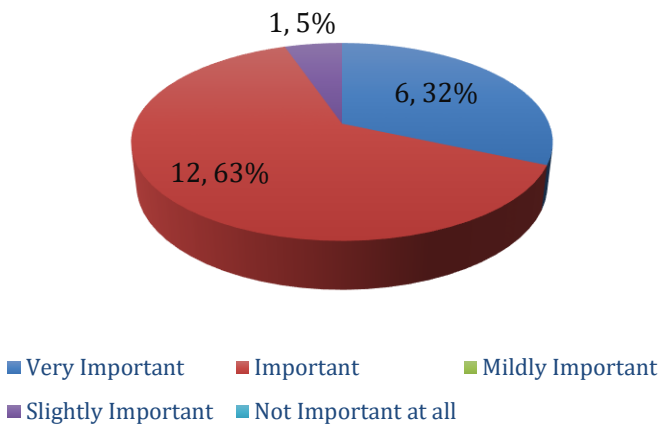


Figure 41. Results Question 3.

Based on the comments made by the respondents, the main ideas presented by them are grouped:

- Experiences such as telemetry and floating SFV would be useful and replicable to improve the agriculture of the participating economies, however, they have a high investment cost. In turn, these measures would be exposed for planning and implementation of innovation projects in their own economies.
- Other comments made are that it would be useful to know the price or rate of water applied for irrigation in Chile, which was not deeply discussed in any instance.
- Finally, the fact that some of the experiences seen are also applied in economies such as the USA is highlighted.

Question 4

What new skills and knowledge did you get from the topics addressed in the field trips?

Based on what has been said by the respondents, the answer with the greatest recurrence and that shows a high interest is the application of floating photovoltaic systems, telemetry systems and artificial aquifer recharge so as to make a better management of the water resource, better techniques of irrigation, productivity and energy efficiency to meet agronomic demands.

Other responses presented by the participants were the interest in understanding the wine production chain, as well as seeing the SCADA type monitoring application.

Question 5

How you will apply the knowledge acquired to your workplace? Please, provide examples (e.g. develop new policy initiatives, organize trainings, develop work plans/strategies, draft regulations, develop new procedures/tools etc.).

Within this question, there was a greater diversity in the ideas presented by the respondents, within which the following central ideas of how to apply the knowledge acquired within their own economies are indicated:

- Propose within the public policies of their economies to replicate projects such as floating photovoltaic systems for saving energy consumption and mitigating the carbon footprint, modern telemetry systems, water resource management improvement technologies, with a Economy development approach. However, it would be necessary to evaluate the high costs that the implementation of this type of technologies could entail.
- Another of the considerations made by the respondents was to carry out training and studies for the technological development of better technologies brought to the industry, techniques of irrigation systems and water management, considering the water scarcity to which the world is located today submitted in general terms.

As a summary regarding this question, respondents showed a positive balance of what they learned and consider it relevant, applicable and useful for the development of public policies, training and innovation what they learned in this activity.

General impacts

From the presentations made at the seminar, it was possible to appreciate the diversity of realities of the participating economies, regarding their climatology, water availability, extreme events, productive systems, public policies, technologies and innovation, among others. This leads us to understand that many of the experiences rescued in the Preliminary Report and Brochure documents have the potential to be applied but not in all economies, given the prioritization of actions or conditions that each of them has in relation to their realities against Climate Change and food security.

When we talk about impacts generated by the different initiatives presented in the Preliminary Report, Brochure, Seminar and field days, we can identify that these are generated at different scales of order, depending on the nature of each project and the objectives set in each of them.

On the one hand, we can identify important impacts at basin levels with a basin storage and transfer initiative, directly impacting the availability of water for periods of maximum demand. Such initiatives require the establishment of public policies and large-scale investment plans, not feasible in many of the economies that are part of APEC.

In the case of canal lining initiatives, these directly impact on the increase of availability at farm level, since the losses due to conduction are reduced, which in many cases makes it impossible to reach the field with water. In this type of initiatives, public - private investment is necessary, with a clear planning of territorial development in relation to productive systems. In many of the economies there are already successful experiences, where we can find a strong participation in the investment from the state and in others where the private ones are in charge of the investments. There are also economies where we can find a joint participation of the state and private parties.

In cases of aquifer recharge, the benefit in increasing the stored volume is evident, which directly impacts the availability of groundwater and the natural interaction of surface-groundwater. Many of these projects require plentiful studies of aquifer characterization and the source used for recharge. It is also necessary to have public policies, regulations or laws that promote and regulate these actions. While there are economies that have all these aspects, many of the economies lack or are recently working on it.

Within the framework of intrapredial initiatives, we can highlight the impacts on the efficient use of water, through the implementation of more efficient irrigation techniques, the use of technologies for the generation of online and historical information for decision-making in water practices, regarding management, by farmers, which saves water, increases productivity and identifies potential problems. All the cases shown in the seminar, the Preliminary Report and Brochure documents, demonstrate the positive impact on decision-making for the management of irrigation water, as well as the increase in productivity. But the considerable limitation for the implementation of technologies in irrigation management and production systems, corresponds to the high levels of investment necessary, as well as the need to establish training and technological diffusion programs to guarantee technological adoption and efficient use of these resources. Many of the economies

are in the process of training farmers to improve traditional practices and incorporate simple techniques to improve their production systems. We can conclude that the implementation of technologies such as telemetry and automation systems in productive management is not a short term option.

When talking about the implementation of public policies, which allow ordering and prioritizing the multiple initiatives that are required to be implemented in each economy, this impacts in a controlled and strategic way all the productive sectors. It also allows to establish a program of initiatives in the long term that guarantees productive development and its consolidation. Many of the economies already have or are working on defining public policies that allow addressing the different lines of action that admit them to have the tools or mechanisms necessary to contribute to food security facing the different scenarios of Climate Change.

Final Comments

Food security in all APEC economies is a relevant topic, threatened by the different scenarios conditioned by Climate Change. In many cases there are periods of extreme drought, change in precipitation patterns, and temperatures; while in other cases the problem is related to extreme events such as floods, frosts and hailstorms. These scenarios have conditioned the prioritization of the different actions promoted and implemented by the economies, which differ in the scale or type of action.

Regarding successful cases on efficient water and energy management identified in the Preliminary Report, the Brochure, as well as the topics addressed in the seminar, it is important to highlight that transversal innovations of APEC economies are related to the new technologies that have been developed during the last years in relation to sensing, telemetry, automation and control, infrastructure and energy generation by non-conventional renewable energies.

Among the different cases and issues addressed, the interest of the economies in telemetry, automation and sensing systems for irrigation management is highlighted, as well as solar panel systems on floating rafts. For all of them, it is necessary to establish demonstration projects in the different interested economies, evaluate their operation and analyze the scaling of each of these initiatives, to continue with a proposal to be incorporated into the public policies of each economy in case economies do not count with legislation on the matter.

Annex 1

Preliminary Report of successful cases in efficient use of water and energy in APEC economies

Annex 2

Brochure's two display design formats

Annex 3

Seminar presentations on 24 July 2019