Asia-Pacific
Economic Cooperation

SUCCESSFUL CASES AND EXPERIENCES ON THE EFFICIENT USE OF WATER IN AGRICULTURE IN APEC ECONOMIES

APEC Policy-Partnership on Food Security
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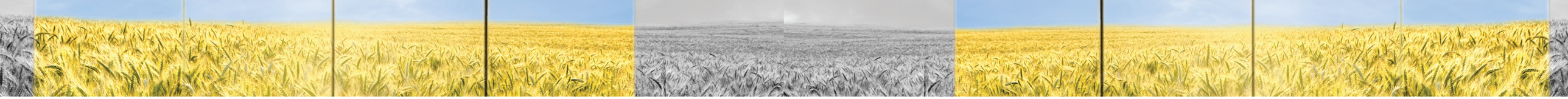

APEC Project: PPFS 04 2018

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

Produced by

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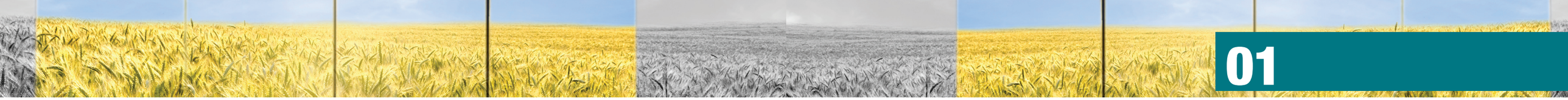

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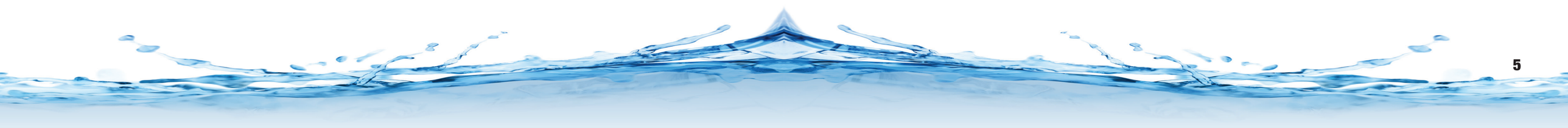
SUCCESSFUL CASES AND EXPERIENCES ON THE EFFICIENT USE OF WATER IN AGRICULTURE IN APEC ECONOMIES



SUCCESSFUL CASES AND EXPERIENCES ON THE EFFICIENT USE OF WATER IN AGRICULTURE IN APEC ECONOMIES

Intrapredial Water Efficiency

Case Nº 1:

Vertical farm for vegetable growing – Sky Greens

Location: Kranji, Singapore.

Case Description:

First vertical farm powered through hydraulic energy and low in carbon emissions in the world (Sky Greens).

The vertical cultivation system is called “A-Go-Gro” technology, which is patented and has three rotating cultivation channels mounted in an aluminum A-shape frame. This frame can be up to 9 meters tall with 38 levels of cultivation channels that can accommodate the different cultivation means (soil or hydroponics). The channels rotate around the aluminum frame to ensure that plants receive uniform sunlight, irrigation and nutrients as they go through the different levels of the structure.

In total, the system has an area of 60 square feet and has 120 towers, in Kranji, 14 miles towards the central business district of Singapore, planning to expand up to 300 more, which would allow the farm to produce two tons of vegetables per day.

Kalinga Seneviratne IPS 2.

Benefits:

- Using green urban solutions, the production of safe, fresh and delicious vegetables is achieved, using as minimal resources as possible of land, water and energy.
- In this system, a large variety of tropical vegetables are grown, such as Chinese cabbage, lettuce, xia bai cai, bayam, kang kong, cai xin, gai lan, nai bai, among others.
- When compared to traditional monolayer farms, Sky Greens patented cropping system intensifies the use of land and can generate at least 10 times more yield per unit area.
- There are daily vegetables crops and they are delivered immediately to the sale spots in the same city.

Types of Investment: Private

Contact Information:

Type of Contact	Developer
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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:

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Oh Farms

Oh Farms

Oh Farms

Case Nº 3:
Application for monitoring and irrigation, FieldNET ®

Location: Nebraska / Omaha, United States.

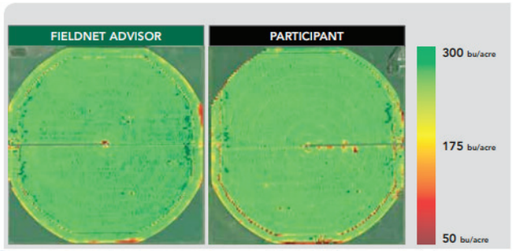
Case Description:

FieldNET is a remote irrigation management tool with pivot, which was developed so that farmers can stay ahead, have more timely and useful information to help decision making, making their the most effective use of time to manage their irrigation, minimizing the need to visit the pivot and improving the water and energy used.

FieldNET ® is an application developed by the Lindsay Corporation enterprise and it has been selected as the winner of the AE50 Award in 2019; presented by the American Society of Agricultural and Biological Engineers, this award recognizes the most innovative designs of the year in engineering products or systems for agriculture and food industries. The application is available in Apple App Store® and Google Play ™.

A field test was carried out in a field located in the north center of Nebraska, where two fields were planted on the same date, using the same corn hybrid. The two fields were very close and has substantially similar soil types. In the control field, the producer used his traditional methods to determine when and how much to irrigate, while in the test field, Lindsay’s associates managed irrigation remotely using FieldNET.

In the field test a soil moisture probe was used to detect the soil water tension, satellite images were also used, including NDVI, EVI and other patented methods of image enhancement throughout the season. An agronomist explored both fields weekly to support crop development.



h2grow.nz

Benefits:

- The results of the field test with FieldNET provided a 3% increase in corn yield, a 17% water savings, resulting in almost $ 35 / acre in profits.
- Offers a remote control and monitoring without problems, integrating the tools and irrigation systems of a farmer.
- It is compatible with almost any electric pivot Brand, offering real-time information so farmers can see exactly what their systems are doing and control them quickly and easily from a smartphone, tablet o computer.

Type of investment: Private

Contact Information:

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myfieldnet.com

Case Nº 4:

Precision agriculture experience with sensor use

Location: level 1/167 Main St, Methven 7730, New Zealand.

Case Description:

In a farm at the foot of the Southern Alps in Canterbury, Craige mackenzie's property and also developer of GreenSeekers technology, a wide range of combinable seed crops is produced. Since 2008, precision agriculture techniques to reduce the variability of the carbon footprint and its effect on the environment have been implemented, in addition to increase the yield of the 200 ha farm.

Among the techniques and worked performed, you can find the Electromagnetic Map (EM) of the soil texture and the implementation of an irrigation system with central pivot, which includes solenoids in each sprinkles so that water can be applied in a variable way by the soil variations. The EM can also detect soil compaction problems, and in the farm they are to vary the seed rates.

Another technique is the installation of humidity probes after each year sowing, which are taken away before next cultivation, providing a continuous humidity registry in 35 areas (farm divisions) through the 200 ha.

Additionally, regulators of plants growth, trace elements and fungicides are applied in a variable way, by means of automatic adjustment of the spray volume, carried out through a locally constructed 24 m drag sprayer; which is equipped with six normalized difference vegetation index (NDVI), known as GreenSeekers, one for each control section, and a Trimble GPS system.

The general perception is that precision technology can be expensive, nevertheless, a large number of systems are just a fraction of the cost and the return of the investment is usually paid in a year or two.

For example, to equip a sprayer with GreenSeekers costs about USD$12,753. To reimburse that it would only take 10 ha of rye grass to produce 800 kg more yield, at USD $ 1.59 per kg.

Benefits:

- Application of a differentiated fertilization.
- Efficiency increase in water used for irrigation.
- Adjustment of seed rates to soil types.
- Increase in wheat yields in the lighter areas from 7 ton/ha to 10-12 ton/ha, while high yield areas have significantly also increased.

Type of Investment: Private

Contact Information:

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Andrew Swallow

Andrew Swallow

Case Nº 5:

Water Conservation Project II

Location: Hebei, Shanxi y Ningxia, China.

Case Description:

The Water Conservation Project II, supported by the World Bank, addressed directly water shortage problems through a series of interconnected operations in the Chinese provinces of Heei, Shanxi and Ningxia, three of the provinces with the highest water shortage in the Northern region of China. To reduce the net water consumption, the project sought to reduce the water extraction for agriculture irrigation in the Ningxia and Shanxi provinces and the groundwater overdraft in the Hebei province. Furthermore, the project also provided farmers with incentives in order to reduce the agricultural production costs and increase the efficiency and the agricultural value in the three provinces.

The total cost of the Project amounts to USD$160 million, being USD$ 80 million financed by the World Bank.

The project was developed between 2012 and 2017, launching four components which are the fundamental pillars: 1) Water works and water saving facilities; 2) Agricultural water saving measures and support services; 3) Management measures and institutional development; 4) Project management and implementation support.

blogs.worldbank.org

Benefits:

- Crop yields increased significantly compared to the 2011 reference figures in all cases.
- Water extraction in Ningxia was reduced in 22.57 million cubic meters (MCM) per year.
- Groundwater extraction in Shanxi was reduced in 5.80 MCM per year.
- The new or improved irrigation and drainage services reached 594,200 beneficiaries of which 287,300 (48%) are women.
- In total, the project has created or strengthened 290 WUA in the three provinces that comprise more than 800 employees and more than 760,000 members (approximately half of them are women).
- Agricultural water productivity in the project areas increased from 1.0 to 1.40 kg /m^3 (of ET).

Type of Investment: Public/Governmental

Contact Information:

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Case Nº 6:
Solid Rain / Water Silos
Location: Jalisco, Mexico.

Case Description:

Water Silos (solid rain) was created by Mr. Sergio Rico Velasco (Engineer of the National Polytechnic Institute Mexico). It is a granular powder based on potassium acrylate, degradable, non-soluble and non-toxic that, when in contact with water, it expands and is capable of adsorbing up to 500 times its weight in water (depending on the type of soil, water quality, weather, plant, etc.). It has been used successfully by many producers to cope with water scarcity, used in the agricultural and forestry areas, as well as in floriculture, horticulture and hydroponics.

The "water silos" have a powder presentation, and the application is quite simple: they are buried in the soil at the root level and when it rains, the water becomes solid (preventing the liquid from leaking or evaporating). Water remains in that state while it is consumed by the plant, according to its needs.

Once the polymer moisture is over, it becomes powder again and when it rains, it again encapsulates the water keeping it in the soil for a period of eight to 10 years. The use of solid water through "water silos" is unique in the world because, in addition to making a better use of water, it allows liquid storage in sacks, buckets and PET bottles in case of lack of rains, as PH, salts and nutrients are not modified.

The main areas where this technology can be used are: agriculture, golf courses, soccer fields, parks, gardens ornamental plants, pots and seedlings.


lluviasolida.com.mx

Benefits:

- In a corn planting in Durango, with an area of 1 ha, it was possible to verify a saving of USD$57,746 in water in three months, 60% less irrigation and 19.82% in cultivation time.
- On the other hand, the Vallescondido Golf Club in Atizapán, USD$18,717 was saved in water and 82.5% in irrigation time, increasing irrigation efficiency from 20 to 80%.

Type of Investment: Private

Contact Information:

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lluviasolida.com.mx

Case Nº 7:
Imec ® Polymer Film
Location: Ibaraki / Mito, Japan.

Case Description:

mec ® Polymer Film is key to a cutting-edge cultivation method that allows you to grow fruits and vegetables in virtually any flat exterior. Made of hydrogel, a super absorbent material that is typically used in household products as disposable diapers, the film works by absorbing water and nutrients through a multitude of nano-sized pores that measure one millionth of a millimeter in diameter. The plants grow on top of the film, but instead of digging in the soil, the roots spread across the surface of the membrane in fan-shaped formations.

At the beginning, farmers were skeptical, but the method is becoming popular among younger producers, such as Ayaka Miura, president of Drop Farm, who grows boutique tomatoes in Ibaraki prefecture. As the polymer film retains water molecules, the plants at the top have to work hard to absorb water and nutrients.

In 2018, Drop Farm sold 20 tons of tomatoes for USD$43,246,000. Sales are expected to double this fiscal year (2019) as the greenhouses expand to about 5,000 m^2.

he method is being used in 150 locations around Japan and one in China, as well as on a farm in the middle of the desert in the United Arab Emirates. The Imec ® patent has been presented in more than 120 economies and registered in more than 100 of them.


Drop Farm.

Benefits:

- The microscopic pores of the polymeric membrane block bacteria and viruses, eliminating the need for harmful pesticides
- As soil is not necessary, sustainable farms can be established virtually anywhere: in the desert, on the rooftops of the city and even on top of the contaminated land.
- Water saving can be quantified in 90% less water compared to conventional farming.
- Stress causes a development of higher levels of sugars, amino acids and phytochemicals.

Type of Investment: Private

Contact Information:

Type of Contact	Developer
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Drop Farm.

Case Nº 8:

Water monitoring system - SenSprout Inc.

Location: Tokyo, Japan.

Case Description:

The water monitoring system, developed by Tokyo-based SenSprout Inc., headquartered in Tokio, was funded through collective funding donations from 138 people worldwide in 2015. In addition, the project won a USD $ 150,000 monetary award in an irrigation start-up competition to support entrepreneurs and new initiatives.

The sensor is a tube-shaped object about 50 centimeters long. Three electrode patches, consisting of a resin film covered by a thin layer of copper, are placed on the part that penetrates the ground. The electrodes detect the electrostatic capacity of the soil to reveal changes in the amount of water retained in the soil. You can tell how much water the roots of the plants absorb. The top of the sensor has a wireless network device that transmits data to a nearby smartphone. The information is stored in an online database in the cloud, and farmers can remotely verify the data on their computers or smartphones to see if their crops need more or less water.

Among the main features of the sensor developed by the SenSprout Company are: soil moisture and temperature data can be easily verified. A cloud service can track farm data anytime and anywhere, allowing farmers to quickly detect and respond to deviations from the appropriate soil moisture content.

Benefits:

- SenSprout sensor units, which consist of low-cost materials, such as resin pipes and copper film, each cost less than USD $ 926 to produce, compared other sensors that cost USD$ 4,640.

- One of the strongest results in the tests carried out with the use of the sensor is that it maximizes the field potential, achieving a high performance and quality, reducing the differences in crop weight from 30 to 5 %, producing more homogenous products.

Type of Investment: Private

Contact Information:

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Case Nº 9:

Viet Nam Irrigated Agriculture Improvement Project

Location: Hanoi, Viet Nam.

Case Description:

The objective of the Viet Nam irrigated agriculture improvement Project is to improve the sustainability of irrigated agricultural production systems in certain coastal provinces and mountains in the North of Viet Nam, helping more than 243,000 families.

The project has the following components:

1) Improved management of irrigation water: to improve the institutional capacity for the provision of modern, efficient and responsible irrigation and drainage services.
2) Improvements in the level of the irrigation and drainage scheme: to improve bulk water supply to the irrigation systems, the provision of services and the management of the selected irrigation and drainage schemes
3) Support services for climate-smart agricultural practices: to leverage the improved irrigation infrastructure and water delivery activities carried out in the previous component to improve productivity and quality of agriculture, increase the farmers' incomes and reduce their vulnerability to adverse climatic events.
4) Project management, monitoring and evaluation.

There are seven selected provinces, in the central coast are: Thanh Hoa, Ha Tinh, Quang Tri and Quang Nam. And the selected provinces in the Northern mountain region are: Ha Giang, Phu Tho and Hoa Binh. It is expected to reach 83,400 ha in total.

The Project is still underway, started in 2014 and its estimated closure is for December 2020. The project has a total cost of USD $210 million, of which USD$ 180 are financed by the World Bank.

Benefits:

Among the achievements made by the program until 2019, the following goals can be mentioned:

- The goal for December 2020 is to intervene 574,800 water users provided with new or improved irrigation or drainage systems, and what was measured in March 2019 already exceeded expectations, reaching 691,011 people.
- By December 2020 a total of 15,700 farmers in the project area that adopt improved production techniques should be reached. In November 2018 it was exceeded by 193% coming to 30,429 farmers.
- Regarding operational water user's associations created or strengthened, from an expected total of 20 associations in 2020, a total of 37 associations were measured in March 2019.

Type of Investment: Public / Governmental

Contact Information:

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Case Nº 10:
Telemetry for table grape orchard
Location: Ica, Peru.

Case Description:

The table grape variety known as Flame Seedless is famous for its cracking problem, which occurs at its destination due to micro cracks, as a result of poor irrigation management in the Veraison period.

The implementation of technologies in this orchard mainly sought to avoid the cracking in fruit and to increase production, improving the ratio of kg of fruit per m^3 of water consumed for irrigation. This cost USD$60,000, including annual maintenance costs around USD$3,400, everything at the expense of the exporting company.

In Ica, Peru, it was possible to irrigate with a productive objective by phenology between 2012 and 2013, according to each vegetative state.

Wiseconn Engineering implemented the data control in a total of 20 points, where each of them included one humidity probe with four levels of depth (20, 40, 60, 80 cm), as well as a drip flowmeter to understand precipitation.

Additionally, a Meteorological Station was implemented, to quantify with greater precision the local technical data of interest, in order to adjust irrigation to the exact need of the crop.

Wiseconn Company

Benefits:

The measures taken, the implementation of the control points and the collection of on-site agrometeorological data allowed:

- To avoid fruit cracking (which was the main and most important objective).
- Average productivity increased a 35%.
- Decrease in Real Kc values due to phenology since 2012, specially during Veraison season (0.4 to 0.5).
- The rate of water applied per hectare was reduced from 12,000 m^3/year to less than 10,000 m^3/year between 2012 and 2014, and currently is around 8,000 m^3/year.
- The personnel costs were reduced in labor, due to lower weeding and cleaning in harvest season.
- Increased quality and quantity of roots.
- Rise in quantified water use efficiency in production, with initial values of 1.16 kg/m^3 reaching 3.32 kg/m^3.

Type of Investment: Private

Contact Information:

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Wiseconn Company

Case Nº 11:
Technification of Surface irrigation
Location: Sinaloa State, Mexico.

Case Description:

The Mexican government is in search of an ambitious program to improve the gravity irrigation system (RIGRAT) in the main irrigation districts, paid by the government and the water user associations. This low-cost program is based in a personalized irrigation assistance for farmers, through extension workers in irrigation.

The RIGRAT Project has the following components: Irrigation extension; Irrigation programming; Irrigation design; Irrigation monitoring; Land leveling; Volumetric delivery; and Monitoring of the RIGRAT Program.

Regarding the project implementation costs, the total investment was USD$16,321,250, where 75% was contributed by public amounts corresponding to USD$13,057,000, and 25% was private contribution, reaching USD$3,264,250.

Jorge Flores Velazquez

Benefits:

- The project allows an increase efficiency of water use and yields using modern practices of irrigation management on the farm, taking into account the restriction of the irrigation scheme.
- Technification of surface irrigation intended to save 10% of water used in crops irrigation.
- Currently, it is possible to track each irrigation and its accumulation based on one year of water per field.
- Net and Gross sheet can be observed and measured.
- One of the project performance indicators is water productivity among the participants.

Type of Investment: Public and Private

Contact Information:

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Jorge Flores Velazquez

Case Nº 12:
Intrapredial Telemetry with energy efficiency equipment

Location: Los Andes Province, Valparaíso, Chile.

Case 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 Wiseconn.

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.

Benefits:

- The DP platform lets you know precisely how many m^3/ha were used.
- A total volume of 8,100 m^3/ha of irrigation was used during the season, which is equivalent to a reduction between 15 to 20% of the average domestic consumption of table grapes in Chile, saving 15% of total energy.

Type of Investment: Private

Contact Information:

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Centro del Agua UdeC

Centro del Agua UdeC

Case Nº 13:
Small-scale irrigation management project

Location: Yakarta, Indonesia.

Case Description:

The objective of this project was to increase rice production and other farming products by developing superficial water irrigation through the construction of dams and the installation of groundwater irrigation pumps in six province in Eastern Indonesia, to contribute and improve the farmers’ incomes and reduce poverty.

This projects was promoted by Japan International Cooperation Agency, who provided a loan of USD$154,585,000 between 1998 and 2004, carried out by the General Directorate of Water Resources, Ministry of Public Works of Indonesia.

The total irrigation area for this project reached near 60,000 ha (in six provinces), widely exceeding an initial plan of approximately 16,000 ha.

The project period was much longer than planned (168% of the panned period) although the cost was lower than planned; therefore, the efficiency evaluation is moderate. The delays were mainly caused by the preparation and additional construction necessary to expand the scope of the project.

No major problems have been observed, taking into account the execution, operation and maintenance system. Thus, the sustainability of this project is high.

Benefits:

- A survey of beneficiaries (16 locations, 132 people surveyed) clearly showed that the rice harvest of beneficiary’s farmers increased 2.3 times after the project implementation.
- 70% of them indicated that they were able to grow high-yield crops, such as beans, chili peppers and vegetables.
- The project has been relevant for Indonesia’s domestic policies, both at time of evaluation as at ex-post evaluation.

Type of Investment: Public / Governmental

Contact Information:

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Case Nº 14:

Pressurized distribution network for irrigation in Los Caleos water community

Location: Nogales, Quillota Province, Valparaíso Region, Chile.

Case Description:

The pressurized distribution networks for irrigation are systems that incorporate pipelines, automatic valves and telemetry, allowing a controlled and efficient distribution of irrigation water, providing records of irrigation water consumption per user, with exact delivery flow rates in real time.

Los Caleos Water Community implemented the pressurized distribution networks for irrigation with a cost of USD$81,105, where the Government contributed with USD$32,457. Maintenance is minimal, thus are maintenance costs, reaching just USD$759 per year.

The whole pressurized distribution network system for irrigation is implemented with a software called “Gestar”, a specialized tool for the design of pressurized distribution networks for irrigation, developed by the University of Zaragoza, whose main values are economy, simplicity and standard. Its latest version, Gestar 2014, provides new functionalities and improvements, highlighting the incorporation of bidirectional communication with Autocad 2002-2012 (available for Premium versions) and the extension of performance of the pumping station regulation modules, which now allows incorporating variable speed pumps, similar or different from each other, working synchronously, in addition to the sequential operation of several pumps of variable speed, similar or different from each other, already implemented in previous versions.

Benefits:

- Since the start up, the water community can plan the distribution of water, to exactly carry out with real records of water consumption per user, to analyze and optimize the water use even more.
- The community can weekly schedule the distribution of water efficiently.
- The operation of the system is carried out with a minimum of man hours per day, where some days can have zero man hours.
- The community now has control over water supply with one click.
- The community eliminated uncertainty about the volumes of water delivered.

Type of Investment: Public and Private.

Contact Information:

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Case Nº 15:

Flow measurement program of the Reclamation District 108

Location: Reclamation District 108, California, United States.

Case Description:

Regarding the Water Conservation Law in California, this requires that water providers in agriculture implement practices to measure the volume of water delivered to clients, reporting aggregated data on farm delivery to the Water Resources Department of California.

In the flow measurement of RD 108, the installation of concrete dumps in at the discharge end of the diversions was included. The box isolates changes in the field water levels, ensures a complete water supply and provides a space for mounting the portable flow meter. Every water operator has a portable flow meter than can be temporarily installed to record the flow speed in a field at the beginning, end or at any moment that there is a change in the flow rate delivered to a field. The flow multiplied by the duration of the flow event can be used to calculate the total volume of water delivered: 450 deviation boxes - 10 Doppler acoustic sensors - 10 Panasonic Toughbooks.

To implement this project, USD$1,000,000 was invested, where 100% is a contribution from private parties, where annually there is an operation cost close to USD$65,000 where 100% is also financed by private parties.

Benefits:

- Among the results obtained, it is detailed that the user interface in the operator’s PC allows them to see the flow data in real time from a wireless water speed sensor while adjusting the flows at the diversion gate.
- The information is automatically transferred to a server in the District Headquarters and the volumes are daily developed for each participation within the district.
- The software also generates reports about water use for each field and water-based invoices delivered to each client.

Type of Investment: Private.

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Case Nº 16:

RUBICON Gates, First Section of Aconcagua River

Location: San Felipe Province, Valparaíso Region, Chile.

Case Description:

This project is subsided by the development unit of CNR, 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 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.

Benefits:

- The project allows precise water delivery.
- Generates reports of how much water is being delivered.
- The gates have a program that sends a signal to a cloud.
- From a mobile app, the gates can be controlled by just one person.
- The gates can also be operated manually from a control board above the gates.

Type of Investment: Public and Private.

Contact Information:

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Recharge of Aquifers

Case Nº 17:

Ponds and basins recharge of aquifers

Location: California, United States.

Case Description:

This case is a groundwater recharge program from Farmington in the astern basin of San Joaquin.

The recharge method chosen is field flooding, a practice where a small perimeter dike is built in the field, which is then flooded to a depth of 18 inches. Because many lands in the region have a gradual slope for drainage, the regular 16 to 40.5 ha plots will have different water depths, ideal for a wide variety of aquatic birds.

The program is run by Stockton East Water District (SEWD), in association with the Sacramento Division of the US Army Corps of Engineers (Corps). The program was launched after the completion of the Farmington Temporary Groundwater and Temporary Habitat Recharge Study in August 2001.

In 2000, the Congress authorized the program USD$ 25 million for groundwater recharge and projects in cooperation with SEWD, to invest in the future of the Eastern Basin (of groundwater) of San Joaquin County.

Benefits:

- By applying this shallow water recharge process, lands can be rotated in and out of the program quickly and economically.
- The construction supplies for the field floods do not require specialized heavy equipment and, therefore, the owner can complete them easily.
- The program provides a profitable process, where the owners can participate through short and long term agreements and receive a compensation market-based for the use of their lands. It is an agreement that essentially allows the rotation of groundwater recharge practices with a traditional use of land, which makes water a commercial crop for eastern San Joaquin County.
- Since its start in 1996, the Farmington groundwater recharge program has included the participation and support of numerous landowners, government agencies, water agencies and environmental organizations.
- The Farmington groundwater recharge program recharges annually an average of 43,171,800 m^3 of water in the eastern basin of San Joaquin.

Type of Investment: Public / Governmental

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Farmingtonprogram org

Case Nº 18:
Recharge of aquifers in the Ica Valley
Location: Ica Valley, Peru.

Case Description:

The Ica aquifer is located in the southern region of Peru. The valley is in a dessert area. The irrigation water comes almost entirely from groundwater, using the flow of the Ica River from the Andean Highs to the sea during the rainy season, from January to April, where the rest of the year is practically dry and without enough resources to supply the high demand. This situation has caused the decrease of the water table during the las two decades, with rates up to one meter per year, threatening the sustainability of the system and the continuity of the activity in the region, as a consequence of overexploitation.

In 2012 41 ponds in 10 recharge areas were implemented in the Ica Valley, in Aquijes, that used 22.37 ha. In 2013, the artificial recharge structure was enlarged, including new distribution ponds for the aquifer in Pueblo Nuevo and Parcona Districts, and a first test in Villacurí area, up to a total of 89, employing 89 ha. The enlargement continued in 2014 with 125 ponds, using 59.3 ha. In 2015 192 infiltration ponds were implemented and inventoried, that used 70.17 ha and worked as management and induced recharge cells of the aquifer.

In order to expand the area of effective infiltration, Juasvi proposed that existing publicly owned land were facilitated as a temporary loan to the valley user boards in order to expand the recharge area. Furthermore, the irrigators' commissions and valley user boards supported the initiative. Thus, in 2016 there were 660 useful ponds, using 234 ha. In 2017 new pools and micro reservoirs were incorporated to the system, reaching 846 with a total infiltration area of 295 ha.

An important aspect to take into account is the influence of the investment in cleaning the channels on the volume infiltrated to the aquifer by induction techniques. The costs invested by the board of users in the cleaning of the channels in the last three years have amounted to USD$42,470.

The costs for the pools are variable, depending on the area and whether it is in surface or in depth. As an example, the work budget of the Comesango Sector, San José de los Molinos District, carried out in November 2016, gets close to USD $ 63,000 for an area of 17 ha.

Benefits:

- Thanks to the cooperative work of all the people involved in the program, and infiltrated volume close to 17 hm³ was reached between January and May in 2017.

Type of Investment: Public and Private.

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JUASVI

Case Nº 19:
Artificial Aquifer Recharge
Location: La Pintana, Santiago, Chile.

Case 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.

Benefits:

- To date, it has been operating continuously for more than 3 years, with a total of 2.5 million m³ infiltrated during the entire pilot program.

Type of Investment: Private.

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Water Storage System

Case Nº 20:

Rangitata South Irrigation Scheme (RSIS)

Location:326 Burnett Street- Ashburton,-Canterbury, 7700, New Zealand.

Case Description:

Rangitata South Irrigation Scheme (RSIS), owned by Rooney Earthmoving, is the largest artificial irrigation site in New Zealand. It is responsible for capturing water from the Rangitata River, storing it and distributing it to farm tanks as necessary; a project that took eight years to finally complete in 2014.

The site covers more than 400 ha (988 acres) and consists of seven storage ponds. Each pond in the irrigation scheme has the capacity to retain approximately 2.3 hm^3 of water, while the tanks on the farm vary widely in size from 20,000 m^3 to approximately 400,000 m^3. The largest tank covers 48 ha and is approximately 8.9 meters deep. Each pond contains an average of about 2.3 million m^3 of water. At full capacity, the scheme can contain 16.5m m^3 of water.

The ponds were built through 'cut and fill' whereby 4 m^3 of soil and gravel were excavated from the ground and used to build the sides of the pond.

The movement of water, whether within the scheme, between the ponds and towards the farmers, is controlled by telephone or laptop by means of telemetric automation, if necessary the process is done manually from the control cabin.

To ensure that the scheme has the ability to take water constantly and ensure that the ponds do not dry out, data on river capacity, river speed and weather forecasts are analyzed.

Despite being able to store such a large volume of water in the scheme, in a drought year the high demand for water means that the ponds can empty quickly.

The scheme cost USD$83,750,000 in its construction and USD$325,000 per year in maintenance.

Benefits:

- On average, farmers receive 0.48 liters of water per second per hectare.
- Storage ponds supply 42 tanks (owned by 36 clients) on farms that irrigate about 14,000 ha of farmland.

Type of Investment: Private.

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fginsigth.com

Case Nº 21:

Barrier Ball Floating Coverage

Location: Bartolillo, Commune of Cabildo, Valparaíso Region, Chile.

Case Description:

The problem of this avocado farmer was the amount of seaweed blooms in the 2,400 m^2 irrigation reservoir that forces him to clean the pump filters up to two or three times a day and replace them every 2 months in the summer season. In addition to the labor work involved, the collapse of filters resulted in the interference of algae in the drippers with consequences on irrigation and crop quality. It is also important to note that the Cabildo area has been facing, since 2009, a critical situation of water scarcity (declared by the government as a Water Scarcity Zone).

After testing with chemical products, raschel nets and other ideas to tackle the growth of algae without good results, the farmer contacted the Barrier Ball® company to install the floating coverage, which had a total value of USD$43,200 financed by the farmer in its whole.

The Barrier Ball® floating coverage is a simple, very effective, multi-purpose, long-term (20 years of life), mature and ecological technology (made with 100% recycled HDPE and NCRE).

The installation was carried out in a particular way, since the terrain made difficult to install the balls directly from the container (bulk shipping), which is why the balls were sent in bags and a forklift was used to unload the truck bags to finally carry them to the side of the irrigation reservoir. The workers only needed to open the bags and push them towards the tank.

Benefits:

- After the installation of the Barrier Ball® floating cover, the filter cleaning frequency was reduced to once a month, the filters now last the whole year, the use of chemicals to combat algae was reduced to zero, the pressure of the drippers located in the upper area of the hills was recovered, and the quality of the crop was stabilized.
- Per year, 3,854 m^3 of water is saved due to evaporation decrease.

Type of Investment: Private.

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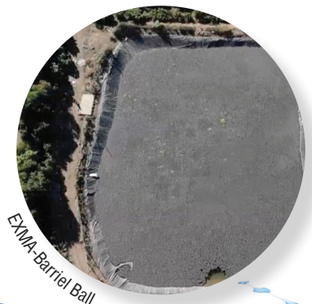

EXMA-Barriel Ball

EXMA-Barriel Ball

Case Nº 22:

Water collection system or Small Water Impounding System (SWIS)

Location: Island Bohol, Philippines.

Case Description:

The small water impounding system (SWIS) aims to harvest rain and runoff during rainy / wet seasons and store rain and runoff harvested for immediate or future use. The main use of stored water is for irrigation of crops, such as rice and other high value crops. Other uses include the production of fish and livestock and for domestic use. There are also inherent environmental functions such as flood prevention, groundwater recharge.

Currently, the department of agriculture is implementing more than 600 SWIS, one of these is the one that was implemented in San Roque in the 1980s. This includes 6 main physical components, earth embankment, reservoir, landfill, exit works and service area with a distribution system. The earth dam is about 25 meters high with a length of 110 meters, the surface of the reservoir is 14.40 hectares and a total canal length of 6,860 meters.

The San Roque SWIS is mainly used to irrigate 110 hectares of rice, for wet and dry seasons of the year. This system is being managed by the association of small water irrigators with 115 members.

The initial investment of this project was financed by the Philippine government with a cost of USD$350,000, where all of the finance was contributed by public funds. For the annual operation of this, some USD $ 1,100 were contemplated, where 100% of these funds were contributed by private companies, SIRISA.

Benefits:

This project benefited San Roque users in different aspects, where the following are detailed:

- Increase in crop intensity from 100% to 200% thanks to irrigation.
- Increase in palay production from 3.0 metric tons to 4.4 metric tons per hectare.
- Possibility of acquiring properties for the company, such as offices or agricultural machinery.
- Able to deliver good rates to all its customers, depending on the use of their machinery.
- They received an award as one of the Outstanding Irrigation Associations in 2018.

Type of Investment: Public and Private.

Contact Information:

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Department of Agriculture VII, Philippines

Department of Agriculture VII, Philippines

Water Reuse

Case Nº 23:

NEWater

Location: NEWater Visitor Center 20 Koh Sek Lim Road Singapore 486593, Singapore.

Case Description:

NEWater is a strategy driven by Singapore on water reuse, which aims to become the most important resource in the near future.

The NEWater process recycles treated wastewater in ultra-clean and high-grade reclaimed water, damping the water supply against dry weather and leading Singapore towards water sustainability.

In 1998, the Public Utilities board (PUB) created a team to test the latest proven use of membrane technology in water recovery for drinking purposes. Two years later, they launched a large-scale demonstration plant that could produce 10,000 m3 per day.

The quality of NEWater was determined to be consistently safe and high, and is within the requirements of the World Health Organization (WHO) and the United States environmental Protection Agency (USEPA) for drinking water. It is recommended for an indirect use of drinking water, to be introduced in raw water tanks. The mixed water is then subjected to naturalization and additional treatment in conventional hydraulic works to create drinking water.

The NEWater treatment is done in 3 steps:

- Microfiltration: microscopic particles, including some bacteria, are filtered at this stage.
- Reverse osmosis: undesirable contaminants are eliminated. Water at this stage is high grade water.
- Ultraviolet disinfection: water passes through ultraviolet light to ensure the eradication of the remaining organisms. Chemicals are added to restore the pH balance. NEWater is now ready to be used.

NEWater is mainly used in industrial clients, and it is delivered through a dedicated pipe network.

Twice a year, NEWater undergoes rigorous audit processes by an external audit panel composed of international experts in engineering, water chemistry, toxicology and microbiology. This high quality reclaimed water has consistently received the best ratings for its high quality, safety and for exceeding international standards.

Benefits:

- Today, there are five NEWater plants that supply up to 40% of Singapore's current water needs.
- Singapore has four water treatment plants, in Bedok (82,000 m^3/day), Kranji (77,000 m^3/day), Ulu Pandan (146,000 m^3/day) and Changi (228,000 m^3/day). In addition, the construction of a new one (Tuas) with 800,000 m^3/day is planned for the year 2020.
- By 2060, NEWater is expected to meet up to 55% of Singapore's future water demand.

Type of Investment: Public and Private.

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Case Nº 24:

Reuse of Wastewater Treatment for Irrigation

Location: Cerrillos de Tamaya, commune of Ovalle, Limarí Province, Coquimbo Region, Chile.

Case Description:

The Wastewater Treatment Reuse Project in the Coquimbo Region is an initiative financed by the Innovation Fund for Competitiveness (FIC-R) of the Regional Government of the Coquimbo region and executed by the Chile Foundation during 2016 and 2018 for a total amount of USD $ 70,671. The project was born in response to the shortage of water in the area, manifested by a deficit of rain and snow, with semi-empty reservoirs and low snow accumulation in the mountains. Under this problem, the project seeks to promote the transfer of technology to encourage the reuse of treated wastewater discharged by rural Sewage Treatment Plants (PTAS), through methodologies that generate quality water, without health risks for humans or the environment, and that are possible to incorporate various productive sectors of the Coquimbo region as required, which allows the same volume of water to be reused several times, generating productive links locally.

The system built in the city of Cerrillos de Tamaya, was a project implemented to take advantage of the wastewater discharged by the PTAS of Cerrillos de Tamaya. The project contemplated the use of 6 l/s of treated wastewater discharged by the PTAS for the irrigation of 5.5 hectares of alfalfa. In this way, the Committee undertook to operate and maintain the rural PTAS so that the quality of the reused water could be used by the agricultural productive sector that reused this new source of water, while the farmer is in charge of the work of cultivation, harvest and commercialization of the agricultural product (alfalfa).

Fundacion Chile

Benefits:

- According to the APR committee, financial compensation was given for the use of treated wastewater.
- A strategic alliance was created between the Rural Drinking Water Committee (APR) of Cerrillos de Tamaya and the farmers, generating a reuse model of treated wastewater at rural level that was of great interest and is currently being implemented as the first case referred to level with high probability of replication in Chile.
- The profits from the commercialization of the product were estimated at USD $ 50,000 per year, with an investment recovery in approximately one year and four months. With annual operating costs of USD$1.4 per cubic meter produced.
- The model will share the profits between the farmers (60%) and the APR Committee (40%), which would mean an additional income for the committee, which could be used in the operation and optimal maintenance of the PTAS, a possible reduction in the rate of user and improve the operational standards of rural PTAS.

Type of Investment: Public / Governmental

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Case Nº 25:

Barsha Pump

Location: Yakarta, Indonesia.

Case Description:

The Barsha pump (rain in Nepal, and where the first one was installed) is the first type of hydroelectric pump developed by the aQysta company. It is a pump driven by a water wheel that uses the energy of the flow of rivers and canals to pump water without operating any fuel or electricity. Depending on the soil, the crop, the climatic conditions and the irrigation technique, a Barsha pump can irrigate up to 2 hectares of land. Although it is optional, it is recommended to use the Barsha pump along with the storage system and efficient water distribution techniques, such as the sprinkler system, drip system, etc., as it helps to irrigate larger areas with a Barsha pump.

The current version of the Barsha pump is 1.5m in diameter, capable of raising up to 20 meters of vertical height and 2km inland on flat terrain, while reaching up to 40,000 liters of water per day, depending on the flow velocity of the water, and its list prices range from USD$995 to USD$1,261.

aqysta.com

Benefits:

- A preliminary test on Sumba (2017) on a plot of 400 m^2 of land, the farmers harvested 370 kg of onion. In the market, it was sold at USD$1.06 per kg, and therefore, the gain was a total of USD$393.34.
- The Barsha Pump saves farmers more than 70% of the irrigation costs during its lifetime.
- The Barsha Pump is a clean technology that does not require operation or maintenance.

Type of Investment: Private

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ecoinventos.com

Case Nº 26:

Samaca Ecological Park

Location: Ica region, Peru.

Case Description:

Fundo Samaca, producer of high quality organic food without negative effects on the climate or the environment, a 96kWp photovoltaic system was implemented to improve and extend its irrigation system.

The pumps, powered by solar energy, transport water to a reservoir that allows gravity irrigation. With the availability in the reservoir, irrigation is independent of the electrical current generated at the time.

System planning was carried out in close collaboration between Fundo Samaca, the company Consorcio Energetico de Huancavelica S.A. (CONENHUA) and Delta Volt SAC. The local work of the installation was divided between several entities, involving the personnel of Samaca and CONENHUA. During the development of the project, attempts were made to maximize the management of the systems by local people.

The system has 320 modules of 300Wp crystalline silicon with 72 cells, 5 photovoltaic inverters, 6 battery inverters in groups of three, a three-phase MC-BOX-12.3 Multicluster Box, a Sunny SensorBox is used to monitor environmental data, a Sunny WebBox Central, two OPzS tubular battery banks each with 1070Ah.

The pumps installed are manufactured locally by Hidrostal Perú company. Normally, the first bombs are switched on in the morning, and depending on the radiation, they are successively connected more. This process is reversed in the afternoon.

Finally, the energy generated and the weather conditions are continuously monitored. It can detect and alert on possible irregularities or failures in the system. The data is stored in a memory for evaluation.

Benefits:

- The system is capable of an annual production of 179,000 kWh of energy with a potential saving of more than 30,000 liters of diesel.
- Carbon dioxide emissions are reduced by 82 tons.
- As there is no connection to the public electricity grid in the sector yet, the solar system replaces the diesel pumps used previously and provides electricity to the entire farm. This includes pumps with a total power of 70 hp, the reverse osmosis system for drinking water, different machinery for production, administration, cooking and common light in homes.

Type of Investment: Private

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Deltavolt

Case Nº 27:

Photovoltaic Solar Power Generation Plant to Supply a Drainage Water Reuse Plant

Location: Yolo County, California, United States.

Case Description:

To generate energy to supply the Sycamore Pumping Plant for the reuse of drainage water.

The Sycamore Solar Plant, a photovoltaic (PV) solar power generation system comprises 30 MECA MS Tracker 10 dual-axis trackers. Each tracker has 56 Trina TSM POS high efficiency polycrystalline photovoltaic modules, for a total of 1,680 photovoltaic modules. The system has a power of 386.4 kW DC under standard test conditions. The DC output of the trackers is converted to 480 V, three-phase AC power via a 333 kW bipolar inverter from Advanced Energy Industries Solaron, with a system CEC rating of 330,876 kW AC.

To develop this project, approximately 3.4 million dollars were invested, where private parties contributed 100% of the financing. The annual operational costs presented in this project are around USD$22,000, where the total of that money is also contributed by private parties.

Benefits:

- The Sycamore recycling pumping plant uses a combined power of 775 horsepower to raise rainwater and field runoff to provide a maximum flow of 7.59 m^3/s to approximately 2,428 ha planted mainly with rice.
- All the PV system output that is not consumed by the RD-108 pumps is fed to the network through a bidirectional meter that allows the RD-108 net measurement credit for excessive generation.
- One of the main results of the photovoltaic generation system is that it successfully supplies 90% of the energy to the Sycamore recycling pumping plant. In an average year, the plant generates approximately 800,000 Kwh of AC power.

Type of Investment: Private

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Jordon Navarrot

Jordon Navarrot

Case Nº 28:

Floating Photovoltaic Panels

Location: San Felipe Province, Valparaíso Region, Chile.

Case 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.

Benefits:

- 30% of the energy consumed by the vineyard is supplied by the floating panels, and it is estimated that very soon they can expand the number of modules reaching 50% in the near future.
- Evaporation of the accumulator tank is reduced.
- Space on land is saved, which could eventually be destined for cultivation.
- In winter and times that it is not irrigated, or when the energy produced by the floating panels is not used, the energy is injected into the system and is discounted when consumed, thanks to the Net Billing Law of the Economy.

Type of Investment: Public and Private

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Case Nº 29:

Photovoltaic Irrigation

Location: Chimbarongo, O'Higgins Region, Chile.

Case 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.

Benefits:

- The main advantage of the implementation of photovoltaic irrigation is the reduction of the costs of the electrical supply for technified irrigation in 100 ha of vineyards.
- The use of frequency inverters improved the energy efficiency of pumping equipment for irrigation.

Type of Investment: Private

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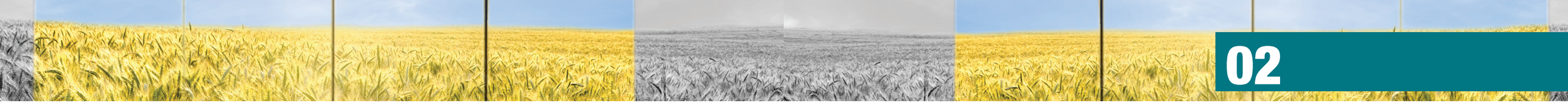

02

RECOMMENDATIONS

Considering the current effects of climate change on the availability of water resources, as well as the extreme events that affect agro-productive systems, it is necessary to have information on successful experiences that contribute to guarantee food security. In this context, this Brochure was prepared and gathers various experiences in management, investment and efficient use of water resources from APEC member economies, as well as the scales of application, methodologies, technological levels and financing.

The information presented of the different cases in this Brochure reflects the actions that are implemented by each of the economy should take into consideration: The water reality of each territory, cultural practices, the productive potential, the characteristics of the farmers (as age educational level), potential barriers in the technological leap of a territory, among others. This allows in each of the modifications to define the mechanism of action that generates the greatest productive impact with the objective of ensuring food security.

It is very important to have quality information on the water reality of each territory (Water Balance), in order to analyze the weakest or causes of problems in agricultural production. In many cases, availability becomes highly relevant in these analyzes, which leads us to consider the accumulation, recharge of aquifers and water reuse systems as a priority, as well as the control and management systems in the distribution in pressurized channels or networks. But it must be taken into consideration that these strategies or actions take a long time to be implemented, and they also demand financial resources.

That is why, in parallel, it is important to deliver the tools to farmers so that they can face any future scenario, through programs of knowledge transfer, dissemination and technological implementation, as well as permanent advice, in order to guarantee technological association.

Regarding the issues addressed in the brochure, it is important to highlight that the cross-cutting innovations of APEC economies are related to the new technologies that have been developed in recent years regarding sensing, monitoring and tracking, being the latter component a fundamental pillar to make future decisions and that will allow a better use of water resources.

Asia-Pacific Economic Cooperation