FINAL PROJECT COMPLETION REPORT

ENHANCING RESILIENCE TO CLIMATE CHANGE OF THE SMALL AGRICULTURE IN THE CHILEAN REGION OF O'HIGGINS

January 2023

INTRODUCTION

This report is the summary of the technical activities as itemized in the Commitment Agreement signed in 2017 between INIA and the Undersecretary of Agriculture as a part of the project “Enhancing resilience to climate change of the small agriculture in the Chilean region of O’Higgins”.

This information conforms to the compilation of data in the Annual Operating Programs of four years. It is an input for the writing of the Project Completion Summary as shown in the Adaptation Fund instructions that finance the project.

RESULT 1.1. IMPLEMENTATION OF A CAPACITY BUILDING AND TRAINING SYSTEM TO INCREASE THE RESILIENCE CAPACITY OF RURAL COMMUNITIES VULNERABLE TO CLIMATE VARIATION AND CLIMATE CHANGE CONCERNING SOIL, CROP, LIVESTOCK, AND WATER MANAGEMENT

Product 1.1.1 Creation of training and technology transfer teams for improved farm technology in each of the 8 towns of the project area coordinated and supervised by local experts from INIA

During the execution of the project (2018 – 2022), INIA assigned experts specialized in topics such as soil management and efficient use of water; adapted crops; sheep management, beekeeping, forage, and pastures; soil amendments; farm equipment; horticulture and agroecological management.

Product 1.1.2 IMPLEMENTATION OF 9 DEMONSTRATION FIELDS

1.1.2.1 Design and location

To establish and characterize the Demonstration Units, a diagnosis was made based on 70 surveys per participating commune: Lolol, Pumanque, Litueche, La Estrella, and Marchigüe, from the interior dry land, and Paredones, Pichilemu, and Navidad from the coastal dry land, which allowed the selection of the most representative farms and ratified the application of the techniques as listed in the general proposal. Farmers were protagonists in the decision-making process. The technical team had an auxiliary role to find opportunities and deficits, generating a design and farm work plan as shown in the example of the following figure (Sector 2 of the Demonstration Unit in the town of Pumanque).

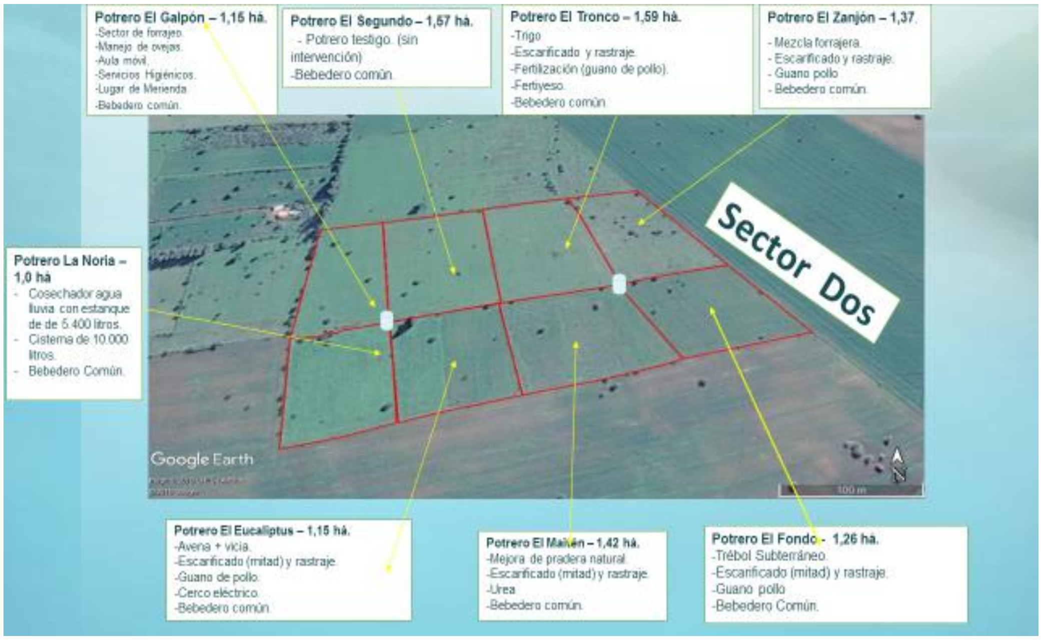

Figure 1. Design and farm work plan for sector 2 of the Demonstration Unit in the town of Pumanque.

The implementation process of the proposal begins with a biological inventory of the demonstration unit and continues with the supply of inputs, soil preparation, and planting.

1.1.2.2 Soil preparation

a) Background: Soil analysis in 64 farms within the 8 towns of the project (3,000 samples) showed clay textures; low percentages of organic matter content; surface and subsurface compaction ("plow pan"); elevated levels of bulk density; low macro porosity and total porosity; and low saturated hydraulic conductivity. Consequently, these soils are prone to erosion, a situation aggravated by topography and rainfall regime.

b) Actions: The general recommendation is that these soils should be subsoil up to 60 cm deep with chisel-type plows, scarifiers, and subsoilers, to achieve vertical plowing and macro porosity above 10%, total porosity over 40%, and hydraulic conductivities over 6 cm/hr, which are the most favourable ranges for the establishment of crops (sheet "Agricultural Machinery for the 9 demonstration fields" at http://changeclimatico-ohiggins.cl/ index.php/doc-8/).

These recommendations as applied in the Demonstration Units showed energy savings in traction for the chisel plow; improvement in the penetration of water in the soil profile; removal of the compacted layer or plow-pan; conservation of earlier crop residues thus reducing the risk of erosion and proliferation of weeds. Also keeps the level and improves the structure of the soil by avoiding excessive loosening caused by other tillage implements.

c) Amendments: Dryland soils show low phosphorus values, pH 5.8; and minimum organic matter content. For this reason, the organic, phosphoric, and calcareous amendments improved the yield of natural grasslands and supplementary forage crops, when added to a fertilization rate based on routine chemical analyses.

d) Comment: These practices could be financed through the Program for the Recovery of Degraded Soils of the National Institute for Agricultural Development (INDAP), which includes more than 40 tasks. However, in-field interviews with farmers it was possible to feel a certain reluctance to apply for subsidies with long-term results such as soil conservation practices, preferring those that generate immediate income.

e**) Key results: The use of a scarifier, practically unknown to these farmers, resulted in higher production of D.M./ha than another type of plow in all the crops evaluated**.

1.1.2.3 Improved forage species for dry land.

a) Strategy: It was planned to establish gardens of varieties in the towns that presented the most extreme conditions in terms of rainfall and temperatures. The hypothesis was raised that the species that best developed in these environments would also do so in the rest of the towns, seeking to determine the species that best adapted to the intrinsic edaphoclimatic conditions of each town. The results obtained in the first year of the project in the various gardens, about the yields of the forage species, laid the foundations to establish the species to be planted as a proposal in the demonstration units in years two, three, and four.

a) Mix of annual legumes (dose of 25 kg of mix/ha):

1. (MED) 400: Subterranean clover (Trifolium subterraneum cv Losa, Dalkeith Campeda, Seaton Park), Hualputra (Medicago polymorpha cv Scimitar) and Balansa clover (Trifolium michelianum cv Paradana, Frontier). Mediterranean

2. (MED) 500: Subterranean clover (Trifolium subterraneum cv Campeda, Seaton Park, Clare, Antas), Hualputra (Medicago polymorpha cv Santiago) and Balansa clover (Trifolium michelianum cv Paradana). Mediterranean

3. (MED) 600: Subterranean clover (Trifolium subterraneum cv Gosse, Antas, Clare), Hualputra (Medicago polymorpha cv Santiago), and Balansa clover (Trifolium michelianum cv Paradana)

b) Supplementary crops (hay or grazing for critical periods)

1. Oats + Peas (Avena sativa cv Super Nova + Lathyrus sativa) in a proportion of 60 - 40%, in doses of 72 kg oats/ha + 88 kg peas/ha;

2. Oats + Peas (Pisum sativum var. Milano) in a proportion of 60 - 40%, in doses of 72 kg oats/ha + 88 kg peas/ha;

3. Oats + Vicia (Vicia atropurpurea) in a proportion of 60 - 40%, in doses of 72 kg.

4. Oats + 60 kg Vicia/ha;

5. Oats alone in doses of 120 kg/ha

6. Triticale (X. Triticosecale Wittmack cv Aguacero) in doses of 200 kg/ha.

7. Sorghum (Sorgum sspp) var Sordan 79

8. Acacia (Acacia saligna) Forage shrub species. 11,504 plants (average of 20 plants per beneficiary) were distributed among project users; 815 of these were in the demonstration units (average of 90 plants per Demonstration Unit). It requires watering in summer. The establishment will be evaluated in the medium term.

c) <u>Results</u>

For the MED 600, 500, and 400 mixtures, yields (kg D.S./ha/year) were 5,531; 5,758, and 5,276, respectively.

In supplementary crops, the highest yield (kg D.S./ha) was obtained with triticale cv Aguacero (15,458), oats cv Urano (12,576), oats/vetch (11,948), oats/peas (9,404) and oats/peas (7,964). These yields translated into bales (35 kg) are equivalent to 442, 359, 341, 269, and 228, respectively.

Sordan 79 sorghum, with irrigation, proved to be a new forage choice for the summer season. In 4 months, it can produce up to 43,000 kg M.F./ha, which translates into more than 7,300 kg M.S./ha, or its equivalent in bales equal to 208 units of 35 kg each.

Alfalfa was experimented with in communes of the interior dry land, but without results, due to low winter temperatures and recurrent frosts.

d) <u>Comment</u>: The experimental introduction of Forage Triticale lines obtained in Mexico could be one of the great milestones of this project. Unlike Chilean-related varieties (e.g., Triticale Aguacero INIA) intended for grain production and haymaking as a by-product, forage Triticale covers the nutritional requirements of animals between August and October, with particularly good regrowth in summer. Today there is no similar choice, and a new commercial variety is due within a maximum of two years. Forage Triticale comes from the rainfed areas of Mexico, with even more extreme edaphoclimatic conditions than central Chile’s dry lands, allowing to obtain up to a maximum of four forage cuttings.

e**) Key results: Improved resilience in farmers by increasing forage production for haymaking from 9,800 kg D.S./ha of oats to 16,500 kg D.S./ha of triticale and grain from 40 qqm/ha to more than 60 qqm/ha** as described in the technical bulletin "Triticale production for grain, in the interior dry lands of the O'Higgins Region" (http://changeclimatico-ohiggins.cl/index.php/documentos/). As a result, the sown area increased from 0 to 20 ha by the fourth year and an INIA nursery was set up that produced 5,000 kg of seed, an input that is now incorporated into the INDAP subsidies. This goes with the increase in natural grassland production, from 800 to more than 1,300 kg MS/ha, in each of the 8 communes intervened by the project, due to soil scarification work and application of organic amendments.

1.1.2.4 Other crops

a) Bakery wheat: The new variety IRAFEN INIA shows good productive behavior in the dry land of the O'Higgins Region (73.4 qq/ha) despite the lack of water and hot temperatures during the grain filling period. However, it became clear that it is not possible to produce wheat with less than 200 mm of rainfall in the season. This limits the continuous production of grain in the interior dry lands.

b) Durum wheat: At the INIA Hidango Experimental Center, it was shown that it is possible to produce durum wheat in dry coastal areas and that advanced lines do exist with the potential to become the first durum wheat variety adapted to dry coastal areas (average 52.8 qi /he has). The quality of grain produced is the best and meets the demands of the Chilean pasta industry.

c) Quinoa: The varieties registered by INIA "Kuru" and "Mauka" stand out for their yield, protein, and fiber content, managing to produce between 1 - 1.5 ton/ha of clean grain in the coastal dry land of the O' Higgins Region.

d) Buckwheat: Also called buckwheat, it did not work because it was sensitive to low temperatures (frost). This restricts its planting date to times of low water availability in the soil profile.

d) Chickpea: It is a crop that is decreasing in dry land, although it is still relevant in the Navidad town. The introduction of biofertilizer increased the yield from 15.33 to 27.5 qq/ha.

e) Comment: The contract farming model linked to durum wheat is an interesting possibility for small farmers within the dry coastal areas who have a minimum production unit of between 5 and 7 ha.

f) **Key results: The new IRAFEN variety, recently registered, was selected at the Hidango Experimental Center specifically for dryland conditions, proving to be the replacement for current varieties.**

1.1.2.5 Sheep management

a) Strategy: To program the health, nutritional, and reproductive management by animal category, adjusting stocking rate to surface area and forage availability. The indicators are stocking rate, body condition, lambing percentage, and lamb weight.

b) Work plan: The general principles summarized below were adapted to each situation, according to the farmer a calendar of activities. In small herds, inbreeding is inevitable, so rotation of rams between demonstration units is important. Rams of the Suffolk Down breed were acquired for the project with progeny tests conducted in Hidango and health certified by the SAG. The periodic determination of the body condition of sheep shows their nutritional level, which, complemented with an estimate of the availability of dry matter (measuring disk, frame cutting, or visual estimation) allows adjusting an adequate stocking rate. Pregnancy diagnosis of ewes by ultrasonography results in the early identification of dry sheep; uniparous; twins and ewe lambs with multiple pregnancies. This allows prompt distribution of forage resources according to the needs of each type of animal. The regrowth of triticale stands out as a summer resource when protein need is high due to lactation. Registering in adequate forms of birth control information such as identification tag, lamb count, sex, and weight, becomes a database for precise decision-making. At 20-28 days drenching against internal parasites and broad-spectrum subcutaneous vaccination is due.

c) Results: In all cases, compliance with the agreed protocols resulted in a decrease in stocking rate/ha in the second year from 3.3 to 3.0, and a consequent increase in body condition and lambing percentages up to 140%, as compared with the earlier average of 90-94%. Lambs reached 28-32 kg at 85 days, when prices are high, before the stress of the summer season. The potentials of the Suffolk Down breed-quite diminished under traditional management were achieved.

d) Comment: Sheep farming may be the most resilient agricultural activity under the climate change conditions expected for dry land. The crops typical of traditional agriculture have been losing relative importance due to market reasons and increasing drought, which leaves lamb production as the most relevant economic activity and regional symbol, its main destination being the local market. This project shows that the species most suited to climate change and that are most favored by soil management practices that perfect the use of rainfall are forage species, such as triticale.

f) Key results: Sheep production, following technical protocols, can reach the productive potential of the Suffolk Down breed, especially by meeting the nutritional requirements of the pregnant sheep thanks to the incorporation of the triticale supplementary crop.

1.1.2.6 Beekeeping

a) Background: Climate change alters the phenology of plants by changing nectar flows and reducing the nutritional value of pollen. This severely affects production, worsened by the loss of hives caused by growing resistance to varroa parasite treatments and outbreaks of American foulbrood.

b) Strategy: Although there is a traditional experience in this area, to achieve the honey production potential of the region, it is necessary to apply strictly scheduled protocols for high-tech integrated nutritional, reproductive, and health management. To this effect, each Demonstration Unit was implemented for five first hives to support the didactic work for groups in situ. However, individual training and monitoring of the work plans of each user, who received between 5 and 8 hives, was especially important.

c) Results: A total of 140 hives were delivered in the 8 towns, which grew to 239 in the fourth year. Complying with the work program doubled the number of hives. The average honey production per hive was slightly higher than the regional mean (19 kg) but still much lower than the potential. The lack of equipment for honey extraction diminished and, in a few cases prevented the harvest, while in others, the "harvest opportunity" was lost. The total gross income per hive was $81,238 but prices were lower than the market due to defects in the format and presentation of the product. It is considered that the producers are overcoming a learning stage and that the economic results of this first stage are satisfactory considering that family labour is used (Gross Margin per hive between one and three million approximately).

d) Comment: The O'Higgins Region shows excellent natural resources for apiaries which is a strength for novel producers. This is especially true for Navidad y La Estrella towns, where the best results were obtained.

1.1.2.7 Reforestation

a) Background: Although this action is not explicitly described in the project, planting trees on land suitable for forestry is one of the most effective ways of mitigating the effects of climate change because it is a carbon sink that absorbs solar radiation and collects and stores 18 times more water than bare soil. In addition, it is part of a government committee that promotes a plan to "...reforest our country, favoring native species."

b) Strategy: Deliver plants of Acacia saligna, Peumo (Cryptocarya alba), Maqui (Aristotelia chilensis), Quillay Quillaja saponaria) and Canelo (Drimys winteri), for planting in the Demonstration Units and in farms of producers of the 8 towns where the project is executed. For this, an agreement was signed with the National Forestry Corporation (CONAF), which supplied the plants from its nurseries free of charge.

c) Results: The program considered the delivery of 14,000 plants, fulfilling to date a total of 12,472 among 402 beneficiaries. The remaining 1,528 units will be delivered to the beneficiaries present during the project's closing ceremony.

d) Comment: Eight hundred and five plants were delivered to the Municipality of Marchigüe, which requested them to enable an abandoned property used as a dump by the locals.

Product.1.1.3.- Training in sustainable soil management, plowing practices, fertilization, soil fertility, recovery practices, and holistic soil management.

1.1.3.1 Background

As described in point 1.1.2.2, dryland soils are poor and compacted, so they must be subsoiled with chisel-type plows, scarifiers, and subsoilers, in addition to applying fertilization and amendments as shown by soil analysis. Producers lack adequate machinery and service providers are not interested in small and distant areas. The equipment provided by the project made possible the implementation of the technological innovations necessary to adapt practices to climate change.

As part of the essential technology transfer program for the correct execution of these tasks, the following sheets, bulletins, and videos were published, available in the Documents Library of the project website (http://changeclimatico-ohiggins.cl/index.php /doc-8/):

• Agricultural machinery for the 9 demonstration fields

• Use of organic amendments in the management of rainfed grasslands in the O'Higgins Region

• Technique of scarifying or subsoiling the soil in strips to ease the infiltration of rainwater.

• Control and management of minor gullies

• Safe use of pesticides, dosage, and regulation of sprayers

• Zero Tillage, soil, and water conservation work (video)

• Scarifying Plow (video)

• Origin of Soil Compaction (video)

• Pit (video)

These materials were presented, analyzed, and discussed on field days, in technical committee meetings, and direct supervision with users.

1.1.3.2 Activities

The operation works of the agricultural machinery contemplate the stages of the trial phase, first, second and third, including work between November 2019 and May 31, 2021, a period that was monitored by the Institute of Agricultural Research (INIA). After these stages, the Management and Planning Unit (UGP) continued with the execution of tasks between the months of September 2021 and February 2022.

The work of agricultural machinery has been one of the most important components of the project, especially due to the approaches to recovery of non-productive soils, improvement of sustainable practices, and benefit to users with limited opportunities to use machinery. About the above, the dry land of the O'Higgins Region is characterized by the presence of unproductive soils, normally eroded and compacted, limiting its use to animal production, forest plantations, and some annual crops with shallow roots. This type of soil allows the greatest amount of rainwater supplied during the winter and part of the spring to be lost through runoff, impairing the infiltration and accumulation of water in the soil profile, as well as unavoidable erosion, especially on land with slopes.

Thus, farmers in the dry land of the O'Higgins Region lack adequate machinery for the movement and preparation of soils, besides, both the long distances and the small areas of users prevent companies that provide services agricultural machinery agree to carry out this type of work. Due to the above, it is that the use of agricultural machinery, implements, and implements in the project have been essential to improve soil conditions, the productivity of crops in the area, the incorporation of new forage alternatives adapted to climate change and, therefore, above all, increase in the profitability of the farmer.

During the first period (trial phase and first stage) there were delay problems in the most important soil tillage tasks, especially scarification, due to the use of tools of inappropriate quality for the characteristics of the dryland soil of the region. O'Higgins broke and failed to perform the job promised. Likewise, the tractors presented different mechanical failures throughout the project, which led to the cessation of work in some communes for considerable periods. Other problems of low activity were due to climatic conditions, rains concentrated in short periods in clayey soils, causing pooling of water on the surface.

In the aforementioned period (November 2019 to May 2021), INIA had the task of listing the areas worked, according to what was done by the contractor company and the compliant receipts requested from the beneficiary farmers. In this period, a total of 8,282 ha were intervened in the communes of Lolol (1,262.15 ha); Paredones (1,148.49 ha); Pumanque (1,295.1 ha); Pichilemu (956.2 ha); Litueche (927.41 ha); Marchigüe (932.96 ha); La Estrella (1,140.8 ha); and Navidad (618.86 ha).

After May 2021, to be more precise, from September 2021 to February 2022, the Management and Planning Unit (UGP) allowed the continuity of the use of agricultural machinery in the eight communes indicated above. The area reached in this period was 1,413.42 ha (Lolol: 161 ha; Paredones 67.7 ha; Pumanque 237.7 ha; Pichilemu 233 ha; Litueche 195.4 ha; Marchigüe 182 ha; La Estrella 212.65 ha; and Navidad 134 ha). In both periods, the total intervened area was 9,695.42 ha.

The tasks with the greatest relevance in the territory and the entire period were disc harrowing with 3,753.68 ha and scarifying with 3,618.01 ha, the equivalent of 38.72% and 40.6% of the total, respectively. Below these works, the application of organic amendments stands out with 700.8 ha and forage baling with 522.9 ha, which corresponds to 7.23% and 5.39%, respectively. These four works achieve a sum of 8,914.01 ha, involving 91.94% of the total intervened surface. The baling surface could have been considerably higher, however, the pastry equipment (including the baler) was acquired in the last period of the project (November 2020).

4,382 machinery services were supplied, of which 3,232 correspond to male and 1,131 to female users; 73.76% and 25.81%, respectively. Twenty properties (0.43%) correspond to social reasons (schools, technical schools, and other organizations). The number of farms served does not refer to the number of different users, since some farmers benefited on more than one occasion with the same or different tasks.

As previously mentioned, one of the most relevant problems in the rainfed area is the low access to agricultural machinery, especially due to the distances from the urban areas that provide services, as well as their access to carry out work on small surfaces. unprofitable. However, in the hypothetical case that the benefited users had leased the machinery service, the aid generated by the project would exceed five hundred million Chilean pesos, according to reference rental values for each of the tasks carried out.

The work of agricultural mechanization in the eight towns of the dry land of the O'Higgins Region has considered among its tasks; the improvement of the soil structure through the incorporation of organic matter, increased infiltration, and maintenance of rainwater humidity in the soil with the use of scarifying plows; waste incorporation and soil loosening with the use of disc harrows and rotary cutters; planting of grains for animal consumption and meadows with the use of tops and zero tillage seeders; management of the prairie and fodder with the use of mowers, windrowers, and balers. Based on the foregoing, the social, economic, and productive aid that the project has generated in the more than 9,700 hectares worked especially for the benefit of small-scale agriculture is very relevant.

Regarding the useful life of agricultural implements, it generally varies between 15 to 20 years, with an average annual use of 300 to 400 hours. In the case of agricultural tractors, the useful life varies between 15 to 18 years with an average annual use of 1,000 hours. Currently, the 8 tractors have an average of 2,500 hours of work, only 15% of their useful life, and the disc harrows have an average of 300 hours of use, just over 6% of their useful life. Scarifiers are the implements that represent the greatest number of hours of use, especially due to their reduced working width (2.7 m) and their low forward speed (2 km/h), they show an average use of approximately 910 h per implement, which means 20% of its useful life. The foregoing allows all the implements, equipment, and machines of the project to be in a position to continue providing services to small-scale agriculture, for which a continuity project must be generated to meet the demands for agricultural services in areas extreme, and there is a greater benefit farmer - soil - crop, in response to the variant climatic conditions that affect the areas described.

For the continuity of the use of agricultural machinery in the rainfed area, the use of continuous jet seeders to implement crops under zero tillage is established as an innovative tool. This would allow the incorporation of organic matter into the soil from the residues of the previous crop, an adaptation of conservation tillage implements without the investment of soil, less soil erosion due to bare surfaces, recovery of natural meadows, and implementation of artificial meadows, less intervention of machinery, less soil compaction, among other benefits.

Product 1.1.4.- Training in the use of crops (wheat), forage (legumes and grasses), fruit trees (olive and walnut trees), and Livestock (sheep) tolerant to climate variability and climate change, including the acquisition of seeds, plants, and animals.

The general training strategy was based on personal contact with users, valuing traditional knowledge and proving on the ground the importance of integrating it with the technologies necessary to mitigate the effects of climate change. Field days in the Demonstration Units are the starting point that guides the definition of work plans agreed upon with each user. Agricultural schools and community organizations are included. The methodological resources are workshops; workshops, seminars, and field days with the support of pedagogical material in bulletins, files, sheets, and videos, delivered on paper and available in the Documents Library of the project website (http://changeclimatico-ohiggins.cl/index .pup/doc-8/) The most outstanding by category are:

Wheat

• IRAFEN-INIA: New variety of bread wheat for dry land in the O'Higgins Region.

Forage

• Production of Triticale for grain, in the interior dry land of the O'Higgins Region.

• Sowing of Triticale Aguacero in rainfed areas (video)

• Management and use of degraded natural grasslands

• Use of organic amendments in the management of rainfed grasslands

Sheep

Sheep production is linked to the customs and lifestyle of the dry-land farmers. Beyond the crisis that this industry has suffered at a national and global level, it continues to be one of the main sources of income for small producers, who achieve in the local market higher prices than international ones. The principles exposed in the demonstrative units are presented in point 1.1.2.5. and they were applied with the supervision and permanent evaluation of the professionals of the project. The informative materials generated are:

• How to save lambs using ultrasonography in sheep (doc)

• The dog, definitive host (doc)

• Nutritional requirements of the pregnant sheep (doc)

• The Electric Fence (video)

Rams of the Suffolk Down breed were acquired with progeny tests conducted in Hidango and health certified by the SAG, which was rotated among the beneficiaries, thus solving the problem of inbreeding inherent in small herds and perfecting the useful life of the males.

Beekeeping

Although the area has the potential to produce high-quality honey, it requires a high technical level and, in general, the producers do not have adequate experience. Especially didactic material focused on novice users was edited.

• Beekeeping Management Manual for hives of the Demonstration Units and beneficiaries of the Climate Change project.

• Integrated management of high-impact diseases for beekeeping (booklet)

• Varroa check (video)

• Bee feeding (video)

• Control of American Foulbrood and Vespula germanica (seminar)

Orchards

Almond and walnut trees in the Pichilemu sample unit showed significantly higher vegetative growth when scarifying between rows. Fruit trees were not among the main demands of users.

Product 1.1.5.- Training in efficient water management in demonstration fields (including the acquisition of equipment) through the application of irrigation technologies with the use of renewable energies (solar and wind).

On the one hand, the technical feasibility studies for the installation of wind systems indicated that their implementation was not feasible, because the wind potential detected in the areas where the demonstration units are located was not sufficient for electricity generation based on energy from mini-wind projects.

According to the studies carried out, the average annual wind speed, in all the demonstration units, did not reach the minimum wind speed limit (5 m/s) that is required and indicative of the technical feasibility of carrying out this type of project. mini-wind farms focused on self-consumption electricity generation.

Likewise, the studies determined that the average annual wind speed, determined for the nine demonstrative units, oscillated between the values of 2.3 and 3.7 m/s, measured at a height of 25 meters at ground level.

Notwithstanding the foregoing, pre-feasibility economic studies were carried out on the nine demonstration units, considering all the necessary implements and installation and regularization costs.

Finally, it was determined that only the cost of the 50-meter tower represented between 55 and 71% of the project's total cost, which raises the total value of the proposal to values that do not justify the project's economic feasibility.

In short, the high cost of the project means that the total projected savings that the wind system would produce throughout its useful life (25 years) will not exceed the initial cost of the project. Due to the above, the return time of the investment through the energy savings generated by the wind system far exceeds the useful life of the system, thereby causing negative rates of return for this type of investment. Therefore, the use of the photovoltaic solar resource was prioritized, as a viable, known, and proven alternative in the areas of interference of the project. To fulfill this objective, 101 pieces of photovoltaic equipment were acquired and distributed to the same number of beneficiaries, distributed in the eight communes where the project was developed and these were mainly used for the extraction and distribution of subsurface water.

RESULT 1.2. IMPLEMENTATION OF MEASURES AND TECHNOLOGIES TO INCREASE THE AVAILABILITY OF WATER RESOURCES FOR RURAL COMMUNITIES OF THE COASTAL AND INTERIOR DRYLAND COMMUNITIES OF THE O'HIGGINS REGION

Product 1.2.1.- Installation of water harvesting equipment in 558 properties including training and acquisition of materials, equipment (roofing materials, pipes, mobile tanks, pumps with renewable energies (solar and wind radiation), and installation of greenhouses.

1.2.1.1 Rainwater harvesting for vegetable production

a) Strategy: The program promotes the production of vegetables for self-consumption and the eventual sale of surpluses, using the water accumulated from winter precipitation. To this effect, a simple infrastructure is built that allows the collection of rainwater and its conduction to a 40 m2 greenhouse. The model considers 5,400-liter tanks that begin to fill in May with the first rains which can accumulate up to 20,000 liters in the season. The management plans were designed based on traditional knowledge, adding maximum diversity of species; ecological control of pests and diseases (cultural rotations, trap crops, the attraction of natural enemies); waste and guano recycling (compost, bokashi) accompanied by a permanent transfer program.

b) Informative material generated:

• Techniques for capturing, accumulating, and using rainwater (doc)

• Construction of polyethylene greenhouses with polycarbonate cover

• Plastic posture for the greenhouse (video)

• Biofilter (video)

• Biofumigation (video)

• Improving the use of pesticides (video)

• Production of hydroponic green forage

• Correct use of the technical irrigation system (doc)

• Bokashi Fermented Manure

• Sowing Calendar Autumn - winter and spring – summer

c) Results:

• 558 producers with a rainwater collection, accumulation, and use system installed on their farms, which includes 40 m2 greenhouses. Of these greenhouses, 326 were installed with a polycarbonate roof, which increases the useful life of these structures.

• To this initially committed result, 4 schools in the Lolol, Marchigüe, Pumanque, and Santa Cruz towns were added, with the installation of a Collection System, accumulation, and use of rainwater with greenhouses. These will allow students to become aware from an early age of the importance of caring for water and its efficient use. Due to the above, the total of Systems built-in execution of the project reached 662.

• 31 producers with a hydroponic green fodder production system installed on their farms, which includes a production structure with three levels and 30 trays, which allow the generation of 81 kg of hydroponic green fodder (fresh material) in 2 m2. The system is also sustainable since it uses rainwater as the main element and the latter is not discarded, since the system allows the recirculation and collection of excess irrigation water, being collected and accumulated again for use.

RESULT 2.1. INSTALLATION OF AN INFORMATION SYSTEM FOR AGRO-CLIMATIC RISK MANAGEMENT AND ADAPTATION TO CLIMATE CHANGE.

To achieve the objectives, component 2 considers two results, which correspond to:

Result 2.1.1.- Improve the management of relevant agroclimatic information for decision-making for present and future climate changes among local MINAGRI professionals and agricultural communities.

The result 2.1.1., considers the following product to obtain the achievement of the objective, which corresponds to:

- Product 2.1.1. Reinforcement of the existing network of automatic weather stations.

The activities carried out to achieve the results established by the component were the following:

- Implement a groundwater monitoring system for direct and indirect beneficiaries of the project, through citizen science, complemented by measurements in deep observation wells through measurement equipment.

In this objective, the work agreement with the Water Center of the University of Concepción was used to monitor groundwater through APR wells in the communes of the project. They are detailed in Table.1, in the Annexes and Tables section, and in Image.1 which shows "Groundwater data monitored through APR of the project towns

- Strengthen and improve access to local agroclimatic information through the construction of the Regional Agroclimatic Observatory (OAR) through outsourcing of services.

In this objective, actions were achieved that allowed the improvement of the Regional Agroclimatic Observatory (OAR, Image.2, Annexes and Tables), which emphasizes the improvement of local information, the development of information products based on AGROMET meteorological data, the improvement of the spatial resolution of the agrometeorological indicators, meteorological, hydrological and agricultural drought, indicators the provision of citizen science data provided by the farmers participating in the project, forecasts and alerts associated with the agricultural and forestry activity of the O Higgins Region. Thus, generating resilience to climate change from a local perspective, allowing to complement an improved version of the national observatory.

The OAR developed will serve as an example for the extension of this platform at the national level. It is currently available on the servers of the Ministry of Agriculture. (https://oarohiggins.minagri.gob.cl/), which ensures its operation after the end of the project.

Training courses on the use and operation of the Regional Agroclimatic Observatory (OAR) were carried out for the use of agrometeorological information aimed at decision-making in agricultural management.

Six face-to-face courses were held, where each of the functions of the OAR was reviewed, pointing out how this observatory serves as a tool for access to agroclimatic information seen in the Participatory Agroclimatic Tables. Allowing farmers to obtain information from the forecasts on different time scales provided by the Chilean Meteorological Department, International Forecasts regarding the ENSO phenomenon, as well as information from citizen science and AGROMET weather stations, and finally the vegetation indicators provided were reviewed. on the platform, which helps decision-making in agriculture.

Result 2.1.2.- Creation of capacities for the analysis of climatic and weather data and integration in agricultural decision-making.

The activities carried out to achieve the results established by the component were the following:

- Train technicians and farmers in the interpretation of agro-climatic indicators for decision-making for people from the project and SIRSD institutions and operators through courses on the use of agrometeorological information for decision-making in agricultural management.

Training courses were developed for professionals participating in the project, as well as for other public officials associated with the project, such as PRODESAL officials, and municipal officials, to generate skills and knowledge regarding the role of agroclimatology and technical decisions in the different activities of livestock of the O'Higgins Region. Table.2, Detail of themes, courses, and target groups.

Also, Introduction to agroclimatology and climate change talks were held for students from rural schools and high schools in the O'Higgins Region, training more than 200 students on these topics. I'd like to mention that 1 field day was held with students from the Tambo high school of the town of San Vicente de Tagua Tagua.

- Strengthen the existing network by incorporating new sensors according to the feasibility study, prioritizing the incorporation of new existing meteorological stations and/or complementary sensors for the measurement of agroclimatic variables.

During the execution of the project, it was determined based on the coverage of the Stations already installed that it was necessary to complement the existing networks. Therefore a Meteorological Station was installed in the town of Navidad. Thus, managing to strengthen the existing network with data. Image.3, Annexes and tables.

As part of the strategy to strengthen the network, 50 kits of rain gauges and thermometers were delivered and installed to farmers participating in the project, to collect daily information on temperatures and precipitation. Farmers were instructed to periodically upload the data to a digital platform that allowed the systematic processing of this information and its use in participatory agroclimatic tables as a source of local information, which was contrasted with the different forecasts provided by the Meteorological Directorate of Chile (DMC), to teach with concrete examples the agroclimatic differences that exist in contiguous territories and how the geographical relief, proximity to the sea, and other orographic factors influence these differences, which are manifested in the different production systems. Image.4, Image that identifies the 50 installation points of the rain gauges and thermometers.

- Generate Rural agricultural Extension for component 2, to transmit relevant agroclimatic information for dryland farmers through different means of communication. In addition, Extend the experience of the participatory agroclimatic tables to directly train farmers from the 8 towns in terms of knowledge on the agroclimatic situation, decision making, and empowerment of the community instance.

Within the rural extension activities, informative capsules were carried out, which were broadcasted on local radio stations in the intervened towns. In addition, 70 sessions of agroclimatic tables were held, a fundamental contribution to the achievement of the activities and dissemination of relevant agroclimatic information to dryland farmers, through different methodologies implemented in the sessions.

The great milestone of this objective was the successful adaptation of the methodology of participatory Agroclimatic Tables to the reality of the dry land of the O'Higgins Region. This work ended with the co-creation of a bulletin with local productive recommendations for each of the developed tables that seeks to reveal the ancestral vernacular knowledge of the different agricultural communities, as well as contribute to the new scientific-technical background for the adaptation of the peasant family agriculture (AFC) to the challenge that climate change imposes on us. The great achievement of this project was the adaptation of the methodology of the participatory agroclimatic tables to the agricultural reality of the small national AFC, the accreditation of the participants as local agroclimatic managers, and the generation of a digital library delivered to the farmers with the different resilient practices developed by the project. Set Image.5, activities carried out in the field.

- Expert consultancy for the training of regional special capacities.

An expert consultancy from the University of Chile was hired to carry out an introductory course on Agribusiness and property economics. This course consists of 4 explanatory videos that will be available digitally for the farmers of the project. In addition, a face-to-face course on this subject was carried out, to make a practical drop to the farmers of the project. Set Images.6, Agribusiness face-to-face course taught by the University of Chile.