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TITLE OF THE PROJECT

ANALYSIS OF THE COST BENEFITS OF INNOVATIVE IRRIGATION SYSTEMS IN AGRICULTURE

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PRESENTATION OF THE COMPANY COMUNIDAD DE REGANTES DE PLIEGO

The Region of Murcia

Figure 1. Region of Murcia, Spain

History

The history of the region of Murcia is complex, rich and extensive, involving in many periods that of the whole of the Region of Murcia (Figure 1).

The duality between field and orchard is a constant throughout the history of the Murcian municipality and has determined the human settlements in the districts located in both geographical spaces.

The Roman era begins with the conquest by Scipio, in 209 BC, of Carthago Nova, an important economic and political center of the western Mediterranean. The city acquired great importance in this period largely due to the exploitation of the rich mineral deposits scattered along the Murcian coast. Meanwhile, in the interior of the region, Romanization led to the creation of some sparsely populated rustic towns.

Later, the period of Arabic domination started in 713 when General Abdelaziz arrived in the region to confront the Hispanic-Visigothic army of Teodomiro in Cartagena.

The city of Murcia was founded by Abderramán II in the year of 825, and during this time a period of economic growth began. The Arabs took advantage of the course of the Segura River, near the city, to create a complex network of ditches, pipes, weirs, waterwheels and aqueducts. These are the antecedents of the current irrigation system, which served to take advantage of the resources of the fertile Segura orchard. Until the second half of the 11th century, Murcia was not an independent kingdom and the city paid vassalage to the kings of Almería. With independence, and throughout the 12th century, Murcia became a great economic and political center, which led to an increase in public works, with the construction of numerous religious buildings and fortresses.

However, the border pressure exerted by Castilla and the political disorders of Lorca, Mula, Cartagena and Aledo, generated a period of instability. As a result in 1243 the kingdom of Murcia submitted to the vassalage of Castile. Later, in 1375, Castile and Aragon signed an agreement establishing the dividing line between the two kingdoms but border instability persisted until the final conquest of Granada in 1492, giving way to a time of greater balance.

With the achievement of peace, a phase of rapid economic and demographic growth begins, with all the cities of the kingdom flourishing throughout the 16th century. The alternation of peak times with others of marked decline is a constant in the history of this region. Thus, the 17th century was marked by great droughèèèts, the origin of plagues, epidemics and food shortages. After the hard interval of the War of Succession between 1702-1713 there is a new recovery process: the cultivated surface is increased extraordinarily, the irrigated areas are expanded, the population registers a great increase and the effects of the progressive trade opening. As in other times, this economic splendor is reflected in the increase in constructions.

After this golden age, the 19th century opened with a new crisis caused by a period of drought, followed by major floods and the war against Napoleon. It was not until the middle of the century that the situation was reversed. The economic activity was extended to the exploitation of mineral deposits, also beginning the process of industrialization. Despite this, the region would reach the 20th century with an industry of foreign capital and a trade that had not been able to cross regional borders. With the dictatorship of Primo de Rivera during the years 1923-

1929, Murcia joined the rhythm of the country, promoting industry and strengthening the canned, citrus and pepper sectors, modernizing its agriculture.

Geography

The Autonomous Community of Murcia is located in the southeast of the Iberian Peninsula. It occupies a total area of 11,314 km2, which represents 2.2% of the national territory. Located in the Arco del Mediterráneo, it borders to the east with the province of Alicante; to the west with Granada and Almería; to the north with Albacete and to the south with the Mediterranean Sea.

Economy

With an area 11.314 km2 and 1.518.486 inhabitants, this region represents the 20% of national exports of fresh fruit and vegetables from Spain, with more than 309,618 hectares of agricultural area of which 83% of the land is irrigated.

A practice that was introduced on a large scale in the VIII century by the Moorish population on which the agriculture of the region depends.

The capacity of exporting companies, their cultivation techniques and the professionalism of farmers and irrigators, are the characteristics for which this region is known as "the Orchard of Europe".

The orography and climate of the place mean that almost all kinds of products can be grown on its land. However, it has a special disadvantage : the drought. The lack of rainfall is a problem that has affected farmers for decades.

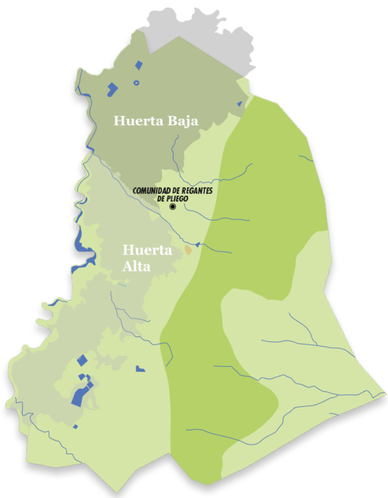

Figura 2 Municipality of Pliego, Murcia, Spain

The Municipality of Pliego Fig. 2, covers 29.34 km2, with 3.868 Inhabitants, from which 69% were born there.

The Municipality has 185 companies distributed in the sector of transport and commerce, service, construction and industries.

This region has a crop land of 1087 ha of which 585 ha are irrigated and divided into two (2) types of crops: woody crops like non-citrus fruit trees, apricots, citrus, olives groves for oil and herbaceous crops like tubers and vegetables. But as we mentioned before the region has a semi-arid climate so during the hot season the daily average temperature is 30°C.

Comunidad de Regantes de Pliego

Overview

The irrigation communities in Spain are ancient communities, unique in the world and very efficient with the aim of managing the scarce water resource to be distributed with the utmost rigor and equity. Irrigation Communities organize the collective use of public, surface and underground waters that are common to them. Their priority function is the distribution and administration of the water granted, subject to regulations sanctioned by the Administration and drawn up by the users themselves.

The irrigators Communities are defined as the grouping of all the owners of an irrigable area, who are bound by law, for the autonomous and common administration of public waters, without intention of profit. (Campo García, 2014). It then refers to a specific area of irrigable land, which enjoys a water concession to irrigate that area of land. In this way, it is indicated that the water concession is given to the land, and not to the owner of the land, so called “comunero”. Therefore, when a community member sells his land, he is transferring, together with his property, that right that corresponds to the land.

History of the company

The history of the company starts in 1992 with the foundation of Comunidad de regantes de Huerta Baja by Martín Jiménez Fernández . A sector that in its beginnings was abandoned and without an irrigation system. It came from managing no other irrigation system than the traditional one, with an abandonment or no cultivation of the land with percentages around 70-80%.

A few years later in 1996, was founded Comunidad de Huerta Alta. But the irrigation system was poorly designed, subject to continuous breakage due to the large differences in altitude. And in 2013 to improve the efficiency of irrigation systems and better manage the water resources, the two entities were unified as Comunidad de regantes de Pliego and were allocated 5 million euros to fix the irrigation system of Huerta Alta and build the irrigation system of Huerta Baja from scratch.

From 2014 as part of the integration of the communities they started a modernization program that led them to:

1. The installation of remote control systems.

2. The construction from scratch of a ring system for Huerta Baja. Meanwhile on Huerta Alta the existing system was modernized to a Branched system.

3.The covering of two of the basins to prevent water lost by evaporation of 20 to 30%

4.The installation of 1,773 photovoltaic panels divided into two plants.

In 2020 all these changes led the company to win "Sostenibles por naturaleza" an award for the efficient and sustainable use of water.

Entity unification process

Irrigation Community "Huerta Baja", was constituted by the users who have the right to use the waters of Trasvase-Tajo Segura, as well as the aquifers of "La Esperanza" and "Caños". Including those of the so-called new ones of the "Juncal". The irrigable surface included the traditional irrigation of the Huerta Baja and the irrigation of the Juncal.

Irrigation Community "Huerta Alta". Its constitution includes the irrigators of the Agrarian Transformation Societies "El Cherro" and "Las Anguilas", owners of the groundwater from the set of wells called "El Prado". The irrigable surface is divided into two sectors, Sector I ("El Cherro") and Sector II ("Las Anguilas"), corresponding to the previous irrigable surface mentioned. It is also constituted with the purpose of managing the resources that may correspond to it from the Transfer-Tajo Segura and the Pliego River Dam.

They had not one associative entity, but 5 associative entities managing the irrigation system, which was not sustainable economically or in terms of efficiency. With this plan they managed to have a base entity where all the plots, farmers in the municipality of irrigated land of sheet and part of mula, are all integrated into a base community as the first issue that had to be resolved. All this with the aim of contributing to the improvement of the management of water resources that are destined or could be destined to the irrigable area.

On March 22 of 2015, the Segura Hydrographic Confederation approved the modification of the ordinances and regulations of "Huerta Alta" Irrigation Community, which is renamed the Pliego Irrigation Community, as an ordinary community that integrates users of the former "Huerta Alta" and "Huerta Baja" Irrigation Communities, declaring the "Huerta Baja" Irrigation Community and the Pliego General Irrigation Community extinct.

The company currently

Comunidad de Regantes de Pliego, is a small company in terms of area with 400 parcels on approximately 850 hectares of irrigable area distributed between Huerta Baja and Huerta Alta, but large in number of community members, with around 1,500 "comuneros". Is located in the Region of Murcia, Spain, and more precisely in the municipality of Pliego.

The modernization plan gave results, obtaining benefits in the communication and action systems in the containers, implementing these changes in the technique, and the channeling of hydrants. As well as the use of innovative technology for the use and control of this irrigation, making the irrigation system even more efficient, directly controlled by the farmer through applications that can be used on any mobile device, tablets or computers.

In this way, it can be seen that the crop is receiving the water that the farmer previously programmed, the guarantee of that supply and that control generates an increase in planting in the areas that were without any planting, increasing the sustainability of agricultural resources, having water as a fundamental resource.

Thus advancing on the one hand in the system of evaporation losses in areas such as Murcia due to the high temperatures in the summer meant an evaporation loss in the reservoir of around 25%, which could be detected, controlled, and classified.

However, one of the priority objectives that the company continues to have, is the reduction of energy costs to 0, changing electricity consumption for renewable energy.

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Content of the project

Executive summary

The present study is focused on analysing the irrigation system of the Comunidad de Regantes de Pliego and its modernization via the telecontrol and automation systems in water irrigation management. In order to do so, the Comunidad de Regantes de Pliego was in charge of facilitating the information needed for the cost-benefit analysis. The real impacts that the integration of these systems has brought within their supply chain after the modernization plan finished in 2020 is also an aspect discussed in other oroject developed by our international colleagues involved in the practical training of MULTITTRACES Erasmus+ project.

The region where the Comunidad de Regantes de Pliego is located, in the region of Murcia, is characterized by its semi-arid climate where low rainfall added to high temperatures causes scarcity of water resources. Despite the issues faced by this region in what refers to water resources availability and the high need for this natural resource in agriculture, the agriculture sector is a lot more relevant in this region than at the national level. Moreover, over 20% of the Spanish national exports of fresh fruit and vegetables, with more than 357.738 hectares of agricultural land during 2021 (CREM, 2022), of which 83% of the land corresponds to the irrigable area is coming from this part of Spain. Thus, irrigation systems are vital for the proper management of water resources in agriculture, supplying the amount necessary for the growth and development of crops. To improve the current systems, it is necessary to consider the integration of new technologies such as remote control that allow more efficient use of resources.

Therefore, the Comunidad de Regantes de Pliego modernized the irrigation system via the remote control system and automation system able to save not just water, but also energy. As such, the price of water was reduced from 0,30 euro cents to 0,28 euro cents per m^3 for the farmers.

The remote control and automation systems are supported by humidity sensors and meteorological stations that are distributed in the almost 850 hectares corresponding to the irrigable area within the Irrigation community of Pliego.

The sensors help measure variables such as soil moisture, surface or subsoil temperature, and conductivity, allowing to have accurate and live information on soil conditions. On the other hand, the meteorological stations take data from all the environmental and agronomic variables that influence the development of the crop such as temperature, pressure, humidity, rain, evapotranspiration, wind and solar radiation. All this data allows future irrigation planning together with soil moisture to know when to water the crop.

The integration of other technologies could also improve the accuracy of the data within precision agriculture. Crop mapping is considered one of the most efficient, allowing crop zoning and thereby knowing the corresponding irrigation cycles for each crop found in the area.

It must be underlined that the irrigation system of the Comunidad de Regantes de Pliego increases the efficiency of irrigation and, thus, leads to water saving being water one of the most valued natural resources in this region without which agriculuture could not be carried out at the level of benefits expected.

1. Project overview

1.1. Introduction

The proposed project aims to analyse the problems faced by the agriculture sector in the region of Pliego given the low water resources available and the high need for irrigation in agriculture, one of the oldest and most important human activities. Agriculture is highly dependent on climatic factors, including rainfall and water sources. It is not new that the Region of Murcia is among the aridest European regions, where agriculture plays an important role.

Since 2017, the Murcia region has been facing one of the most severe droughts, where the water supply for agriculture has been drastically limited. The main problems were caused by overexploitation and the fluctuations of these water flows, with agriculture representing the main consumer, requiring a very large volume of water, about 4,500 mc/ha.

The Comunidad de Regantes de Pliego managed to build, in 2014 one of the most advanced irrigation systems in Europe, reducing water waste. This system is equipped with several water tanks, which can store the water extracted from the underground waters of the rivers in the region, distributing it further to the farmers. However, as depicted in the other projects developed by our international colleagues, the problem is the high energy consumption required by water extraction systems. The Comunidad de Regantes de Pliego compensated for the necessary energy consumption with the help of a photovoltaic panel installation, in the context of long and sunny days. In order to increase energy production for its own consumption, it is planned to install a hydraulic turbine. Although this requires high investment costs, it is profitable because it does not affect the environment, and has minimal operating costs.

1.1.1 The irrigation water management sector

Irrigation is mostly considered as an effective way to increase agricultural production, supplying the amount of water necessary for the growth and development of crops. But at the same time the agricultural sector is also known for being the sector that consumes the largest amounts of this source, and is most affected by its scarcity. Especially in areas with semi-arid climates where low precipitation added to high temperatures, causes scarcity of water resources.

Thus, irrigation water management has an essential role, establishing proper timing and regulating irrigation so that it covers the necessary water requirements of the crop without wasting water, energy, plant nutrients or degrading the soil, all looking for greater efficiency.

Therefore, the Comunidad de Regantes de Pliego implemented a remote control systems as a fundamental tool when it comes to managing water resources by using different ICTs (computer, electronic and telecommunications technologies).

In addition, the system allows remote action on the elements of the hydraulic networks, (the hydrants), from which water is provided to the irrigator. The basic functionality of a Telecontrol System is to centralize the information. This is why the remote control installations facilitate the automatic and remote reading of the volume of water used, and allow the opening and closing of the valves controlled remotely.

In irrigation communities, automation and remote control is a system that helps improve competitiveness, facilitates the planning and execution of infrastructure maintenance tasks, and helps optimize available water, since it allows irrigation at any moment of the day.

1.1.2 Interest of the company and circular economy

The interest of the Comunidad de Regantes de Pliego in integrating the remote control system within its modernization plan is then reflected in the search for the optimization of energy consumption, the guarantee of continuous supply and the reduction of operating costs, which can lead them to make more efficient use of the resources available.

This is where the concept of circular economy is integrated into the project, since irrigation management is here similar to the role that ecodesign plays within the circular economy, creating a certain product or service using the least amount of resources, optimizing the amount of materials and energy, protecting resources and reducing emissions.

The remote control system is then an instrument that allows decisions to be made based on the collection and analysis of data that contribute to improve the efficiency of the use of resources.

1.1.3 Objective of the project

The objective of this project is to carry out a cost-benefit analysis of the irrigation system of the Comunidad de Regantes de Pliego as a company that integrates almost 1,500 community members of the region.

1.1.4 Circular Economy and water management

The water currently available around the world will only be enough if we find ways to use it and manage it thoughtfully. Rapid population growth in recent years means more and more water is needed and energy demand is increased. At the same time climate change and the excessive use of pollutants increases the need for fresh water both for consumption as well as for usage in the agriculture industry, as water is vital for cultivation. In the water industry Take-Use-Discharge is the model we most commonly see and it is the least beneficial and also not at all sustainable. In a circular economic model there is great opportunity for governments, companies, and businesses to find new ways and work innovatively to reuse and recycle water, in order to realize all the ways we can regenerate the environment. Sustainability is very important, especially when the resources we have are limited. Working in such ways can help reuse water to produce energy and simultaneously it helps with preserving natural systems. The energy needed for production could be found and produced by the company in order to limit expenses and work more efficiently. Even though the cycle of water is in a way recyclable, circular economy helps use maximum amounts of water.

In the last two decades water management in Spain has been going through a gradual transition due to growing water problems. Spain has historically solved its water policy issues by regulating the water supply through the state-subsidized construction of extensive infrastructure. Lately it is mostly focused on the sustainability of the resource. Law changes have been really affecting that change, specifically: The 1985 Water Law, The 1999 Water Law reform, The European Union Water Framework Directive (2000) and lastly the 2001 and 2004 Laws of the National Hydrological Plans. Intense urbanization lately, economic problems, droughts and growing conflicts about water management are some of the reasons why Spain has to focus on solving such problems.

The Spanish strategy for the circular economy was designed in order to make better use of the resources, materials, and products available, but also to achieve more innovative and sustainable development and growth, and the importance of the circular economy in achieving this transformation. In fact, the intention of the Circular Economy Strategy is perfectly described in its definition: establishing a set of rules that aim an optimal decision in each moment. This implies planning, establishing goals, looking into the future with the eyes of the present and being efficient. Thus, it is necessary to define short, medium and long-term goals, and to develop actions that are continuously monitored and updated. It is important to know what to do, but it is equally important to define who will carry it out (and how to achieve it). These are, indeed, the elements that must compose any strategy. As such, there are different axes: production, consumption, waste management, secondary raw materials, water reuse, research, innovation and competitiveness, awareness, training, and employment. Moreover, the Ministry for Ecological Transition has established mechanisms to follow up and monitor the action plan and the presentation of an annual progress report.

It is the action plan 2018-2020 that is being taken as a reference counting some sectors as main priorities, such as construction and demolition, agri-food, industrial, consumer goods and tourism (see figure 1).

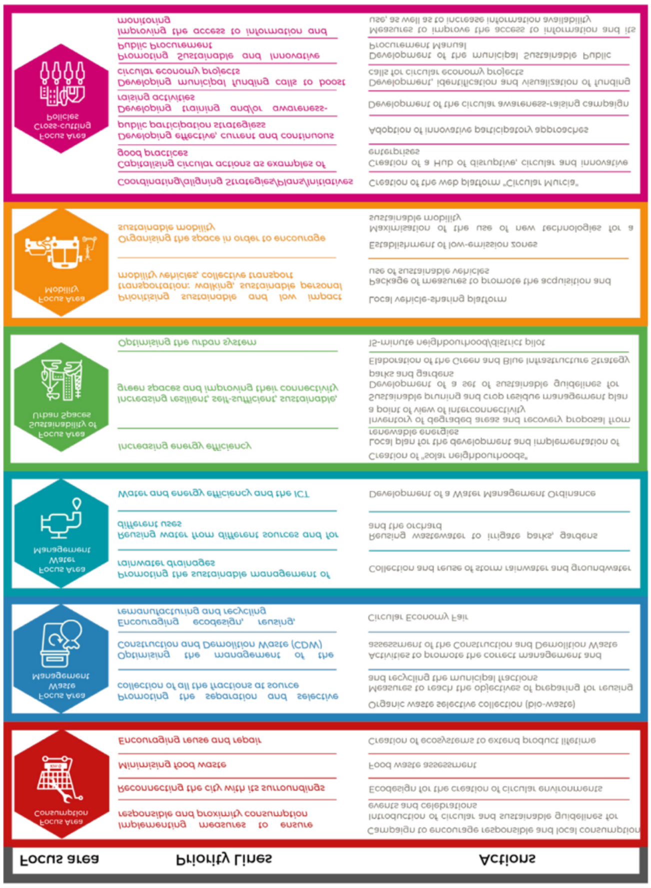

Figure 1. Priorities of the Murcia Strategic Plan for Circular Economy

Moreover, there are clear goals established de depicted in figure 2. The objectives of the Murcia´s Circular Economy Strategy seek to undertake the following challenges: reducing waste and emissions generation, expanding product life cycle, turning urban spaces into sustainable areas, and raising awareness on the need for a change of model.

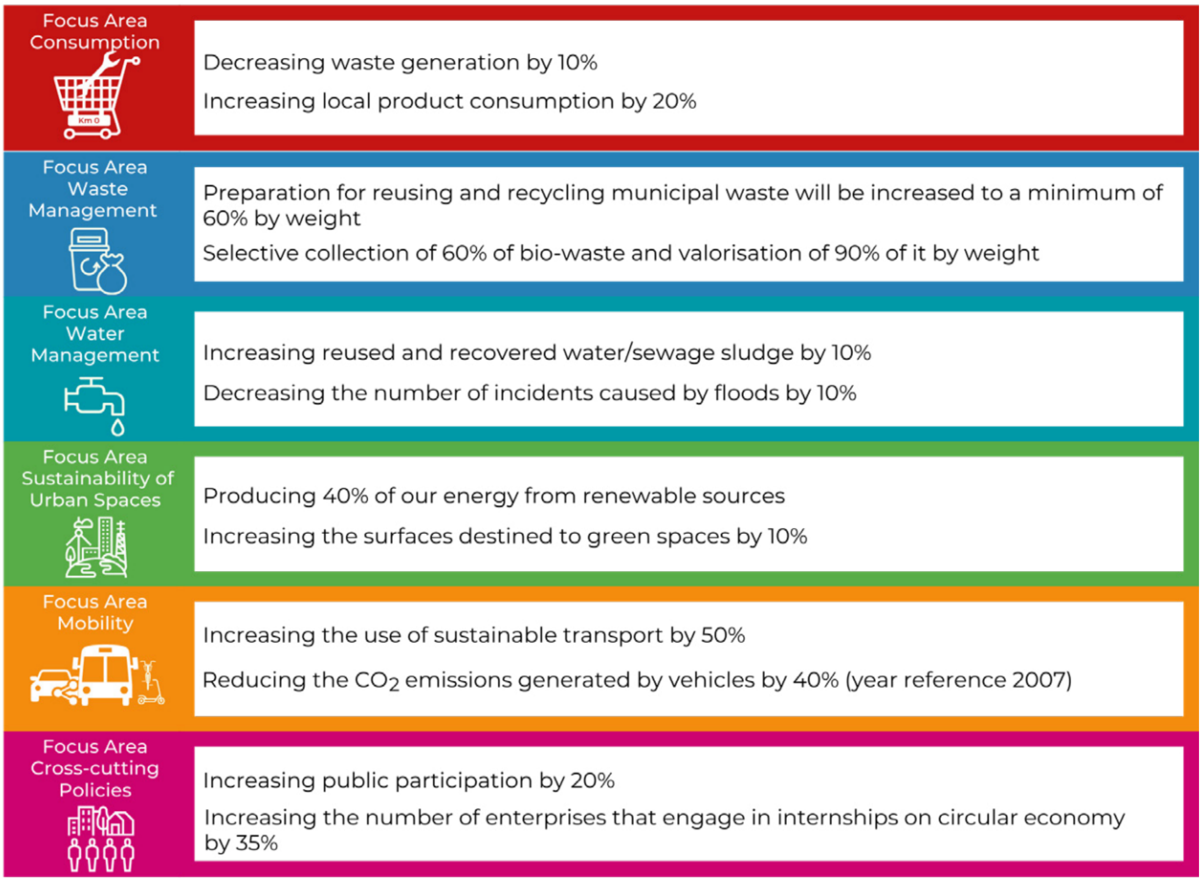

Figure 2. Goals of Murcia´s Circular Economy Strategy

The Region of Murcia is one of the 17 Autonomous Communities of Spain, has only one province and is located in the southeast of the Iberian Peninsula, between Andalusia and the Valencian Community. This region covers a total of 11,314 km2, i.e., 2.23% of the national territory, and counts with 1,493,898 inhabitants (INE, 2019). This region is distributed into 45 municipalities, with most of them having between 20,000 and 50,000 inhabitants. Still, the City of Murcia, together with those who live in Cartagena and Lorca, make up half of the region's total population.

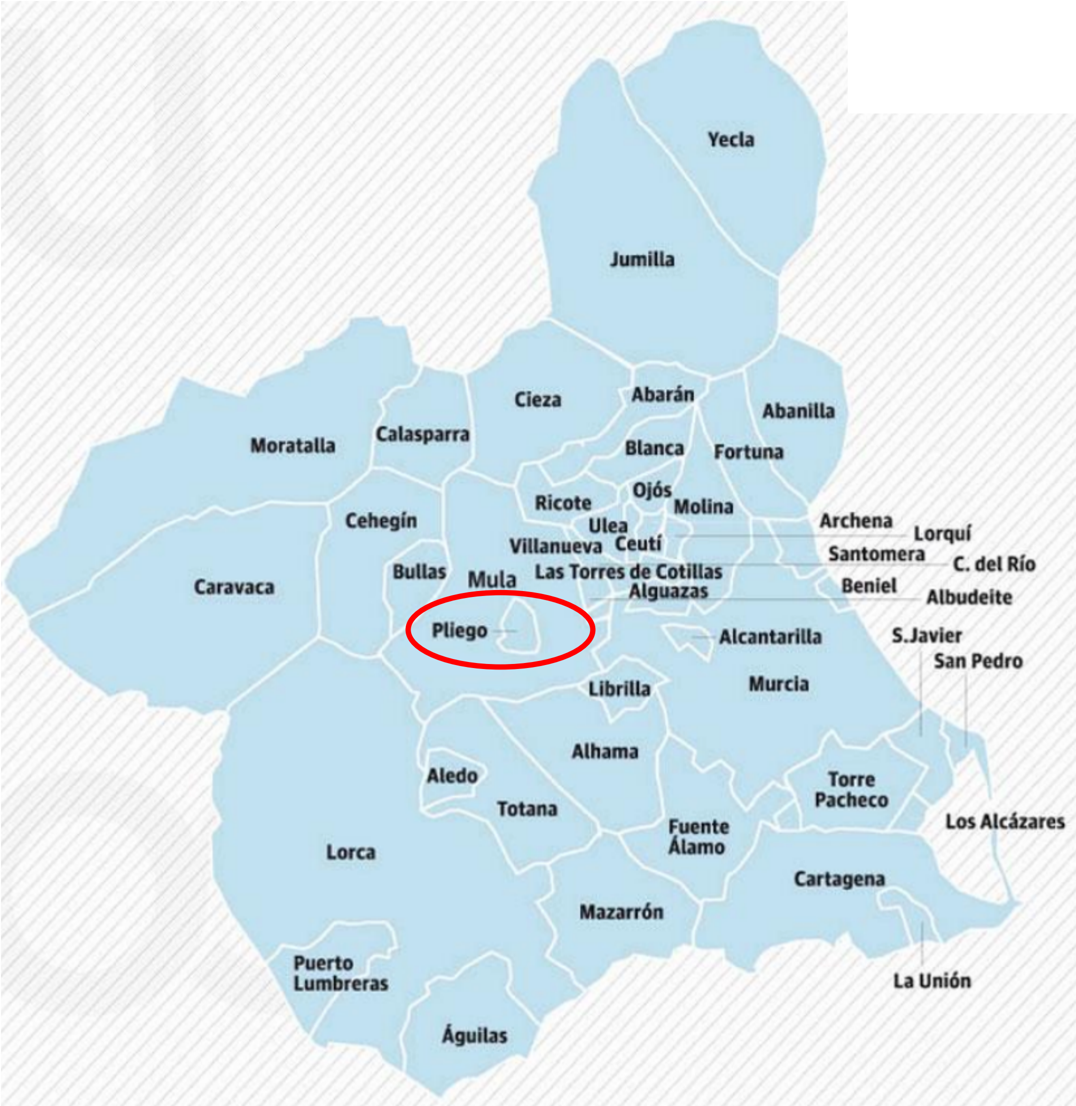

Figure 3. Distribution of the Region of Murcia

It is worth mentioning that the Mediterranean climate of the Region of Murcia implies hot and dry summers, mild winters, although with frequent frosts in the interior, and rain in spring and autumn. The southeastern part of Spain, where the Region is located, is the driest area in Europe. In fact, the region under study is characterized by scarce rainfall, concentrated in a few days of the year, with maximums in autumn. The average temperature ranges from 14 °C to 18 °C, with a temperature range of up to 20 °C. Rainfall is between 300 mm and 500 mm per year.

Under this context, it is not surprising that water management is among the most relevant aspects to take care of in the Region of Murcia, a territory that counts with an important agriculture sector, contributing over 5% of Gross Value Added, doubling the national average. The relevance of agriculture is also valid for the municipality of Pliego, our case study, despite its progressive incorporation into new productive areas can be observed: community services, environment, catering, tourism, etc. Furthermore, the local economy, until the middle of the 20th century, was marked by the fact that its main source of activity was agriculture, but in self-sufficient agriculture. The population of Pliego does not tend to migrate to other regions, not event to urban areas.

Therefore, in terms of circular economy and the strategy of the region of Murcia in this regard, the support and adoption of circular principles are expressed as both, great necessities and an opportunity to ensure, among other things, that urban and rural areas develop in parallel and in connection; which will bring about numerous economic, social and environmental benefits.

WATER MANAGEMENT AND CIRCULAR ECONOMY IN MURCIA REGION

Most of the world's water supply comes from surface and groundwater sources. The growing demand due to population growth requires a reduction in the pressure on these natural water sources in terms of quantity and pollution. Due to water scarcity, alternative water sources are exploited in the Region of Murcia, such as salt water and reused water, especially for agricultural irrigation. The focus area "Water Management" of Murcia´s Circular Economy Strategy includes different priority lines and actions as depicted in figure 4.

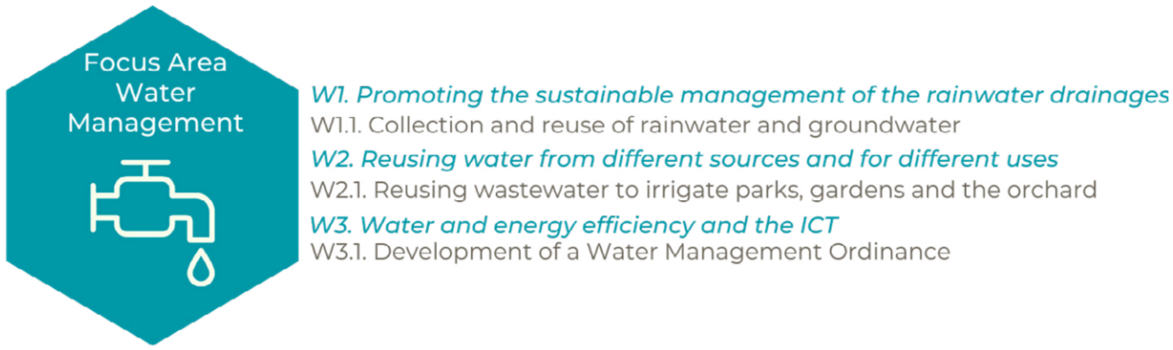

Figure 4. Water Management Priorities

Promoting the sustainable management of rainwater drainage

Murcia can and must make progress in rainwater harvesting and groundwater harvesting, activities that will be key to combating water scarcity.

Reusing water from different sources and for different uses

SDG 6 sets specific targets to reduce water pollution and the percentage of untreated wastewater, and to increase the reuse and efficient use of water resources.

Water and energy efficiency and the ICT

The concepts of "Water-Smart Society", "digital water" or "multiple waters" will be present in the European and national agendas of the next decade, focusing on the development of technologies and digitalisation, new business models, the promotion of the availability of different sources of water to complement the current ones, innovative governance approaches, as well as deepening awareness, integration and collaboration between organisations and citizens (WaterEurope, 2016).

However, water is a scarce resource in this region due to the inadequacy and irregularity of rainfall. Therefore, in the region of Murcia managing scarcity and rationalizing the use of water are a must. Along this line, sustaining agricultural productivity, guaranteeing food security, and enhancing economic growth while facing climate variability, diminishing labor force, and changing soil conditions require innovation in agriculture. Murcia region has gradually incorporated technological and agronomic applications to its farms: storage and regulation techniques, localized irrigation, irrigation automation, water reuse and recanalization and this has caused the productivity of water in the Region to be among the highest in Spain.

NATIONAL HYDROLOGICAL PLAN

Before entering into details regarding the hydrological plan, it should be clarifying the hydrological profile of the region under study. In the Mediterranean the temperatures usually vary between 4°C and 33°C and rarely drop below 0°C or exceed 36°C, at least this was the case until this summer (of 2022).

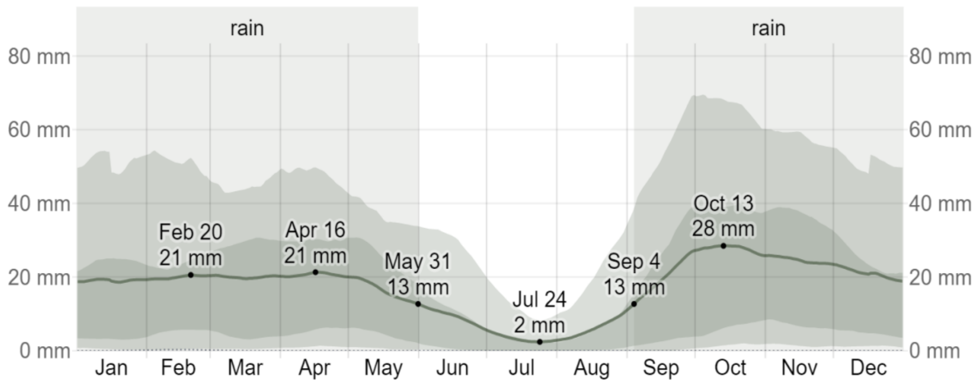

Figure 5 - Average Monthly Rainfall in Murcia, Cedar Lake Ventures, (May, 2018)

While winters are long, cold and the sky is cloudied, summers are very hot, and humid and the sky is clear. The coldest month of the year in Murcia is January, with an average low of 4°C and a high of 17°C. In terms of humidity and precipitation, October is the most favorable from this point of view, with a sliding 31-day rainfall of at least 13 millimeters. The hot season lasts for 3 months, from June to September, with an average daily high temperature above 30°C. The warmest month of the year in Murcia is August, with an average temperature of 33°C and the lowest of 21°C. Given the characteristics of this region, during summer there is a chronic insufficiency of rainfall. The driest month is July, with an average of 0.5% days with at least 1 millimeter of precipitation.

Ventures(2018)

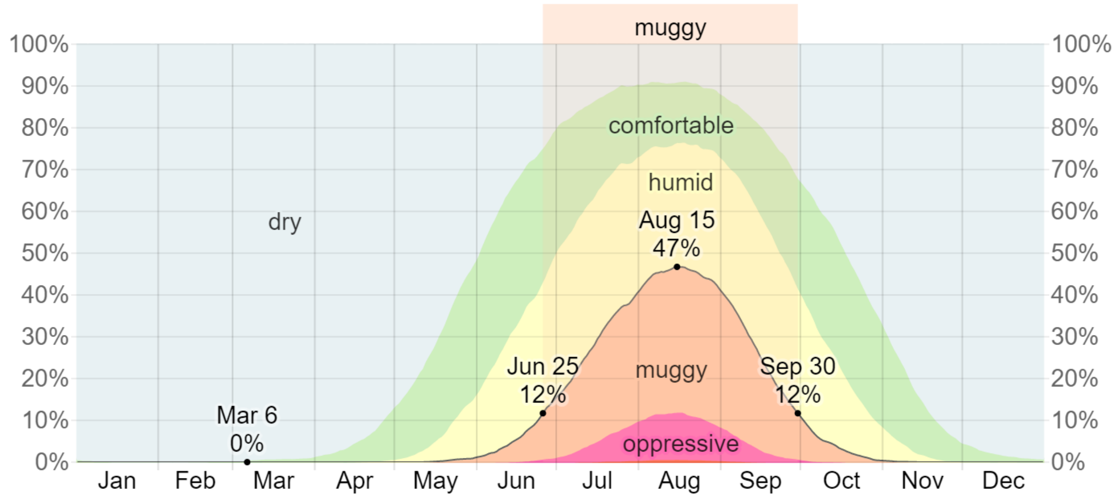

Figure 6 - Humidity Comfort Levels in Murcia Region, Cedar Lake

Under the continuous rise in temperature and longer droughts brought on by climate change, far-reaching impact is expected especially in the water supply, whchi will most likely affect hardly sectors like agriculture. In fact, complicated situations were already faced in the region of Murcia and the rest of the Segura basin are facing one of the most serious droughts, with water supplies to agriculture already having been cut back drastically and the threat of restrictions to domestic supply becoming more and more real with every day that no significant rainfall replenishes supplies in the near-empty reservoirs.

The springs remained the main resources available in the semi-arid areas within the Region of Murcia, such as in the districts of Mula, Pliego and Bullas.The region's hydrographic network consists mainly of the Segura River and its streams: (a) Mundo River, which originates in Albacete), and addes the utmost volume to the Segura; (b) Alhárabe River and its branch the Benamor; (c) Mula River; and (d) Guadalentín, Sangonera or Reguerón (see figure 7).

Figure 7 - Hydrographic map of Murcia Region, Wikipedia

Overexploitation and fluctuations in these flows have caused ongoing problems. Thus, alternative solutions had to be developed. The transfer of water resources complemented with initiatives for desalination of marine waters, savings and reuse is the strategic option that best meets the requirements of economic rationality and territorial balance, offering greater stability against possible changes in future scenarios, and a framework most suitable for the sustainable use of water resources. Hence, Tajo-Segura water transfer (see figure 8), one of the alternatives considered since 1979, became the most important water infrastructure in Spain. Suddenly it became possible to plant crops that require irrigation in many more areas of the Segura basin and in the Region of Murcia (Campo de Cartagena).

Figure 8. Tajo-Segura water transfer scheme

It must be underlined that the highest need for water consumption is linked to agriculture, which requires 767,417.7 m^3 of water for irrigation (i.e., 4,500 m^3/ha). Aiming at reducing losses and making the most of groundwater, the help of a well-developed irrigation system is needed, which also helps to monitor the use of water. The Region of Murcia has long used this method to support and develop agriculture.

In fact, the Research and Innovation Strategies for Smart Specialization (RIS3) identified among its priorities a limited number of economic development priorities, based on innovation and knowledge and aligned with the existing and potential sectors of the Region of Murcia. It is necessary to emphasize the dynamic character of RIS3 exercise, subject to continuous analysis and to new evidence and circumstances that may therefore be subject to the update. Among these priorities, only some are directly linked to the efficient use of water resources:

- **Food chain**
- **Environment and water cycle**
- Logistics and transportation
- Habitat
- Health and welfare biomedicine
- Tourism
- Sea and marine environment
- Energy

Efficient use of water resources
Murcia's agricultural sector has a consumption of 619.113 Hm^3, while the Segura Basin has a "natural" resource availability of 440 m^3/inhabitant/year, an insufficient amount for sustainable socioeconomic development.

In 2021 the updateding process of RIS3 started (RIS4) which will lead to a plan that will be live up to 2027. The analysis carried out in this sens underlines that in the area of food security, sustainable agriculture and forestry, marine and maritime and inland research, the distribution of funds will be higher in food security and agriculture.

Among the main sources of financial funding available for water projects, the European Structural and Investment Funds as well as the Agricultural Funds were considered. In the ERDF Operational Program for the period 2014-2020 up to 1 million euros were grantedwith the following distribution:

- 75% Implementation of a lysimetric network in the Mar Menor (implanted in appropriated crops that allows estimating the amount and analysing the drainages of agricultural activity)
- 25% denitrification of the salty lake (Mar Menor) with the collaboration of the Polytechnic University of Cartagena UPCT

In the Rural Development Program (RDP) 2014-2020 there are allocated approx. 10,000,000 € for the following measures:

- 80% Modernization of Irrigation (increased irrigation efficiency)
- 20% Connection of the WWTPs directly with the agricultural parcels when the WWTP has tertiary treatment, (almost 100% except Murcia and Cartagena)

Other projects that are being developed:

- Rainwater harvesting

- Addition of rainwater and reused water to saline water wells and some examples of combining different policies to obtain synergies (e.g., Case of La Paca Lorca focused on unusable saline waters, PDR to connect the treatment plant, Actions to recover rain water, change crops by others with less water demand such as aromatic plants, Training actions, promotion of the rural areas, etc.).

The agricultural demand for water is 15 times the supply, so policies must focus on reducing agricultural demand.

The Communidad de Reganted de Pliego carried out an investment in 2014 aiming at building one of the most advanced irrigation systems in Europe that would help reduce water waste. With the help of accumulation basins, they can store water extracted from the groundwater of the rivers in the region and then distribute it to consumers, in our case, farmers.

2. STATE OF THE ART

2.1. Supply chain

The supply chain of the Comunidad de Regantes de Pliego consists of five steps before the water reaches the cultivated fields: extraction, transport, containment, filtering and distribution.

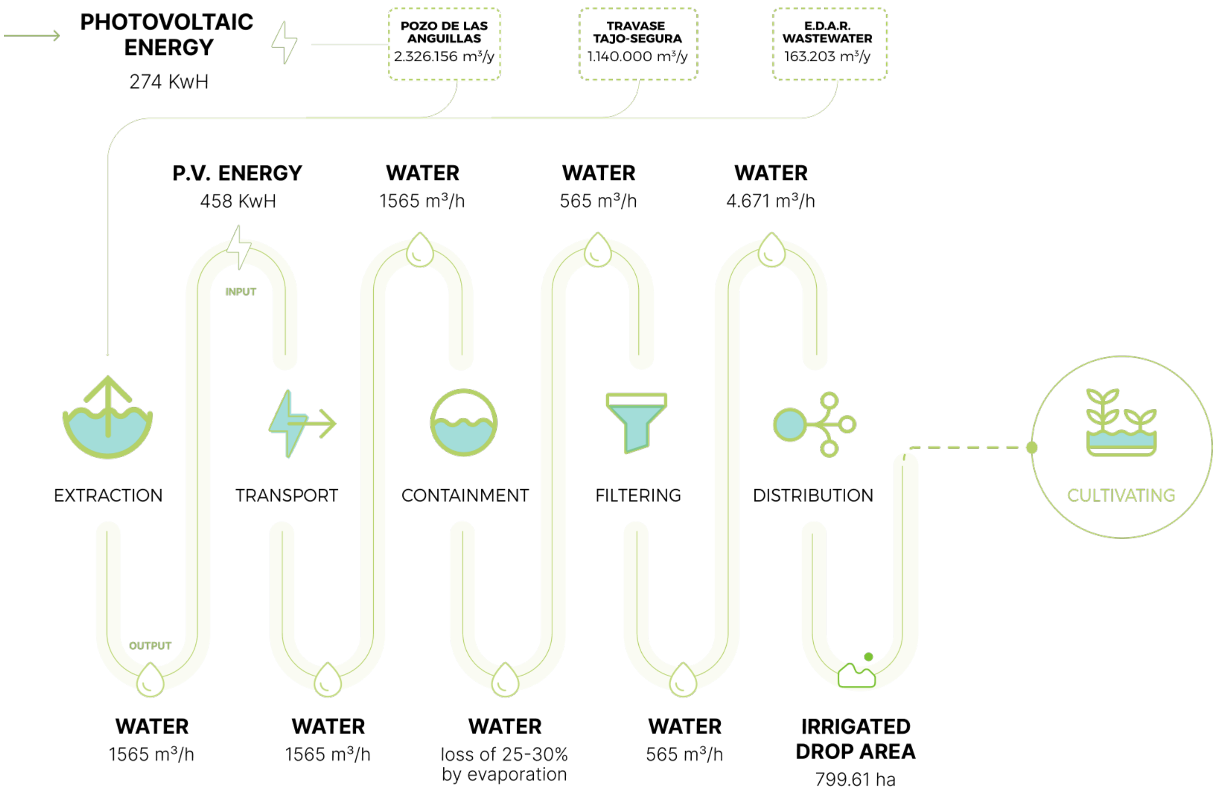

Figure 9. Supply chain of the Comunidad de Regantes de Pliego

Extraction

The chain begins with the extraction of the water. The total amount of water that the company manages is about 3,629,359 m³/year. The Comunidad de Regantes de Pliego obtains water from three different sources:

1. Pozo de las anguilas
2. Trasvase Tajo-Segura
3. The E.D.A.R.

Pozo de las Anguilas is the main source of groundwater for the Comunidad, in fact they obtain from it the majority of the water they use for a total of 2.326.158 m³/year.

The Trasvase Tajo-Segura provides 1.140.000 m³/year of surface water, especially during the hot season.

Finally, the E.D.A.R. (Estaciòn Depuradora de Aguas Residuales) is the waste water purification station of Pliego that is managed by the Confederaciòn Hidrogràfica del Segura. They provide a certain amount of water purified by the E.D.A.R. to all the local Comunidades de Regantes and for this reason, the Comunidad de Regantes de Pliego obtains 163.203 m³/year of reclaimed water. This phase - water extraction and pumping - represents 90% of the total energy used by the company to develop its activity. And although the company has photovoltaic power plants, this only represents 17% of the total energy needed for operation between the extraction and transport of water, leaving 83% that must be acquired from the electrical network.

Transport

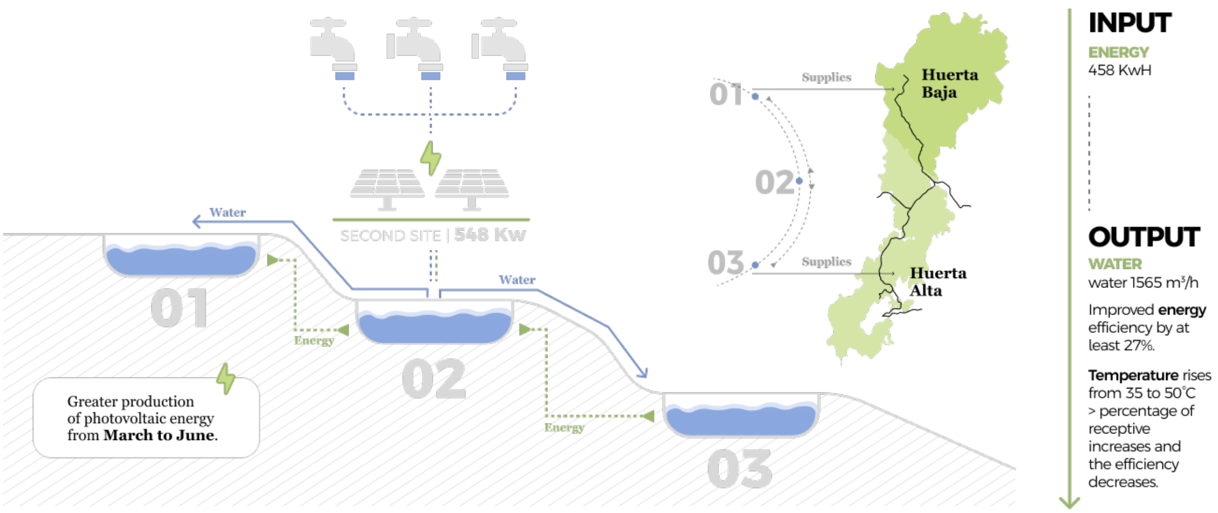

Figure 10. Position of the basins of the Comunidad de Regantes de Pliego.

Since all the basins are at a different levels, the company needs energy to transport the water from one basin to another and for that they use the energy provided from the solar plant, for self-consumption with anti-spill to supply all the electrical receivers, that hang from the main transformation center of the Comunidad de Regantes de Pliego.

The basin on the top supplies the entire Huerta Alta and the one on the bottom supplies the entire Huerta Baja, but there is only one central unit, which is the one that has the water pumps that communicate the water from the lowest to the highest. When there is sun this energy is used to carry water from one basin to another.

Containment

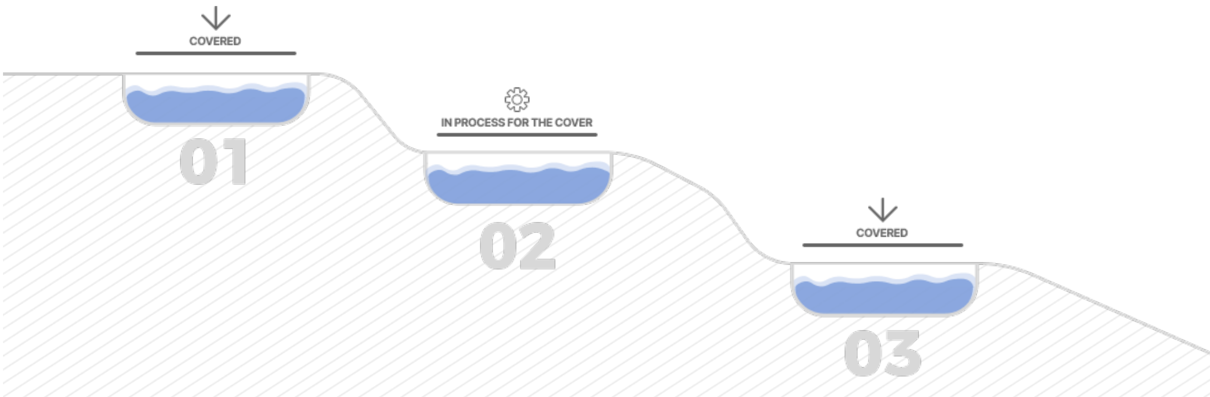

Figure 11. Covering of the basins of the Comunidad de Regantes de Pliego.

For the containment the company has at its disposal three basins in operation and contain the mainstream of 1,565 m³ of water. At the moment just two of them are covered, so they still have a water loss that represents 25-30 % by the evaporation of water from one of the basins. However, the company received the approval by the European Commission for a project involving the coverage of the last basin. It will be financed by the NextGenerationEU fund and will be developed in 2023.

From the higher basin to the lower one, there is a difference in altitude of 40 meters.

Filtering

Before the water is distributed to the two main points of Huerta Alta and Huerta Baja, there are two points of filtering that work with a mechanical system to clear the water and remove any impurities, positioned in correspondence with the basins.

Distribution

The company provides 4,671 m³ per hectare of water that gets to the fields thanks to the force of gravity as they are located high above the fields, reaching approximately 800 ha of crop area.

2.2. Facilities and Modernization Plan 2014-2020

During the period 2014-2020 the Comunidad de Regantes de Pliego completed a Modernization Plan that allowed them to improve the transport, distribution and storage of water and that was carried out by the Ministry of Water, Agriculture, Livestock and Fisheries. The plan was part of the Rural Development Program of the Region of Murcia 2014-2020, that was financed by 63% by the European Agricultural Fund for Rural Development (EAFRD), 25.90% by the Autonomous Community and 11,10% by the Ministry of Agriculture and Fisheries, Food and Environment.

The works included 17 actions carried out simultaneously in the two sectors of Huerta Alta and Huerta Baja that allowed them to replace the current system of irrigation by surface with a localized drip irrigation system; it included a system of automation of irrigation, that helps the management of the system through a device with the internet; and, the implementation of renewable energy plants.

The activities in the sector I Huerta Alta covered 351 hectares with a budget of 3 million euros. Among the actions carried out, the improvement of individual irrigation systems and an extension of the existing irrigation network stood out. In addition, agroclimatic stations were implemented with the aim to favor the decision-making of farmers, the efficient use of water and the reduction of the water footprint.

The weather stations allow greater control, through data of all the environmental and agronomic variables that influence crop development. The company currently has 7 meteorological stations distributed as follows:

- Filtering Station Sector 1, Huerta Alta- Prado
- Station Take 2 of Anguilas - Sangrador
- Station Take 6 of Anguilas - Mill
- Station Take 7 of Cherro - Los Taviras
- Filtering Station Huerta Baja - Oliverica
- Closed - Station H31 Huerta Baja - Cabecicos
- Station Take 17 Huerta Baja - Cañada Los Melgares

At the same time the Comunidad installed 16 humidity sensors based on the different types of soil that, in addition to the data of the weather stations, give the farmers useful insights about irrigation timing and the necessary amount of water.

Moreover, to reduce the evaporation of water from the basins (that reaches 25-30% during the hot season) two raft covers were installed on two of the three basins. The last one that is currently uncovered, will be covered in 2023.

In Sector II Huerta Baja, which has 426 hectares of land and a budget of 5.8 million euros for the modernization plan, the reservoirs were updated. In addition, a general driving system with a length of 3911 meters and filtering station was developed.

It was thanks to the modernization plan that also the 1773 photovoltaic panels were installed. They're distributed in two different sites both located in sector II Huerta Baja: the first one produces 458 kWh while the second produces 274 kWh of energy.

2.3. SWOT analysis

In order to better understand the overall situation of the implementation of the system in the company, a SWOT analysis was carried out in which strengths, weaknesses, opportunities and threats were identified. The graph below shows how some points were regrouped into areas of impact, either at the cultural, regulatory, or delivery level. The type of product was also taken into account at the level of knowledge and communication, infrastructure, and energy and material flows.

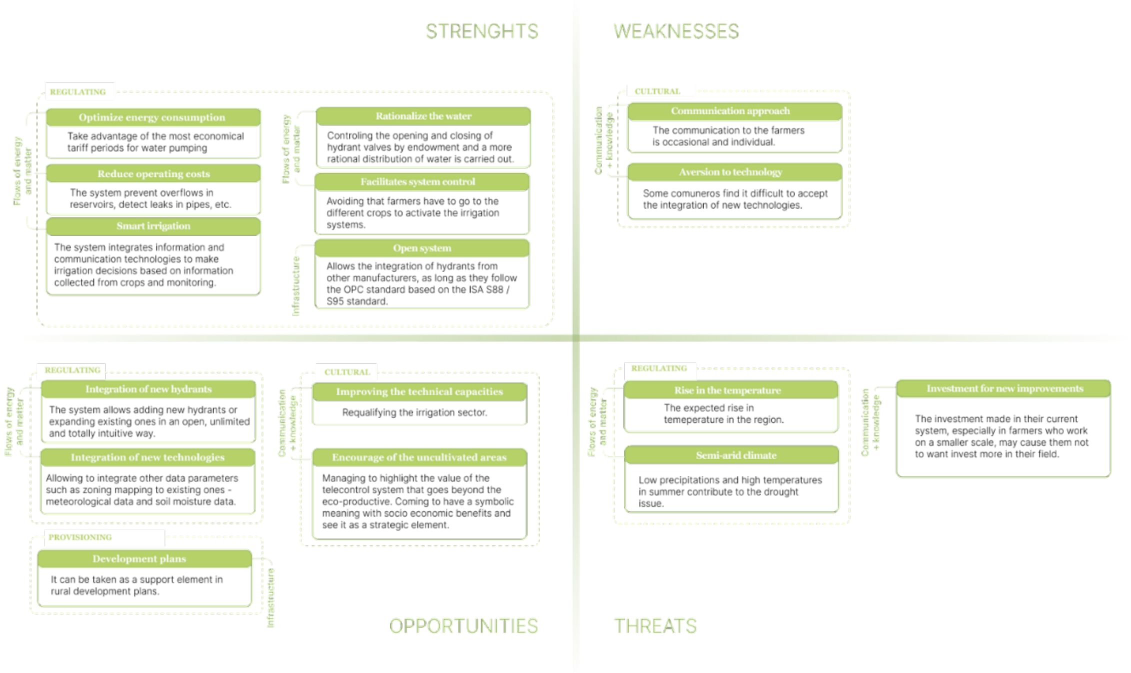

Figure 12. SWOT analyais

Strengths: The company's strengths mainly relate to regulatory actions. Through the implementation of the modernisation plan started in 2014 and with it the remote control system in terms of material and energy flows, the optimisation of energy consumption is considered, as the company can start pumping water when it sees fit, taking into account the most economical tariff periods. It reduces operating costs by avoiding overflows, detecting leaks in the pipes, situations that would entail an expense for the company. It enables intelligent irrigation of the fields as the system integrates information and communication technologies to make irrigation decisions based on the information collected from the crops and monitoring.

In the same way, the system helps to rationalise water by controlling the opening and closing of hydrant valves by allocation and a more rational distribution of water. And finally, it facilitates irrigation, preventing farmers from having to travel to the fields and different crops to activate the irrigation systems.

In terms of Infrastructure, it is an open system, allowing the integration of hydrants from other manufacturers, as long as they follow the OPC standard based on the ISA S88 / S95 standard.

Weaknesses: Since the main activity of the communities is strictly based on the distribution of water for irrigation, they are not directly involved in communication plans with farmers, leaving these tasks in the hands of third parties, such as cooperatives. Communication within the portal of the communal system is very sporadic and individual, they only contact each other when there is a problem of breakage or functioning of the system, and the information channel is very limited. In addition, it is worth mentioning that they only hold two meetings a year but do not develop so many training initiatives on new technologies related to remote control.

Adding the fact that the average age of the community members is 55 years old, of which the majority is within a low socio-economic level, characteristics that make it more difficult for some users to accept the integration of new practices and technologies.

Opportunities: Within the regulation opportunities, the integration of new hydrants is proposed, extending the network in an open, unlimited and totally intuitive way, at the same time it can integrate other data parameters such as zoning mapping as an approach to water management within Precision Agriculture (PA) which is but one part of the more complex system of the so-called Agriculture 4.0. An opportunity with which the company can integrate more information technology to ensure that crops and soil receive exactly the amount of resources needed, depending on the irrigation cycles of the crops.

At the supply level it is also taken as an opportunity for the continuous development plans that have been carried out within the region, a local reality that can affect the way telecontrol is viewed.

In terms of cultural opportunities, in terms of communication and knowledge, it can improve the technical capacities of around 1,500 community members who are part of the community and re-qualify the irrigation sector.

On the other hand, implementation can encourage the cultivation of uncultivated areas, which currently correspond to 30% of the irrigable area, highlighting the value of water for the inhabitants of Pliego, which goes beyond the eco-productive aspect. It has a symbolic meaning with socio-economic benefits and is seen as a strategic element.

Threats: For the main threats to Comunidad de Regantes we have to analyse the external factors, attributed to the environment in which the company operates, first with the region.

The last aspect is related to investment for further improvements, as smaller scale farmers see further investments as unsustainable and unnecessary preferring to leave the systems as they are reducing the possibility of individual investment in the improvement of remote-control systems.

2.4. Water saving through remote irrigation system

Spain has become a world leader in modernized irrigation. According to the newspaper Ágora, in an interview with the president of the National Federation of Irrigation Communities, (Fenacore). It is estimated that remote control systems have been implemented in more than

one million hectares in the country, information that was presented after the last edition of the Survey on Surfaces and Crop Yields in Spain (ESYRCE) carried out by the Ministry of Agriculture, Fisheries and Food of Spain during the year of 2020. It is stated that more than 76% of the irrigated area is in Spain, of which almost 3 million hectares are modernized.

By implementing these systems, irrigation on demand has been possible, especially in those cases in which it is necessary to establish shifts and night irrigations are carried out. The greatest advantage is that it prevents the irrigator from having to go to the farm or croplands after hours, if it is then is when is his time to irrigate, which significantly improves the farmer's quality of life.

The integration of these remote control systems can reduce costs, since they make it possible to choose the moment to irrigate and help to carry out these tasks during the off-peak hours. That corresponds to the time slot between 00:00 and 08:00, during the week and throughout the whole day on weekends and holidays. Hours when electricity is cheaper.

However, it must be taken into account that its implementation requires economic investment and maintenance. According to the president of Fenacore, Andrés del Campo modernization and the incorporation of technology to make more efficient use has allowed us to produce more with less water, but with a higher cost of energy. For this reason, it is urgent to reduce the bill to accelerate the modernization of the 902.000 hectares still pending and continue extending the remote control systems. (Campo, 2020).

2.5. Existing solutions: case studies

Aquarson by Arson and Neiker-Tecnalia. The project is an initiative to improve the management of water resources. With this objective, the Basque company Arson on remote engineering and the knowledge of Neiker-Tecnalia (Basque Institute for Agricultural Research and Development) on agronomy and water needs of crops have joined forces.

Aquarson's technology makes it possible to establish a network of remote equipment communicated by radio frequency which, connected to a centralized management and control software, sends irrigation instructions to the hydrants. Likewise, it collects information on the irrigation tasks carried out and the hydraulic operation of the installation. The irrigation instruction is sent from a management and control application tool, expressly designed for the management of irrigation systems and installed on a computer located in the Irrigation Community offices.

Among the benefits provided by this technology, the possibility of combining various communication methods stands out. The system is capable of establishing its communications by combining GPRS, radio frequency and cable technology (among others) to adapt to the needs of each installation, depending on the type of handling and management required, the size of the irrigated plot and its orography (Aquarson, s.f.).

iControlRemote by AISco. This remote irrigation management product uses GSM technology to monitor and manage the irrigation systems from just one place using the mobile phone. With this system it's possible to find all charts and reports that will help to make the good decisions for the maximum productivity of the operations.

The webpage helps farmers to facilitate the process of organizing, monitoring and controlling irrigation. The system works by installing the control device and linking it to pivots, pump, temperature and humidity sensors, and supports connecting to the mobile phone network, the Internet, and controlling and following up operations through smart phones.

This system integrates three tools, **iControlRemote** displays historical operations in a graphic format and visualizes the status of the irrigation systems during the growing season.

iControlPump which is the automation and remote management tool for pumping. It's well-known problem-free connection between the pumping process and the solenoid valves even on irregular land or where there is no mobile telephone coverage. The last tool is **iControlTotal** which is a remote management and automation tool for pumps, solid set, drip and pivots using the Internet. It helps to increase precision control of the frequency of weather conditions. A multifunctional product custom-designed according to each field's needs thanks to the expansive available features catalog (Aiscosolutions, s.f.).

Smart irrigation in Barcelona: introducing the new system. The new smart irrigation system of parks and gardens in Barcelona, one of the leading Smart Cities in the world. The implementation of this new system was created in collaboration with the Barcelona City Council.

The sensors gather information about humidity, salinity, temperature, wind and several other factors that automatically regulate the amount of water by means of a program that can be managed with computers, smartphones and tablets. The graphical user interface is really friendly.

The general manager of Water Cycle in Barcelona, Antoni Vives, stated that this new Smart irrigation system will enable up to a 25% saving of water and that it’s a system that many cities in the world arguably will implement.

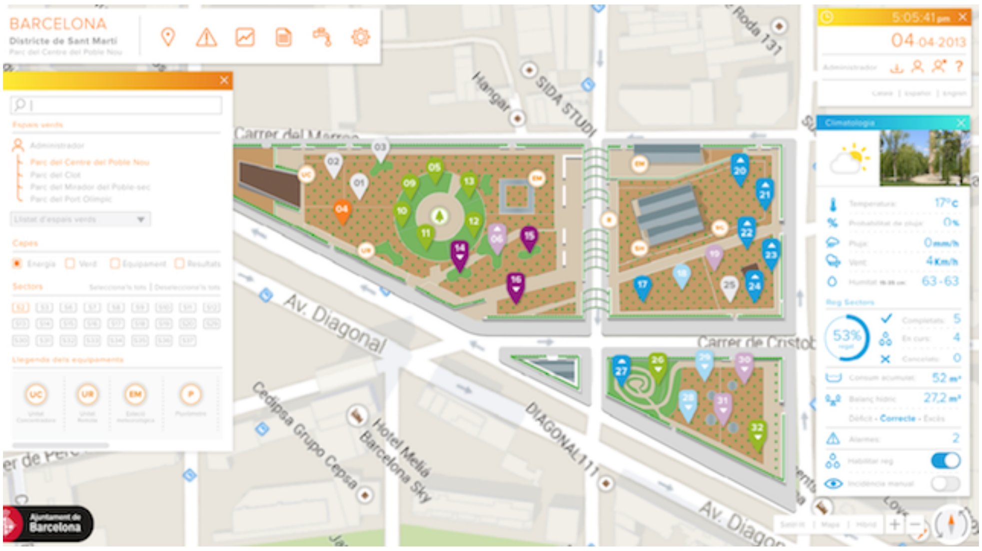

Figura 13 Screenshot Smart irrigation in Barcelona, 2014

Remote-control and Supervision of Irrigation Systems: An Attempt to Better Water Management. This study addresses the control of irrigation systems to ensure proper management of water use. First, we considered the management problem of open channels. For this purpose, a fuzzy controller for the irrigation canal has been developed to control the flow emitted from the dam to meet the settings set downstream of the system and the user's requirements at various abstraction points. did. In the second stage, the supervision stage of the agricultural irrigation system was proposed. The purpose was to control the water distribution of the various plots to be irrigated. To this end, the water management system under consideration, its equipment, and its control software architecture were presented. A functional survey of the system was performed using the GTST-MPLS method (Goal Tree Success Tree-Master Plan Logical Diagram). Finally, monitoring tools related to the developed irrigation system were presented.

2.6. Description of the Company's system

Through the modernization process, the Pliego Irrigation Community company was able to incorporate a remote control system with **Batchline Control** through the **Irrigest Irrigation**, a community control and management application that makes possible to facilitate preventive maintenance tasks and add value to its traditional ditches.

The community is integrated to Batchline Control under the name of Comunidad de Regantes TTS de Pliego sector ll. It handles remote management of the irrigation network and the discharge network, including the control of 8 discharge network stations (transfer intakes, reservoirs, pumps and filter stations) and 146 groups of hydrants.

This remote control system has at its disposal the information that is collected through the 7 meteorological stations that the community has, in order to know the climatological variations of the irrigable zone, information that is integrated into the system and is later communicated to the community members. The second source of information integrated into the system is found in the humidity sensors that are distributed by zones within the company's almost 850 hectares of irrigable area. This technology allows to collect information regarding moisture in soil, surface/subsoil temperature and conductivity. Data that after being processed by the systems, leads to greater knowledge of the current state of crops and leads to better use of irrigation water.

Telecontrol system - Batchline Control, Irrigest

The remote control system uses radio frequencies and GRPs that maximizes the water-energy efficiency of the crops. It allows managing the operation of the irrigation facilities according to the irrigation plan, the electrical consumption of variable speed drives and the water consumption in terms of water flows, pressures and consumption.

The system allows irrigation to be planned according to the relevant information that is available in order to later analyze all the data stored on a server. It monitors the behavior of the installation in real time and, with its analyzes and recommendations, increases the profitability of the operation with a reduction in costs and an increase in production.

It allows pumping systems to be put into operation, reads meters and allows opening and closing valves, from any mobile device. Having the advantage of being able to control it remotely through the Web. The system prevents the farmer from having to go to the field to put the irrigation valves into operation, having the possibility of doing it anywhere, at the most convenient times, taking into account all the data that is collected and stored. The system allows:

Change irrigation schedule dates. Change the dates of the irrigation program must be modified. Start Date and End Date of the irrigation program

Open and close the water outlets. The initial operation of the irrigator is related to the need to turn on and off the water from the phone, computer or tablet.

This is done through the (Activate) and (Deactivate) functions in the Irrigation Program Configuration section.

Having made a previous programming of 24 hours seven days a week. This refers to the time that the availability of water during this previously determined time.

When the irrigation program is (Activated), the hydraulic valve opens and the irrigator has water in his irrigation head; If the irrigation program is (Deactivate) the hydraulic valve cuts off the water supply and the irrigator's irrigation head runs out of water, that is, it closes.

Advanced Scheduled Irrigation Operations. It is used when Program no. 1 has already defined the general irrigation plan for the plantation as it shows in figure 6. It means that the person has already defined the days they want to irrigate, the start time, the duration and the irrigation intervals, which can be up to 4 intervals per day.

This information can be changed, and once configured the registered information is sent to its application in the telecontrol system.

But there may be a need to have water at a time when program 1 does not have water. For this it is necessary to activate program No. 2 to change it to an alternative irrigation program and be able to open (activate) or close (disable) manually, as shown in figure 13.

Consult the history of consumption. With a daily, weekly, and monthly summary of the volume of water used.

Consul the reading history. Which allows knowing:

- The consumption in a certain period- according to date range, week, and daily
- Know the irrigation flow
- Check if the irrigation is working as planned since it does not have a change in the number of drippers.

Figura 13 Irrigation setting of program n1 Font: CR ARGOS, 2022.

Figura 14 Irrigation setting of program n.2 Font: CR ARGOS, 2022.

Meteorological data tool

These stations allow greater control, through data of all the environmental and agronomic variables that influence crop development. The company currently has 7 meteorological stations distributed as follows:

- Filtering Station Sector 1, Huerta Alta- Prado
- Station Take 2 of Anguilas - Sangrador
- Station Take 6 of Anguilas - Mill
- Station Take 7 of Cherro - Los Taviras
- Filtering Station Huerta Baja - Oliverica
- Closed - Station H31 Huerta Baja - Cabecicos
- Station Take 17 Huerta Baja - Cañada Los Melgares

The systems take into account different variables as is shown in figure 8 and 9**.** Taking temperature represented in (ºC), pressure represented in (mbar), humidity represented in percentage (%), rain measured in (mm), evapotranspiration in (mm/hr) and wind represented in (km/h).

One more variable that is taken into account but is only collected at the Huerta Alta-Prado station, also measures solar radiation (W/m2). This information captured by the sensors is sent in real time via GSM/GPRS, so that it can be monitored through from any device connected to the Internet. All these parameters are collected to plan future irrigation along with soil moisture to know whether or not to irrigate the crop.

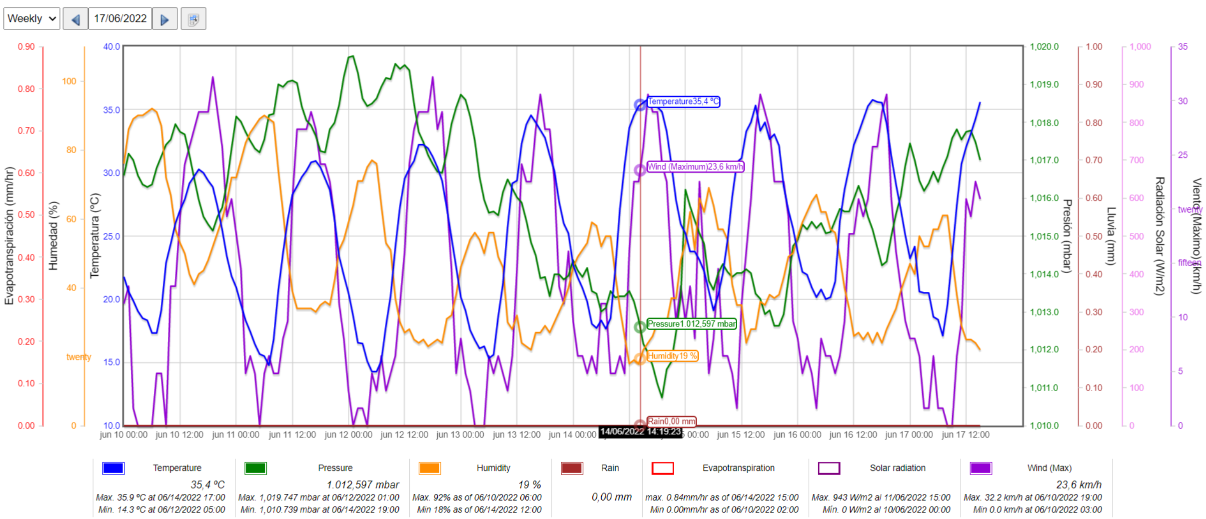

Figura 15 History values from the 13 to 17 of June 2022. Filtered Station Sector 1 - Prado

Font: Comunidad de Regantes de Pliego, 2022.

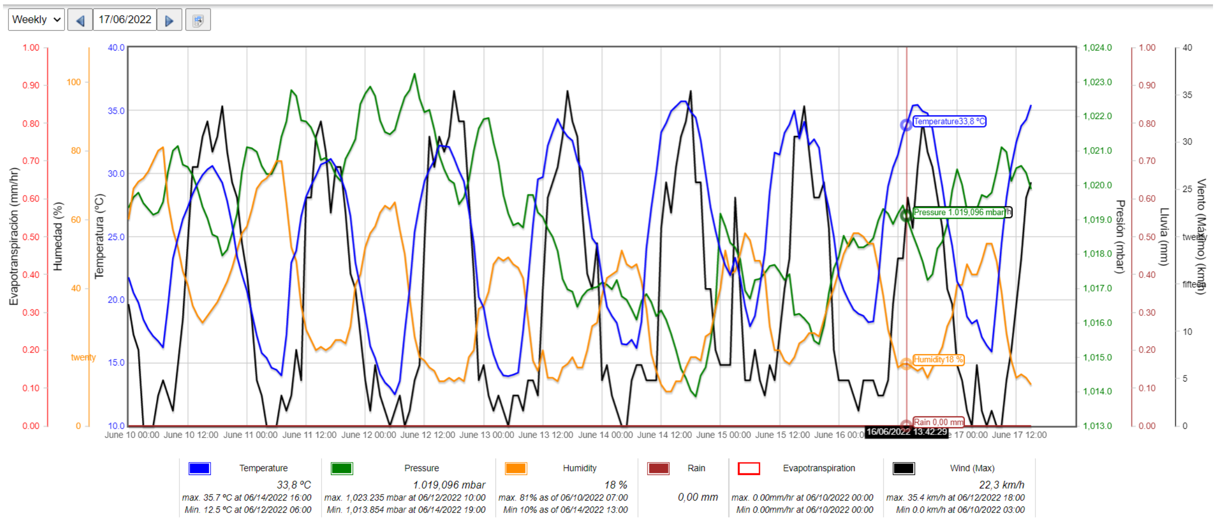

Figura 16 History of values from the 13 to 17 of June 2022. Station take 2 of Anguilas - Sangrador

Font: Comunidad de Regantes de Pliego, 2022.

Humidity, conductivity and temperature data tool

Currently the company has 16 humidity sensors that are distributed in the almost 850 hectares corresponding to the irrigable area of the community between Huerta Alta and Huerta Baja. These humidity sensors consent to measure variables such as the moisture in soil , the surface or subsoil temperature and the conductivity. These sensors are installed in different areas taking into account the characteristics of the type of terrain, which in turn determine the type of crops that are produced there. These probes have the following specifications:

- They are power by : 3 AA batteries
- They have a configurable humidity reading period according to irrigation needs (from 2 minutes to 1 hour)
- Autonomy of : 2 years with measurement every hour.
- Data transmission is carried out: via LoRa radio frequency with a range of up to 700m radius to the Hub/Receiver/Station.
- It has protection against humidity and high temperatures with IP65 approved box.
- Configurable anti-corrosion stainless steel rods to measure at different depths.
- Conductive trend reading (+-0.5ds).
- Reading of surface temperature and subsoil temperature (accuracy of ±1ºC).

These PlantaeSonda sensors allow measuring the humidity of the soil at different depths and automatically, the conductive trend and the surface/subsoil temperature, without the need for cables or installations focused on optimizing irrigation and saving water.

Knowing the humidity, it will be possible to adjust the irrigation cycles, quantity, frequency and duration, to provide the crop with the water it needs within the Easily Assimilable Water zone, as is shown in figure 17. The conductivity reading allows salinity levels to be kept below harmful thresholds for plants.

The two types of depths surface and subsoil the first one allow to measure the surface temperature, which helps to take measurements against frost and other applications. And the subsoil temperature (up to 60cm deep) reflects the state of the root activity of the crop and improves the application of fertilizers and treatments.

These sensors are customizable in measurement depth (up to 1 meter) and reading frequency (from 2 minutes to 1 hour per reading). The probes can be installed both on the surface and buried according to the client's preferences and irrigation characteristics.

In addition, the probes are configured with agronomic algorithms based on the type of soil in which they are installed and its level of conductivity.

The probe housing is IP65 certified, resistant to water and other chemical elements, thus allowing the sensors to be perfectly compatible with the application of irrigation and other phytosanitary products.

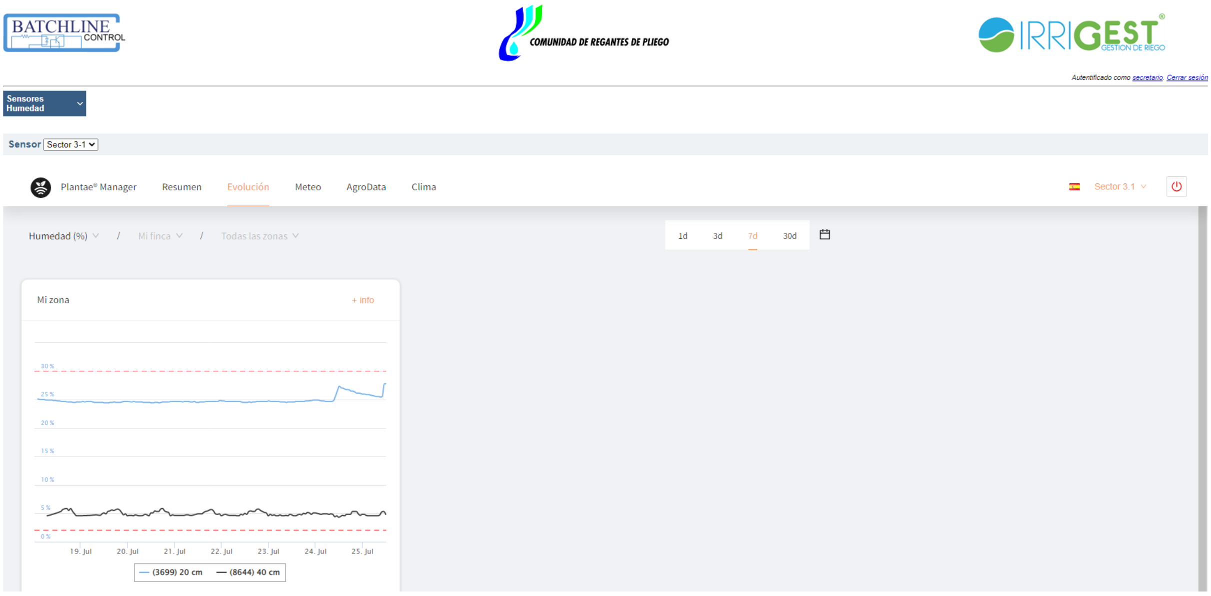

Figura 17 Percentage of humidity in the area of a community member

3. WATER: A BASIC NATURAL RESOURCE VITAL FOR PLIEGO

3.1. ANALYSIS OF WATER CONSUMPTION

Concept	Year 2021 m3	Year 2020 m3	Year 2019 m3-hours	Year 2018 m3-hours	Year 2017 m3-hours	Year 2016 m3-hours
SECTOR 2						
Subsector - Las Anguilas	240.669,50	331.374,00	317.591,60	294.057,00	346.688,00	283.278,00
SECTOR 1						
Subsector - El Cherrro	224.330,20	264.166,20	276.317,80	282.721,00	247.347,00	339.630,00
Supplies to works			25	10.996,100		
Traditional irrigation S1	0 h	0 h	25,50 h	25,50 h	66,50 h	191,50 h
	0,00	0,00	3.213,00	8.379	7.623	
Relief irrigation	26.923,00	26.232,00	32.329,00	53.976	56.182,00	50.148,00
Traditional irrigation S2	0 h	0 h	694 h	2.270,25 h	1.484,25 h	2.600 h
	0,00	0,00	87.444,00	286.051,50	187.015,50	327.600,00
Drip irrigation	275.495,00	337.229,90	196.606,60			
Total liters /m3	767.417,70	959.002,10	913.527	936.180,50	844.855,50	327.600,00
Total revenues	214.876 €	268.520 €	274.058 €	280.854,15€	253.456,65€	301.245,30 €

Figure 18. Water consumption

In the table above, we can see the information on water use for crops irrigated with water from the Comunidad de Regantes de Pliego.

We have divided the years by colour, so that we can see the differences before and after the modernisation plan, which began in 2020. Thus, the data we see from 2016 to 2019, are prior to the Modernisation Plan (Mod. Plan), that is, the years before the application of the sensors. As we can see, for these years, the amount of water used for irrigation was much higher, compared to 2020 and 2021 (after the Mod.Plan).

Thanks to the changes in the irrigation system, the company contributed to both energy and water savings, and in this way it has managed to increase the crops in the territory, especially in Huerta Baja and that is what has led the company to reduce the price for the consumer from 0.28 /m3 to 0.30 cents/m3, after the modernisation plan.

We can see that in the first year, after the Mod.Plan, the cost is gradually decreasing. Although only 2 years have passed since the Mod.Plan and we do not have much data, we can already see that a pattern is forming in the decrease of the cost and use of water, which helps us to realise that the use of modern technologies really has a positive result, both for the company and for the farmers.

Therefore, from the above data, we believe that if the company continues to use modern technologies for irrigation, the cost for farmers and water consumption can further decrease in the coming years.

3.2. Saving water through Precision Agriculture

Precision agriculture is just a part of the Agriculture 4.0 revolution. It is also known as "site-specific crop management," and it is "an information and technology based agricultural management system used to identify, analyze, and manage variability within fields for the improvement of profitability, sustainability, and environmental protection”. Fields are often different in soil types, altitude, soil chemistry, fertility, productivity and types of cultivation. The application of precision agriculture practices, makes producers able to specify the farm input needs (including nutrient and pesticide application and irrigation) throughout an individual field.

Free public access to the Federal Global Position System (GPS) made it economically feasible for producers to use new precision tools, techniques, and services to enhance their efforts to save energy and reduce costs. These include yield monitoring, grid soil sampling, variable-rate application of nutrients, remote-sensing applications, soil electrical conductivity monitoring, and zone soil sampling.

In addition to cutting production costs and saving energy, precision agriculture reduces environmental pollution and improves water quality by reducing nutrient runoff. Other benefits include:

• Improved crop yield;

• Reduced compaction by limiting traffic to specific travel lanes;

• Increased opportunity to operate equipment after dark;

• Labor savings through reduced implement overlap; and

• More accurate farming records

Sensors are really important in monitoring and paying close attention to details during the irrigation process, and even though they are usually perceived as an expense, in the long run

they prolong the life of the irrigation system and provide the best and most sustainable results. Their most important goal is to help use the full potential of the resources. Even the smallest change in temperature, the power and the direction of the wind or rainfall can have a huge impact on the crops and specific management is needed. Smart irrigation systems can help adapt to changes and react rapidly. With the use of sensors, the farmer has the ability to extract the most out of all these natural phenomena and use them to his/her advantage. Furthermore, they help farmers manage everything remotely through applications and websites without having to check every change by physically being there. This saves time, money, and energy and ensures access to data 24/7, every day of the year.

4. INVESTMENT COST AND PROFITABILITY

The works carried out (including remote control) were financed 100% by Publica Administration counting with European funding, national and regional funding as depicted bellow:

- 63% from the European Agricultural Fund for Rural Development (EAFRD).
- 11,10% by the Ministry of Agriculture, Food and Environment of the Government of Spain.
- The remaining 25,90% by the regional administration (Region of Murcia).

The basic cost of the remote control and automation of the Huerta Alta system, corresponding to sector I, and Huerta Baja, corresponding to sector II, was distributed as follows:

Remote control and automation sector I	Total budget of material execution sector I	% of RC and automatization within the total material execution of sector I	Remote control and automation sector II	Total budget of material execution sector II	% of RC and automatization within the total material execution of sector II
390.544,90 €	3.444.381,51€	3.91%	**550.341,65 €**	6.299.096,36 €	**8,74%**

Figure 19. Modernization of the irrigation system of Pliego: some economic fugures

The integration of the remote-control system and the automation of the system for Sector I corresponding to Huerta Alta has a cost of 390.544,90 €, which is equivalent to 3,91% of the total budget for the material execution of the project in Sector I. For Sector II corresponding to Huerta Baja, the adaptations made are worth 550.341,65 €, which represents 8,74% of the budget for the material execution of Sector II.

The total amount of the remote control and automation system that integrates the Huerta Alta and Huerta Baja sectors amounts to 940.886,55 €. The data on installations and other expenses related to the system installations are not specified in the documents, for this reason the total value is taken as the aforementioned, taken from the base bidding budget of the C.R. of Pliego.

As for the benefits, these are identified, on the one hand, as direct benefits for the farmers in terms of the reduction in operating costs that labour and transport entail for travelling to the fields to manually irrigate their crops, as well as, as mentioned above, a reduction in the cost of water supply per cubic metre, from paying 0,30 cents to 0,28 cents.

On the part of the company, the costs that the community must assume in order to supply the service to the irrigators in the area are taken into account, showing the benefits that the implementation of the system brought about.

The following table shows the final result of the exercise. From here we should highlight that the greatest income during the years 2020 and 2021 comes from the national and regional contributions that the community received during these periods for an amount of 876.942,75 € to improve the efficiency of the system. Although the year 2020 has such a low value compared to the previous year, it must be taken into account that this was the period in which all the changes in the system were made. In the year 2021 the net income corresponds to € 28.541,69 with a higher provision in the following years.

Concept	CCAA 2019	CCAA 2020	CCAA 2021
Net amount of turnover	637.517,92 €	526.288,76 €	543.579,79 €
Allocation of non-financial fixed asset subsidies and others	438.471,38 €	876.942,75 €	876.942,75 €
A.1) Operating Income	**47.434,54 €**	**- 3.478,21 €**	**17.841,12 €**
Financial income	34.247,81 €	27.489,75 €	26.418,11 €
Financial Expenses	-23.169,40 €	19.666,87 €	-15.717,56 €
A.2) Financial results	**11.078,41 €**	**7.822,88 €**	**28.541,67 €**
A.3) Income before taxes	**58.512,95 €**	**4.344,67 €**	**28.541,67 €**
A.4) Profit for the year from continuing operations	**58.512,96 €**	**4.344,68 €**	**28.541,68 €**
A.5) Net result of the year	**58.512,97 €**	**4.344,69 €**	**28.541,69 €**

Figure 20. Financial figures

These costs are directly related to the service offered by Pliego R.C., in this case the supply of water for irrigation. The main reduction in cost is reflected in the suppliers' voice, which refers to the cost of water and energy that the company must assume.

In 2019, before the implementation of the system, the suppliers had a total cost of 113.073,44€. The following year, when the system was implemented, the cost for suppliers decreased, reaching a total cost of 95.976,91€, a decrease in energy and water costs.

In the first year after implementation, in 2021 the cost to suppliers increased again, but this growth does not mean that the system is not becoming more efficient. There is a 20% increase in the use of materials which, according to the information provided by the community, is related to the growth of crops in the area. Here we also take into account crop diversification as the amount of resources needed will depend on the type of crop. The water needs of a vegetable crop are not going to be the same as those of crops such as almonds or olives, which need a minimal amount of water compared to vegetables. Therefore, even if there is an increase in the use of materials, it is not reflected as inefficiency in the use of resources, but as a change, an increase related to the growth of the crop.

Concept	CCAA 2019	CCAA 2020	CCAA 2021
Suppliers	113.073,44 €	95.976,91 €	113.445,89 €

Figure 21. Cost of suppliers

Another benefit is reflected in the maintenance costs that lead to other operating costs, here there is an increase in 2020 of 36.843 € with respect to 2019, taking into account that this was the year in which the changes in the system were completed, which implied an increase in maintenance, however in the following year the cost of operating costs decreased, taking into account that the system allows the reduction of costs and risks associated with maintenance and operation and the reduction of unexpected breakages.

Concept	CCAA 2019	CCAA 2020	CCAA 2021
Other operating expenses	369.537,71 €	406.380,34 €	376.908,33 €

Figure 22. Other operating expenses

4.1. Net present value

The NPV is determined by applying a 'discount rate' to the identified costs and benefits. The NPV is calculated as follows:

$$NPV = - I0 + \sum_{t=1}^{n} (Bt - Ct)/(1+r)t \text{ or}$$

$$NPV = - I0 + \sum_{t=1}^{n} (CFt)/(1+r)t$$

Where:

I0 is the investment cost; - ***940886,55 EUR***

Bt is the benefit at time t;

Ct is the cost at time t; - ***95976,91 EUR***

CFt is the cash flow at time t; - ***4344,67 EUR***

n is the expected exploration time of the project;

r is the discount rate - ***5%***

NPV 2022	30.025,92
Investment Cost	40.000
Benefit at the time	5.589,13
Cashflow at the time	21.146,89
Expected Exploitation time of the project	20
r = 5%	0.05

Figure 23. NPV Calculation for 2022

4.2. Payback period

Due to our proposals, we believe that there will be significant economic changes in the near future for the Comunidad de Regantes de Pliego. The payback period showcases the amount of time that the company will need to recover, find balance in expenses and profits, and finally earn money after following our proposal. Our forecast for the payback period is between 2 and 3 years.

Initial investment	40.000
Average cash flow	22.061,52

Figure 11: Table of Payback Period Calculation for 2022

4.3. Internal Return Rate

IRR= 28%

Year	Cash Flows
2020	4.344,67
2021	28.541,67
2022	21.146,89
2023	25.507,38
2024	30.766,99

Figure 24. Internal Return Rate 2020-2024

5. Conclusion

It is clear that the impact of the digital telecontrol systems used by the company in water production and irrigation, is positive, with lots of opportunities for the company to make a positive change in the environmental crisis and the demand of the region in water sources. In the first chapter of the report, the company's telecontrol system is introduced along with the objective of the project. EU Policies on Agriculture and Circular Economy are also mentioned, along with the integration of Circular Economy in the project particularly. Also there are the details of how the system works, how telecontrol systems improve irrigation and some case studies based on telecontrol systems used in irrigation. In the second chapter, the system Irrigest is explained, along with information on how and why the chosen solution works. The technologies send out precise data on the amount of water, soil moisture, temperature, etc. (and other factors when needed) that is necessary for the irrigation of crops. There are also suggestions on more technologies that could be implemented in the system and maybe improve it, and also a general overview of the benefits. At the same time, with the implementation of even more digital control systems and technologies and the help of more trained professionals of a similar work experience background, the company can receive even more precise data and therefore manage to achieve a larger reduction in water and energy use and an even lower price per m3, throughout the following years.

In the third chapter, is the economic analysis based on the data from the company. At the end, according to the info gathered before and after the implementation of the modernization plan and comparing all the data, we have evidence on the success of the irrigation modernization program.

Only by using technologies similar to the ones mentioned in the research, can this positive impact be achieved.

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Co-funded by the
Erasmus+ Programme
of the European Union