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Climate Recovery Plan in the Metropolitan Area of Murcia (Spain)

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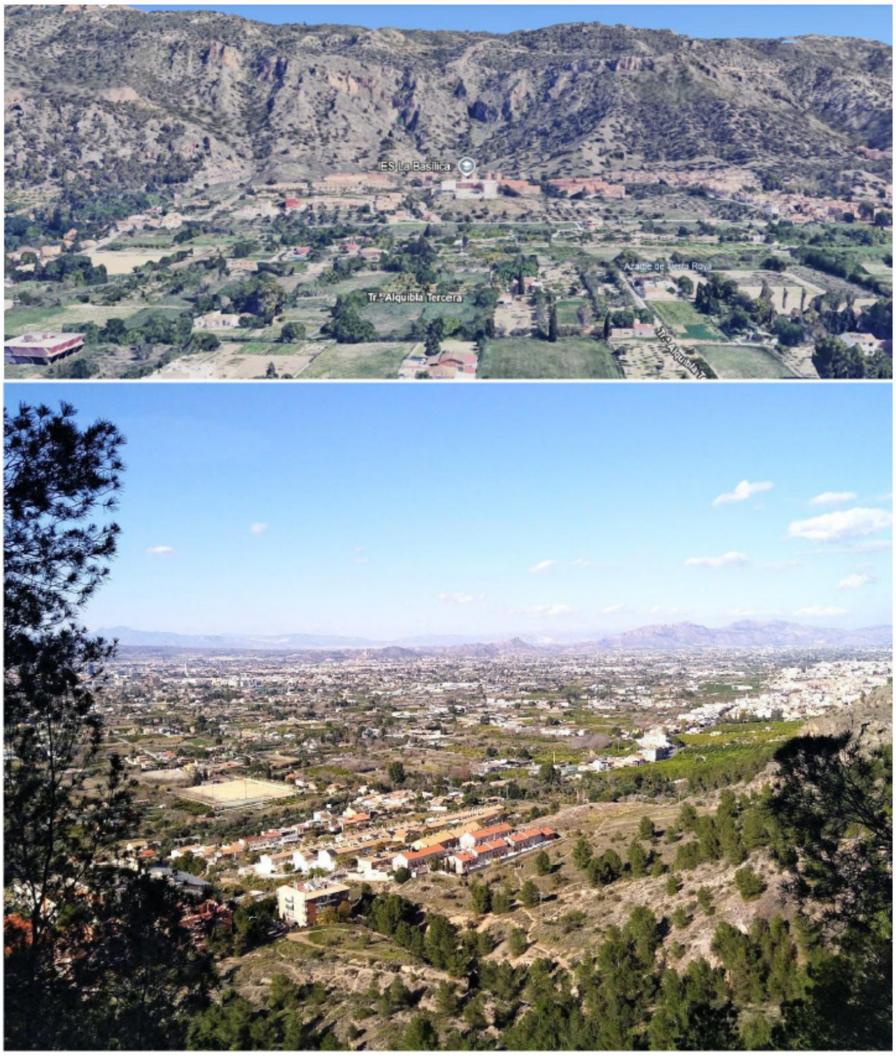

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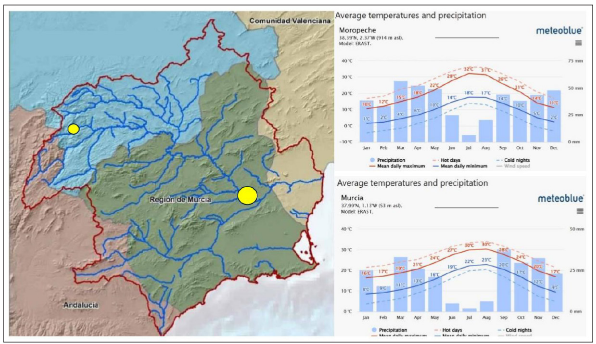
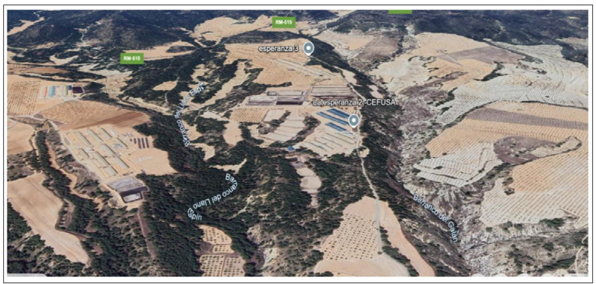
The Spanish metropolitan region of Murcia, with a cadastral area of 1,230 square kilometers, is located in the east of the country in the valley of the Segura River (a basin area of 19,525 square kilometers), which flows into the Mediterranean Sea. Murcia's share of the entire river basin. the percentage is 6.2%.



The landscape is dominated by agricultural land, which suffers from water shortages, especially in the summer months. Like all areas and basins of Spain. The basin is dominated by agriculture, which is dependent on sufficient water. In the rainy season (winter months), rainwater quickly drains from the landscape and contributes to the flood risks of cities and towns in river valleys.



During the dry season (summer half-year), it hardly rains. At that time, the country suffers from a severe water shortage. In the upper part of the basin, July is the most critical month. Throughout the basin, due to historical damage to the landscape, the landscape gradually dried up. Small water cycles gradually emptied, and it stopped raining.

In terms of long-term trends, monthly totals in the winter half of the year are increasing and trending upwards. Year after year, extremes are increasing and the risks of torrential rains and subsequent floods are increasing. This is confirmed by the flood disaster of **October 29, 2024** in the neighboring basin of Valencia. For this reason, we have made a framework analysis of the state of land damage in the cadastre of the city of Murcia in order to understand the principles of land damage.

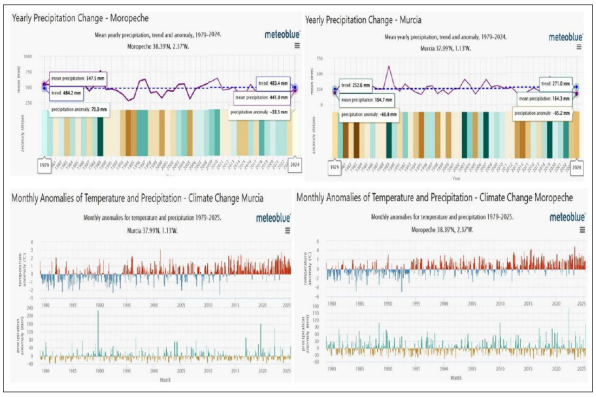
In the forest landscape, deep erosion grooves confirm the often dramatic runoff of rainwater from drainage areas, which accumulates in valleys and causes flood risks.

In addition to the high fluctuation of river flows, the urban environment is also threatened by its own urban waters. This is facilitated by all the already built infrastructure for rainwater drainage from paved areas in urban environments, as well as from transport infrastructure. From road culverts, through rainwater collection from paved areas through drainage gullies, to rainwater management in landscape structures.

The Segura River, with a length of 325 km, collects water mainly from rainfall from a basin of 19,525 km^2 . It is deeply cut in the city of Murcia and in flood conditions (mainly in the winter half of the year) reaches a flow of more than 1000 m^3/s.

Precipitation in the Murcia metropolitan area tends to decrease more rapidly in the upper than in the lower parts of the basin (closer to the sea). In the lower part of the basin, rainfall is more dependent on the maritime climate. Here, annual precipitation amounts to barely 300 mm, while in the upper part of the basin it reaches 500 mm.

The trend in climatic characteristics is very worrying. Since approximately 1995, there has been a steady increase in temperatures in the country. Average monthly temperatures have been steadily increasing both in the upper and lower parts of the basin. This affects the risks for the economy of growing agricultural crops. For this reason, the cultivation of agricultural crops is oriented towards technologies that reduce water consumption. This further reduces water evaporation from the land, which subsequently increases the overheating of the land surface.

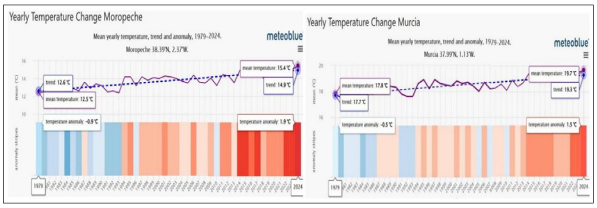


The growth of greenhouse agriculture is already contributing to rising temperatures and longer dry periods in the summer months, followed by an increase in extreme heavy rains and floods in the winter. This trend is unsustainable in the future and requires systemic changes in the country's water management.

Let us note the increase in average summer temperatures in the upper part of the basin (Moropeche). Here, in the last 50 years, average annual temperatures have increased by 2.4 degrees Celsius. In Murcia (an increase of 1.6 degrees Celsius), this increase is slower. The influence of the nearby sea, which moderates the increase in temperature, can be seen here. In principle, it can be stated that this trend in the entire basin is dangerous.

All municipalities in the river basin could start their own plan to change stormwater management through ecosystembased stormwater retention. The goal is for it to Rainwater, which now flows away from the cadastral area during the rainy season without any use, remained in the landscape and performed ecosystem services (soil fertility, landscape thermoregulation, creation of water resources, carbon sequestration, and mitigation of weather extremes).

To understand this opportunity, we offer a framework solution using the example of the city of Murcia: what it means, what are the possibilities and what are the opportunities. This whole concept is also based on the principles and the knowledge of Professor Millán Millán, a climate expert who lived and worked in Valencia.

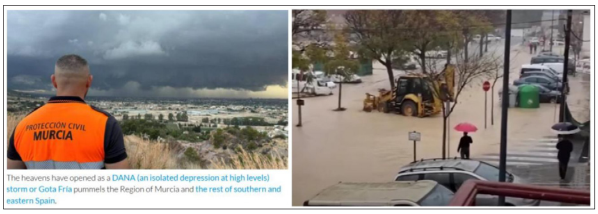


The professor pointed out that summer storms have ceased to exist because the land is damaged and dried out. Professor Millán Millán's basic message and the resulting challenges are:

1. Summer storms disappeared because humans drained the land. From the research of Prof. Millán Millán It turns out that land use immediately changes the hydrological cycle according to the degree of damage to the earth's surface. The water cycle is very important for the landscape. If you cut down a forest, we immediately change the water cycle. Professor Millán Millán was looking for an answer for the locals why there is little rain in the summer. He realized that the rainwater that is retained by the vegetation evaporates into the atmosphere, forming clouds and forming rain. In this way, the same water is repeatedly recycled between the land and the atmosphere. 40-60% of precipitation comes from evaporated water and this is called the small water cycle.
2. The more water there is in the soil, the more vegetation grows and the more water evaporates. This way, the water is kept in a permanent cycle between the Earth's surface and the troposphere. The more vegetation can grow, the more moisture evaporates into the atmosphere, cooling the environment and subsequently producing more frequent rainfall.
3. Evaporated water also has the ability to transfer and release heat. When water turns into steam, solar energy is converted into latent heat. This latent heat is carried by the water vapour to the cooler layers of the atmosphere and vice versa. When the vapour condenses into water, the latent heat is released and warms the air (sensible heat). When water changes from liquid to vapour (evaporates), cooling occurs. Huge volumes of water are involved in this process. With sufficient water, more than 10 mm can actually evaporate per day in Spain if there is water in the country. This means that we need to draw up and implement a plan that can deliver enough water to each hectare of land per day in the hot summer so that actual evaporation approaches potential evaporation.
4. The Iberian Peninsula has undergone massive drainage in the last 2,000 years and drying up of the land. The beginning of the Industrial Revolution brought about extensive changes that were last century, they turned into mass drainage of the land and drying up of entire territories.

5. The mass industrialization of the country has brought a decrease in water vapor in the atmosphere and its lack for cloud formation. According to Professor Millán Millán, this is the key answer to the question of why summer storms are decreasing: they have gone with forests, with the drying of the soil and the elimination of wetlands, because less water evaporates. From artificially created surfaces without vegetation, more heat and less water vapor enter the atmosphere. Reducing the saturation of the soil with rainwater contributes to the drying of ecosystems, the loss of vegetation, the heating of the Earth's surface and the warming of the lower part troposphere.

6. Every failed summer storm, every failure of the system to release heat and water into the atmosphere below, not only reduces vegetation growth, but leads to more severe storms at times when the Earth's surface temperature drops. This happens at the time of the winter solstice in the fall, winter, and spring. These winter storms then form from the sea frontal systems and further erode what is left of the soil. This increases further soil damage, loss of fertility, decline in biodiversity and overheating of the earth's surface. Until complete drying with the transformation of green land into desert.



As small water cycles empty and operate with an ever-decreasing volume of evaporated water, cloud formation and rain formation are limited. The increase in temperature has an impact on the decrease in precipitation in the summer half-year. The decrease in precipitation is also reflected in the increase in solar radiation in a given country, because the conditions for cloud formation deteriorate due to the lack of water vapor in the atmosphere. The relationship between temperatures in the country and precipitation across the Iberian Peninsula is summarized in two diagrams

The first diagram shows the characteristics of monthly precipitation angles and temperatures in the Iberian Peninsula in selected locations. The dominant precipitation activity in the Iberian Peninsula is in the winter half of the year.

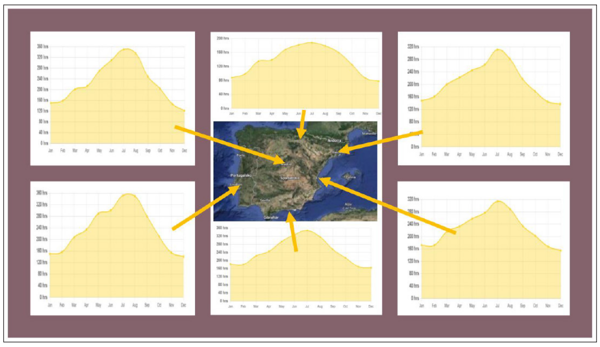
In the summer half of the year, precipitation totals are lowest at all stations and from north to south of the peninsula. Soil damage causes it to dry out. This reduces evaporation, cloud formation and the subsequent decrease in precipitation. From the individual characteristics of monthly precipitation totals in the summer half-year, it is clear that precipitation in the summer half-year decreases from north to south. We recommend noting the abundance of precipitation in the months of September and October. Monthly totals on the eastern coast of the peninsula are significantly higher than on the western coast. This is probably related to the temperature difference between the temperature in the seas and on the land. On the eastern coast, the temperature of the Mediterranean Sea is higher than the Atlantic. Therefore, our recommendation is to start revitalizing the damaged landscape on the eastern coast.

In the south of the peninsula, it hardly rains in the summer. At the same time, the drying of the soil contributes to its overheating and affects the formation of precipitation. The length of sunshine also contributes to the truth of Professor Millán Millán's findings. We know that sunshine depends on the length of the day and cloudiness. While the Pyrenees achieve 1,620 hours of sunshine per year, the rest of the peninsula has 1,000 hours of sunshine more.

Such a big difference at such a short distance is a big anomaly. Interestingly, in the north, in far Finland, the sunshine reaches 170 hours more (Tytuvÿnai – 1791 hours). The explanation of this anomaly is possible through the 2nd law of thermodynamics. Apparently in the past there was less cloud cover in this mountain range and therefore more sunshine, because more horizontal clouds formed over the entire Iberian Peninsula

Due to the damage and drying of the peninsula, this mountainous area is likely to experience higher and more intense rainfall. This results in higher flood risks. It is possible to assume that if the water retention capacity of the soil and landscape structures for the ecosystem use of rainwater were to be increased across the Iberian Peninsula, the incidence of extreme rainfall would decrease and at the same time summer precipitation would increase.

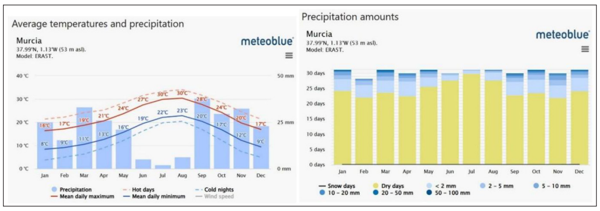
If we look at the nature of precipitation throughout the peninsula, there are practically no small water cycles here. This is manifested in the fact that at the beginning of the summer half-year, as temperatures rise, precipitation decreases and cloudiness also decreases. The entire Iberian Peninsula is in fact dependent on a large water cycle, which comes sporadically and even with a regular supply of rain in extreme volumes, and with it comes the risk of flooding during the rainy season. At a time when the warming of the Mediterranean Sea and the Atlantic culminates, there is a relatively rapid cooling. This is associated with the risks of extreme flooding. If the drying of the Iberian Peninsula continues, the territory will turn into a desert, in which extreme droughts and catastrophic torrents of rain will alternate



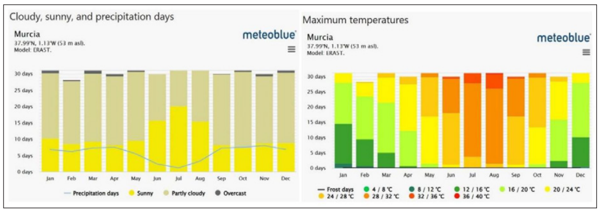
The example of the metropolitan area of Murcia, how to do it in its territory and be an example for the region, Spain and the Mediterranean countries. As an example, we offer at the level of the cadastral area of the city of Murcia, with an area of 1230 km^2, the opportunity to understand the solution to reversing this dangerous trend

The parched landscape above Murcia offers many opportunities to irrigate it to enhance vegetation and increase evaporation, reduce surface temperatures and protect the Murcia metropolitan area from flooding.

Here are the basic climatic characteristics of the city of Murcia. As the temperature rises at the beginning of summer, precipitation automatically decreases. In the summer period, there are barely 2 days per month with precipitation. Even less than 2 mm. The decrease in precipitation lasts until about mid-September, when the intensity of solar radiation drops to a minimum during the winter solstice. At that time, the temperature of the seas peaks. The rapid decrease in the temperature of the Earth's surface changes the flow of atmospheric currents from the sea to the land (the 2nd law of thermodynamics applies). This supports the formation of rain and the supply of precipitation



In the winter, rain occurs almost every third day, with intense rains exceeding 20 mm. Occasionally, rains with a total of more than 50 mm occur. While in the summer, clouds appear in the sky approximately every third day, in the winter half of the year it is the opposite. The sky is cloudless on average every third day. This is in the winter half of the year, when average daily temperatures are below 20 degrees Celsius. We need to achieve higher cloud cover in the summer because clouds are extremely important for reducing the intensity of direct solar radiation on the surface of the country. This contributes to reducing temperature fluctuations during the day.



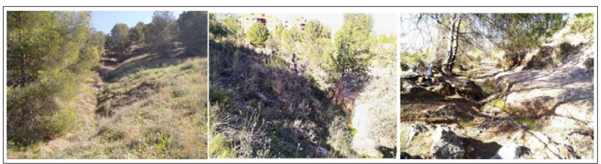
The occurrence of summer heat is also an important parameter of climatic characteristics that can be influenced. In July and August, average temperatures climb above 35 degrees Celsius almost every third day. Increasing cloud cover with higher evaporation can cool the country's temperature. By increasing evaporation, it is realistic to reduce the occurrence of extreme heat.

State of land damage

The marginal mountain and hilly ecosystems are very dry with a dominance of pine trees, which can handle extreme drought. During times of intense rain, rainwater flows through erosion grooves. In these erosion grooves and in the dried forests in general, it is possible to implement a number of nature-friendly activities solutions that can retain and retain rainwater in ecosystems and slow down the processes of surface and soil water runoff, as well as soil erosion.

Erosion grooves in the surrounding slopes from the southeast side of the city of Murcia.

Every cubic meter of retained and retained rainwater will strengthen the resilience of vegetation and trigger ecosystem services (biomass production, soil revitalization, groundwater recharge, increased evaporation and temperature reduction in ecosystems). There is enormous potential in this area to implement ecosystem rainwater retention in all such landscape types – in forests, but also in fields, pastures, built-up areas, or valleys and floodplains of streams and rivers.



A large amount of rainwater from ravines and erosion grooves flows onto paved surfaces in urban areas. As part of development projects, ditches are being constructed to redirect rainwater runoff water from erosion grooves, ravines and built-up areas into the nearest watercourses, which carry rainwater to the main watercourse where it contributes to flood risks.

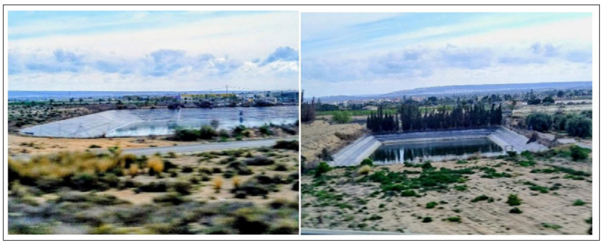
It is solved similarly in urbanized environments. Gutters, channels, canals and storm drains of waste sewers accelerate the drainage of rainwater.

There are extensive damaged areas in the landscape structures that are not used, or are waiting to be used. They are more or less with varying degrees of damage and dryness. They contribute to the overheating of the landscape

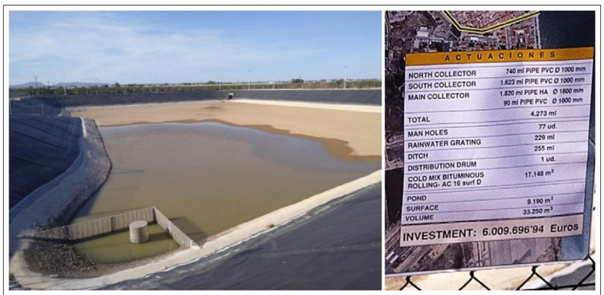
There is great potential in rainwater management on transport infrastructure areas. For example, roundabouts. They have blind spaces that can be used to collect rainwater as air conditioning units. The classic method of collecting rainwater into collection channels in today's era of climate change is very dangerous. Massive rainwater drainage channels can be used to transport rainwater to areas that are otherwise unused.

Entire bare hills and dry slopes can become ecosystems with lush green vegetation if rainwater is retained. This is a major challenge for technological solutions to develop ecosystem-based rainwater retention in degraded landscapes to enhance water renewal in small water cycles

On the one hand, the entire water industry is oriented towards the rapid drainage of rainwater from the landscape, and on the other hand, large projects are being built to collect rainwater into constructed and foil-lined reservoirs. So that this rainwater can then be used for irrigation or agricultural crops, or, for example, rare trees in city parks, so that they do not dry out. This is investment- and operationally demanding. These approaches also have the effect of limiting the natural infiltration of rainwater into the subsoil, which limits the renewal of groundwater and soil moisture.



On the one hand, rainwater is drained from the land in the long term, which systematically supports emptying of small water cycles and on the other hand, investment-intensive projects for collecting rainwater are invested (see figure below). If, according to this strategy, investments were to be made in water management using a classic model on a sectoral basis, it is unrealistic to reverse the risks caused by climate change. According to preliminary calculations, it is necessary to create conditions in the cadastral area of the city of Murcia to be able to return approximately 50 million m^3 to the small water cycle system annually and several times more at the level of the entire Segure river basin.



A classic sectoral approach would require the construction of at least 1,000 such reservoirs in the country's structures, as you can see in the picture above. Each of them is investment-intensive and managing such an investment plan is unrealistic. For the territory of the city of Murcia alone, an investment of more than €6 billion would be needed with a classic sectoral water management to create water resources for irrigation of agricultural crops.

The alternative is the ecosystem retention of rainwater in landscape structures without concrete, without foils and directly in the systems and structures of the forest, agricultural and urbanized landscape, with rainwater being collected directly in all forms of the landscape, its use will be supported. however, evaporation and the creation of subsequent benefits for a more frequent frequency of rain from small water cycles. For this, it is necessary to prepare legislative frameworks based on the principle of regenerative management of water resources and soil through the widespread ecosystem use of rainwater in all landscape structures, which will strengthen the return of lost water to small water cycles.

Draft investment plan for the 1200 km² area of the city of Murcia

In the last 10 years, there have been 8 episodes of intense rainfall at the level of 40 mm, one episode at the level of 150 mm and one episode at the level of 160 mm. From the point of view of economy and efficiency of the solution, we recommend implementing measures on an area ecosystem solution at the level of intense rainfall of 40 mm. With this solution, more than 95% of the rainwater that now flows away from the cadastral area without benefit will be returned to the system of small water cycles. However, this is only a rough calculation, which is influenced by the structure of ecosystems, relief, soil permeability, geological structure. We estimate that for the damaged landscape at the level of the Murcia cadastral area, the runoff of rainwater can range from 100 to 300 m3 per hectare, depending on local conditions. To understand the connection, we used the average runoff of rainwater from one hectare at the level of 138 m3

These are rough calculations that will need to be made for individual parts of the drainage areas of the Murcia cadastral area.

For the metropolitan area of Murcia, with an area of 1200 km^2, the volume is 16.56 million m3, which statistic on average once a year it flows into the Mediterranean Sea in a flood wave. This is also the case for the entire Segura river basin, from which an estimated 300 million m3 of rainwater flows away annually without benefit. Since the territory of the city of Murcia, as well as the entire Segura river basin, is extremely dry, the flowing rainwater can be a source for the restoration of ecosystem services. The current solutions based on reservoirs in which rainwater is collected for irrigation are extremely expensive and is unilaterally oriented only towards the use of collected rainwater for irrigation.

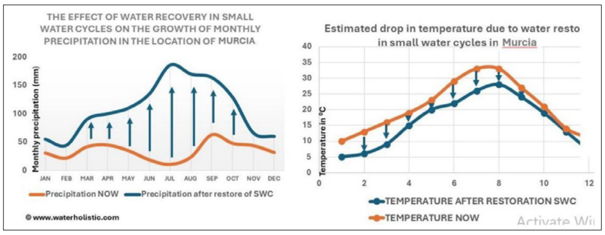
We remind you that during the rainy season, a rainwater collection system implemented on an ecosystem principle can retain all the rainwater flowing away in the area. This means that if measures are taken on a hectare that can collect rainwater once and cyclically with a volume of 138 m3 with a probability of occurring once a year, then the increased . retention capacity of each on each hectare during the rainy season can retain rainwater several times. We estimate that this is 2-3 times more collected water than the increased retention capacity of the implemented measures on each hectare. Let's assume that these measures can retain 3x more water during the winter period (rainy season), then for the territory of the metropolitan area of Murcia, approximately 50 million m3 can return to small water cycles annually.

How much of this will be realistic could be the subject of research into changes in the impact of ecosystem rainwater retention on restoring water resources, increasing fertility, and enhancing biodiversity.

Plan for the Metropolitan Area of Murcia

If water retention measures based on the ecosystem principle were implemented in the amount of 17 million m3 , the entire territory would be flooded in the coming years. 17 million m3 per area means 14 mm. We estimate that an estimated 50 million m3 would return to small water cycles each year.

By implementing the entire plan, it is estimated that after ten years, approximately 500 million m3 of water will start to function in small water cycles, which is 416 mm more precipitation than before. This water would fall into the country in the form of free rain. We estimate that about a quarter of this rainwater would contribute to increasing groundwater reserves



At the beginning of the implementation of the plan to saturate the soil with rainwater, the share would be about one tenth, because the dominant part would be capillary water - water in the soil. We remind you that gravitational water will begin to form only after the soil is saturated with capillary water. This capillary water will be pumped out by vegetation for its growth and cooling in the summer. It can be realistically assumed that after the implementation of the entire plan, the soil moisture conditions will stabilize and the percentage of rainwater in the underground will gradually increase, which will increase groundwater reserves. This will be reflected in the stabilization and subsequent gradual rise of groundwater levels.

According to estimates, an air conditioning effect will be achieved in the territory of Murcia, where summer temperatures could drop by more than 5 degrees Celsius (see graph of monthly temperatures after the restoration of the functionality of small water cycles).

The implementation of the entire plan will result in an annual increase in capture of at least 715 thousand tons of CO_2. from the troposphere by more intensive photosynthesis, which in terms of carbon credits means (at the current CO_2 price on the market – 66.51€/ton) 47.55 million €. This will cause an improvement in biological and chemical processes in the soil with an increase in fertility, which will naturally increase organic carbon in the soil. We need to know that 55% of the volume of humus is organic carbon, which is obtained through photosynthesis. The more watered the land is, the more organic carbon is bound in the soil.

In the case of the plan for the territory of the city of Murcia, this would mean improving soil fertility by increasing the organic carbon reserves in the soil every year. For the territory of Murcia, this is more than 130 thousand tons. Calculated per hectare of land, organic carbon will increase by approximately 1 ton per year. This will have a positive impact on reducing the consumption of chemical soil fertilization. This is another money saved for farmers, by reducing the consumption of industrial fertilizers.

The estimated investment costs for changing the management of rainwater in the Murcia city cadastre are at the level of €300-400 million. On the carbon credit alone, the return on investment is 8.4 years. This does not include the funds saved for water resources and increasing fertility. We estimate that the fertility of cultivated agricultural products will increase and the costs of their cultivation (water, industrial fertilization) will be reduced by at least €50 million per year, which would return the invested investments within 4 years. Other significant benefits would be reflected, for example, in reducing energy consumption for air conditioning in cities in the region. Air quality would improve and there would be a number of other benefits that will need to be evaluated from the plan. This would be for the region has attracted a lot of attention also because it is a great opportunity to show a real solution to reversing climate change, through a functional climate recovery plan. We remind you that the figures given are rough estimates, based on the experience of the WATER HOLISTIC team, which will need to be elaborated in detail.

On this principle, it is possible to implement a plan for the restoration of the entire Segura basin and also of the whole of Spain. The program can be implemented at the level of public policies of local and regional governments. Ideally, it should be implemented at the national level, defining legislative criteria and obligations for all owners of forests, agricultural land, or real estate in urban areas. It will be necessary to build the entire implementation capacity of such a program, a system of advice and financial instruments.

The preparation and implementation of such a plan will allow to increase the water retention capacity of soil and landscape structures over the course of a decade with a number of synergistic effects. The water retention capacity of soil and land is a public-beneficial function of the landscape and individual plots, which, when increased, activates the ecosystem functions of soil and plots. It is therefore in the public interest to increase the water retention capacity of soil and land in the landscape, which can be ensured by a system of financial solidarity in supporting this public-beneficial function of soil and landscape. Soil is the carbon and water bank of the country.

Activating hydrological and climatic functions of land is possible through systemic assessment and financing of soil and landscape ecosystem services.

Note on possible discussions: We assume that this framework proposal for solutions from a sustainable perspective may arouse both interest and doubts. What we have summarized in this framework proposal is the result of more than 30 years of knowledge and research into the impact of economic land use on changes in the temperature regime of the land and the impacts on the temporal and spatial change in the distribution of precipitation, as well as the resulting solutions and benefits for the area of water, food, environmental, climate and social sustainability of investments in the restoration of small water cycles.

If you are interested in a deeper understanding of the context, the author team is ready to develop proposals and justifications of benefits for both the public and private sectors at all levels of interest.

The basic message, which emerged from more than 30 years of research on experimental and theoretical knowledge, is that it is realistic to achieve that in the metropolitan area of Murcia, but also in all municipalities on the Iberian Peninsula, or in any other municipality in the Mediterranean countries that follow this path, it is possible to achieve by proposing solutions that the summer heat will decrease regionally and locally by more than 5 degrees Celsius, that the incidence of summer storms will increase, that the reserves of water resources in the country will increase, that the already dried-up rivers will be restored and that the economy of agricultural crop production will improve with fundamental economic prosperity. Another important fact is that morning dew will gradually be formed due to the condensation of water falls above the morning.