AdriaClim

Climate change information, monitoring and management tools for adaptation strategies in Adriatic coastal areas

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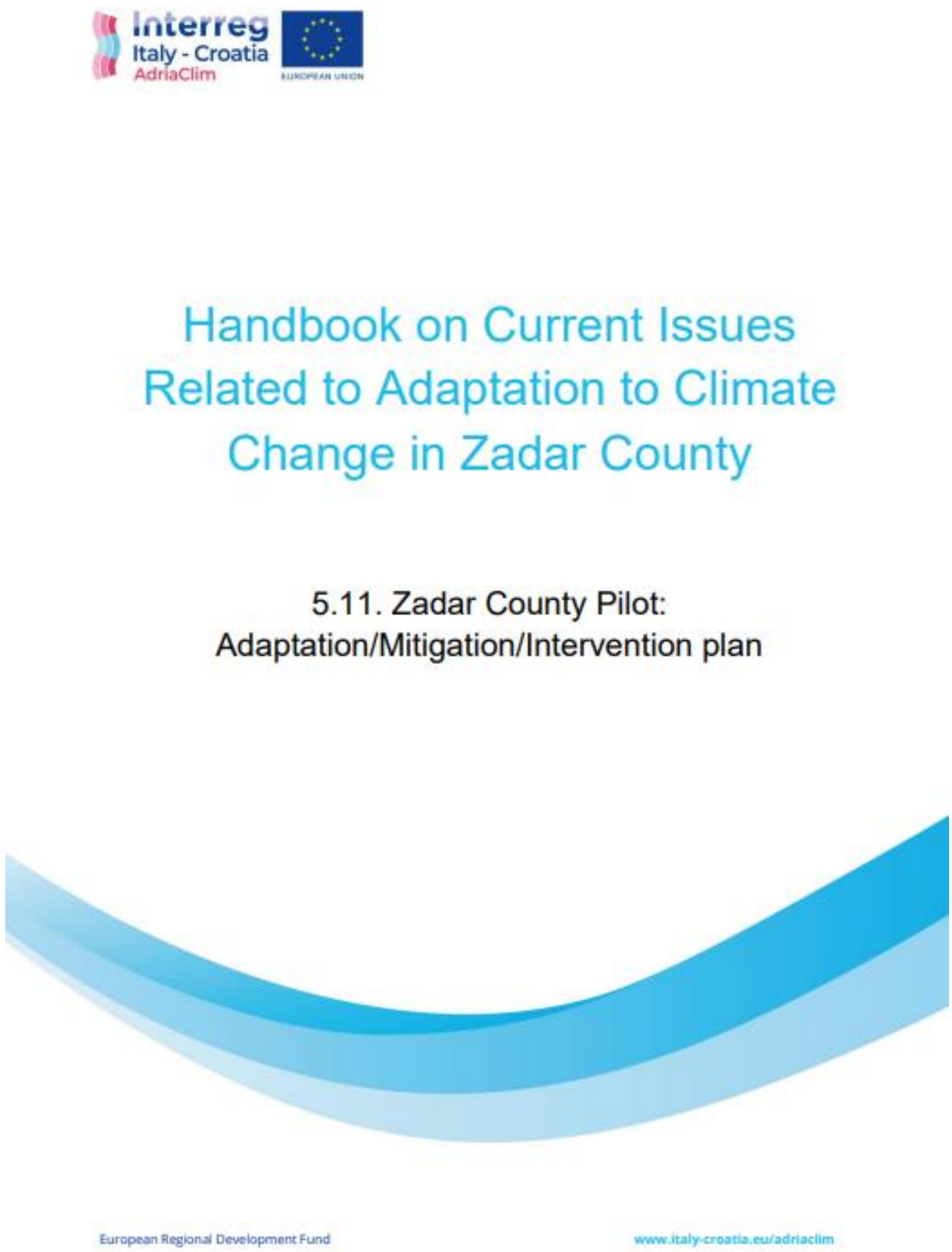
Table of contents

1. Aims and content of the document

Handbook on Current Issues Related to Adaptation to Climate Change in Zadar County was created as part of project D.5.11.1 Zadar County Pilot: Adaptation/Mitigation/Intervention Plan. This handbook describes the soil, the importance of soil analysis, climate parameters (temperature, humidity), structure of agriculture and irrigation in Zadar County, weather conditions in 2021, etc. The data were collected from the pilot location of the University agricultural property Baštica, where as part of the AdriaClim project, with the aim of developing and improving the existing climate change monitoring systems, by encouraging the development of strategic documents and adaptation plans to current changes, an innovative solution for collecting water from moisture in the air - AquaWeb - was created. The prepared manual will be used in future planning in this area regarding agriculture and adaptation to climate change in Zadar County.

2. Handbook on Current Issues Related to Adaptation to Climate Change in Zadar County



Handbook on Current Issues Related to Adaptation to Climate Change in Zadar County

5.11. Zadar County Pilot: Adaptation/Mitigation/Intervention plan

European Regional Development Fund

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Contents

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1. Soil

More than 95% of food or food raw materials are obtained from the soil. According to Kisić (2019), the soil is considered the "skin" of planet Earth because it has the same role as the skin on the human body. If we remove, destroy or devalue that "skin" in any way, the survival of planet Earth will come into question. Caring for land resources, natural resources and biological diversity should become the responsibility of the entire social community. Soil represents the largest and most important natural resource that humanity possesses. Unfortunately, with increasing exploitation, its degradation occurs, which reduces the possibility of producing quality food for consumption and disrupts biological diversity in the ecosystem.

Most often, soil is defined as a loose layer of the Earth's surface, located between the lithosphere and the atmosphere, formed from the parent rock under the influence of pedogenesis factors and the action of pedogenic processes (Kisić, 2019). The most important pedogenetic factors can be divided into two categories: active (climate and organisms) and passive (relief, parent substrate and time). Pedogenic processes include wear of the lithosphere, decomposition of organic matter and synthesis of humic substances, formation of organo-mineral compounds, migrations and specific processes. The soil has three important ecological functions, namely: biomass production (the most important role of the soil), soil is a universal medium for filtering and transforming substances, and in addition forms a demarcation between the atmosphere, groundwater and plant cover. Soil is a habitat for numerous animal and plant organisms. The largest number of organisms on planet Earth live in the soil, so the soil is directly related to biological diversity (Blum, 2006, Vukadinović and Vukadinović, 2018).

Soil (Figure 1) and land (Figure 2) are two terms that are often used interchangeably, and the difference between them is significant. Namely, soil is a natural formation created by processes of soil formation (pedogenesis), while land is a broader term and refers to the surface of the land, i.e. land is a term for the way soil is used. Soil, along with water, is presently, and in the future even more so, a factor that will define the limits of the development of the human population (Kisić, 2019).

Figure 1. Soil
(Source: Vukadinović and Vukadinović, 2018)

Figure 2. Land
(Source: Ministry of Agriculture, 2020)

Soil is extremely important in mitigating climate change because, along with oceans and carbonate rocks, soil contains the largest global carbon stock (twice as much as the atmosphere and three times as much as the total vegetation on Earth). Due to the extremely slow process of creation, it is considered a non-renewable or, at best, conditionally renewable resource (MINGOR, 2020).

1.1. Soil properties

Soil is a natural polyphase system consisting of a solid, liquid and gaseous phase. The solid part of the soil consists of a mineral part that originates from the parent rock and an organic part, which mostly consists of humified organic matter (Kisić, 2012). The liquid part of the soil is a water solution, and the gaseous part is air (Špoljar, 2007). The most active part of

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the soil is the liquid part and water. The water in the soil serves as a solvent and all pedogenetic processes take place in it. It is a source of oxygen and hydrogen for the synthesis of organic substances, participates in the physical and chemical processes of mineral wear, and also affects the temperature regime of the soil (Pevalek-Kozlina, 2003).

Layers called horizons can be recognized on the soil profile, and they are important as an indicator of the origin, dynamics and properties of the soil (Nortcliff et al., 2011, Sofilić, 2014). Soil differs in physical and chemical properties. The physical properties of the soil include the mechanical composition, structure, density, porosity, thermal properties and air in the soil. Considering the size of the particles, the mechanical components of the soil are divided into: clay particles, dust and sand. Sand retains water the weakest, while clay and dust have a greater ability to retain water. The most important mechanical component of soil is clay. Soil structure is the arrangement, size and shape of structural aggregates that are created naturally or under human influence. Soil structure is one of the most important factors of soil fertility (Kisić, 2012, Vukadinović and Vukadinović, 2018).

The chemical properties of the soil directly affect the nutrient potential as well as its fertility. One of the most important soil components is humus. The composition of humus varies depending on the type of soil, i.e. depending on the substance from which it was created. Humus affects the overall stability of aggregates in the soil, reduces the possibility of soil erosion, prevents leaching of nutrients, etc. The organic matter in the soil formed by humus affects the growth and development of the plant in all its life cycles.

Soil is a habitat for numerous plant and animal organisms, which are divided into macro and micro-organisms. The most numerous organisms are bacteria, fungi, algae and insects. The number of living organisms under the surface of the soil is many times higher than the surface part, and this is also evidenced by the fact that the fertile soil in the arable layer contains approximately 25 t/ha of living organisms (Bašić, 2009). The most important microorganisms in the soil are bacteria because they enable very important processes to take place such as humification, mineralization, oxidation, reduction and nitrogen fixation. Organic matter in the soil originates from the remains of living organisms. Bacteria and some fungi break down these residues into simpler, i.e. more accessible, compounds that are then available to plants. Organic matter also affects the physical and chemical properties of the soil and serves as a "storage" of water and nutrients. A lack of organic matter would completely impair the productive properties of the soil (Vukadinović and Vukadinović, 2011, Sofilić, 2014). Cultivated plants, unlike natural vegetation, do not return their organic matter to the soil (Špoljar, 2007), so a large amount of nutrients are removed from the soil and the soil is depleted of biogenic elements.

1.2. Soil fertility

Soil fertility is the ability of the soil to provide plants with the necessary nutrients such as water, air, heat, to provide all the favorable conditions for the development of the root system. Fertility of intact soil can be defined as its capacity to meet the needs of a naturally balanced population. This term denotes that a certain soil can provide the plant with the conditions (nutrients, water, air, heat) for undisturbed growth and development during its lifetime. Fertile soil stimulates the growth of plants by providing them with nutrients, acting as a water reservoir, and also serves as a substrate for plant rooting. In turn, vegetation, tree cover and forests prevent soil degradation by stabilizing it, maintaining the water and nutrient cycle, and reducing erosion by water and wind. The content of organic matter is one of the indicators of its fertility. Soil quality is defined according to the appearance of the plant - visually, and based on overall soil analyzes (Kisić, 2019). Humus is the top layer of soil composed of decomposed organic matter, a very fertile part of the soil. The vast majority of agricultural soils in Croatia have a relatively low humus content of 1 to 3%. One of the most important rules is to enrich the soil with as many nutrients as we have used from it. One of the most important features of soil fertility is the pH value. At a neutral pH value, the most favorable plant growth and development occurs. In arable soils, the pH value ranges from 5.0 to 8.0 (Kisić, 2012).

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For sustainable agricultural production, it is very important to keep the soil fertile in order to maintain the best possible structure, a higher content of organic matter and plant nutrients. Intensive agricultural production significantly affects soil fertility, especially if tillage is done while the soil is wet and moist. In this case, soil layers are compacted. By trampling the soil, the volume of pores in the soil is reduced and the structure is damaged, which has a negative impact on the growth and development of the roots of cultivated crops and the microbiological activity of the soil. For the above reasons, the necessary agrotechnical interventions that require the use of heavy machinery should be carried out when the soil moisture is favorable. In order to maintain soil fertility, it is necessary to keep the soil "alive", which means reducing the use of pesticides and excessive tillage in order to allow microorganisms to unhindered development of the process of converting more complex molecules into simpler ones that are more accessible to plants. Another unfavorable procedure is intensive tillage of the soil, because it promotes aerobic processes that lead to mineralization and loses the humus content in the soil.

1.3. Soil and plants

Soil is the foundation for vegetation that is grown or used for food, fiber, fuel and medicine. Soil and vegetation have a mutual relationship. The main influence of the plant on the soil is the absorption of water and nutrients through the roots, so the soil provides water and mineral substances to the plants. A part of the organic matter is returned to the soil through various plant residues, root by-products, etc. The plant has a great influence on the circulation of nutrients, which affects the abundance and distribution of other plant species (Aguiar, 1999). In nature, there is a closed system of circulation of substances - nutrients. Plants exhaust nutrients from the soil, but with the decomposition of organic matter (plant residues), the nutrients are returned to the soil. In addition to influencing the availability of nutrients, plants also influence the strains of bacteria in the soil. Annuals release much less carbon to the soil than perennials (Zeph et al., 1988). Furthermore, it was established that different cultivars of the same species secrete compounds in different concentrations into the soil (Mendum et al., 2001).

The mobility of nutrients in the plant significantly depends on the pH value of the soil and the microorganisms that break down more complex molecules into elements that are more easily available to plants. By maintaining the pH value, we also maintain biological diversity in the soil, and by maintaining biological diversity in the soil, we keep the soil more fertile for the production of agricultural crops. Constant monitoring of these parameters can be helpful for better, more responsible and efficient agricultural production.

Wild plants and weeds provide a great help in determining the type - condition of the soil. The presence of a certain plant species in an area can provide approximate information about the condition of the soil, for example, acid-alkaline soil, compacted-permeable soil, wet-dry soil, and the like. Also, if a certain type of weed suddenly appears on some cultivated land, i.e. if that species dominates, it unmistakably indicates errors in cultivation technology and soil condition. Thus, for example, *Equisetum arvense* L., *Mentha arvensis* L., *Ranunculus repens* L. indicate heavy compaction of the soil and excess moisture, while *Urtica dioica* L. and *Stellaria media* (L.) Vill) "say" that the soil is rich in humus (Ministry of Agriculture, 2014).

2. Water

Without the presence of a sufficient amount of water, the origin, life and growth of plants on Earth would be impossible. Water is an integral part of all living organisms. In the economy, water has a central place, it enables agricultural food production, forestry, navigation, purification processes and is used for energy production. Water is one of the basic characteristics of our planet, be it in liquid, gaseous or solid phase (Gereš, 2004).

A significant proportion of plant tissues is water, and for the normal development of all physiological functions, plants must contain sufficient amounts of water. Water makes up to 95% of the plant's weight. The water content in the plant can change depending on the plant species, age, temperature, air and soil humidity, and diet. For all plant species, water is a basic ecological factor. It is necessary for maintaining the structural unity of cells, tissues and the entire organism (Židovec, 2019). In the absence of water, the plant becomes stressed. Stress is a state or change in conditions that deviate from the optimal conditions necessary for plant growth and development and cause reactions and changes in structural and functional processes in plants. On soils poor in nutrients and water, plants generally grow weaker and have a lower habitus. This is associated with a decrease in the intensity of photosynthesis, but also with a disturbance in nitrogen and carbon metabolism. If there is a lack of water in the root zone, the ratio of the mass of the roots and above-ground organs changes in favor of the roots, and premature flowering or at times leaf fall may occur. Plants on land often cannot easily reach water, therefore human supply of required water is necessary at certain stages of development, especially in cultivated cultivation (Mičijević, 2020).

2.1. Water in the soil

The water in the soil is bound by various forces that the root system must overcome during adoption. Therefore, water in the soil is divided into two categories: accessible and inaccessible. The amount of water in the soil mostly depends on the texture and content of organic matter. Soils that have a fine structure, thanks to the larger surface area of the particles and the multitude of capillary pores, can retain more water compared to soils with a coarse texture. The mobility of water in the soil depends on the texture and structure of the soil, that is, on the total porosity of the soil, the diameter of the pores and the filling of the pores with water (Vukadinović and Vukadinović, 2011). Water in the soil is divided into:

1. Gravitational - it remains in the larger pores of the soil and flows away under the action of gravity. Therefore, this form is often called "free water".
2. Capillary - remains in the pores under the influence of surface forces of soil particles. It is not subject to gravity because it is held by the forces of surface tension to the walls of the soil capillaries or is "supported" by the groundwater level. This water is available for absorption and represents the most important part of the water.
3. Hygroscopic - it is part of capillary water. With the increase in soil colloid content and the reduction of its particles, there is more and more hygroscopic water.
4. Underground - it lies on an impermeable layer in the ground, due to which further movement is absent, so its function is to saturate the aquifer to the maximum capacity for water. Its level is not constant and depends on the intensity of wetting. In dry periods, groundwater plays an important role in supplying plants with water (Bašić and Herceg, 2010).

In order for the water in the soil to move, a good energy potential must be achieved. The difference in the energy potential will enable the movement of water from the wet area (higher water potential) in the soil towards the dry area, i.e. the area of lower potential, until the humidity will be uniform. There are three basic movements of water in the soil - capillary movement of water, filtration and infiltration. The capillary movement of water takes place

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from an area of higher humidity to an area of lower humidity. Infiltration represents uneven absorption by vertical and lateral movement into unsaturated soil. Filtration refers to the percolation of excess water from saturated soil into deeper layers through soil macropores, which is caused by gravity. The most important thing for plants is the accessibility of water in capillary form. Capillary water is the main factor in soil dynamics and fertility. The water regime of the plant includes receiving, moving and excreting water. Thus, the water balance can depend on the movement, inflow and loss of water. The movement of water through the soil and its losses are very complex, and the process is affected by a number of factors, among which the most important physical properties of the soil (texture, structure, soil depth, depth of groundwater, etc.), then climate (amount and distribution of precipitation, temperature and air humidity, evaporation, etc.) as well as vegetation and plants' need for water and the power of adopting the root system and the intensity of transpiration.

2.2. Water and plants

Water is constantly received and excreted by the plant through a number of different physiological and biochemical processes. It is water that is the most important and the biggest limiting factor for plant growth and development due to the fact that plants need a relatively large amount of it. The most important role of water in the plant is the transfer of nutrients through the root from the soil, from where it is transported to different organs of the plant, and the excess water that is created is returned to the atmosphere by transpiration. Water in the plant serves as a transporter of metabolic products from the place where it is formed to the other organs of the plant and participates in the formation of organic matter through photosynthesis (Bašić and Herceg, 2010). Water makes up as much as 95% of the plant's weight, and they take most of the water from the soil through the root system, although they can absorb it through the leaf (foliar) and other organs if they are not covered by bark or a thick cuticle. In addition to participating in physical and chemical processes, water plays the role of a solvent, carrier of substances, temperature maintenance, and participates in the processes of photosynthesis and respiration. As a phytoecological factor, water has a decisive influence on the choice of agricultural crops.

Water is also a temperature regulator in the plant and thus enables transpiration. Transpiration is a physiological process by which a plant secretes water in the form of water vapor into the atmosphere through openings on the leaf epidermis (stomach). This enables the flow of water from the soil to the roots and to the above-ground organs, where dissolved nutrients come along with the water from the roots to the leaves. Transpiration also serves to cool the plant during hot and dry days. The plant needs a continuous supply of water to compensate for transpiration losses. Lack of water in plants reduces their synthetic ability, protein hydrolysis occurs, oxidase activity is higher and respiration intensity is higher, and photosynthetic activity is reduced, and the transport of assimilates is slowed down.

Although physiologically, water acts exclusively in the liquid state for plants, in agroecology water also plays a role in the solid state (through snow, hail and ice), but also in the form of water vapor.

Water is essential for seed germination. The seed already contains water and this enables it to maintain the life of the germ, however, this amount is still not sufficient for growth or germination. In moist conditions, the seed wakes up from dormancy and the swelling of the seed, germination and development of a new plant are encouraged (Bašić and Herceg, 2010).

The water needs of plants vary depending on the species. According to water needs, plants are divided into hydrophytic, xerophytic and mesophytic. Hydrophytes belong to a group of plants that grow in wet areas, areas near water and in water. The aerial parts of these plants can be completely or partially submerged. Xerophytes are plant species that are adapted to dry areas. Therefore, they grow in places where the availability of water is very low or available in quantities that will be quite sufficient for the plants of such an area. The species of this area absorb water from the environment, can retain moisture for a very long time and have a reduced transpiration coefficient. Mesophytes are a group of terrestrial plants that grow in habitats where there is neither high humidity nor dryness. They represent the flora of forests, cultivated fields and meadows because they grow in areas where the soil and climate are favorable.

2.3. Hydrological cycle

Under the influence of the heat energy of the sun in the water cycle (hydrological cycle) (Fig. 3), water evaporates from the surface of the sea, ocean, land, watercourses and water basins, which represent the beginning of the water cycle in nature. Through the process of evaporation, water evaporates from the soil, and through transpiration through the leaves or leaves, water is lost from the plants. Evaporation and transpiration, i.e. evapotranspiration, is the basic prerequisite for the circulation of water in nature, and the driver of this entire hydrological process is solar energy. The intensity of evapotranspiration largely depends on climatic conditions. Evaporation represents the loss of water from the surface of the rhizosphere in the form of water vapor. Evaporation will be higher the higher the saturation of field water capacity, and it is lower in vegetated than in bare areas, and the reduction of evaporation is achieved by mulching (covering the surface with dead mulch) (Bašić and Herceg, 2010). In addition to evaporation, water can also be excreted from the plant through guttation, i.e. in the form of droplets through special water openings or hydatodes located on the tips of the leaves during times of high air humidity, which in moderate climates is mostly at night. Guttation is most pronounced when there is no transpiration, thus helping the flow of water in the plant when transpiration stops. Tearing or weeping is another way of water loss that occurs if the plant is injured, or if the conduit channels are damaged. Tearing is one of the phenophases of grapevine development and is the first sign of the "awakening" of the vegetation.

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Figure 3. Presentation of the hydrological cycle
(Source: Gereš,2014)

2.4. Irrigation

Irrigation is an amelioration measure by which water is brought into the soil on certain agricultural or park land through an appropriate hydrotechnical system in order to ensure the necessary humidity for plant development (Šimunić, 2013). Artificial irrigation compensates for the lack of precipitation needed to supply plants with water. The need for irrigation in a certain area depends on the amount of precipitation and its distribution during the growing season. Irrigation is also used for other purposes, such as fertigation, washing salt from the soil and protecting plants from frost or refreshing them. In addition to agricultural production, irrigation is also applied to public and decorative green areas. Irrigation of plants has its positive and negative effects. The positive effects of irrigation are increased yield and quality of agricultural products, and improved chemical, physical and biological processes taking place in the soil. Sufficient supply of water through irrigation

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enables the plant to better regulate temperature and participate in photosynthesis. The negative effects of irrigation refer to excessive leaching of nutrients, acidification, waterlogging and salinization of the soil (Šimunić, 2013).

The elements of irrigation are:

a) Irrigation norm - this is the total amount of water that should be added by irrigation during the growing season.

b) Irrigation rate - is the amount of water in m3 that is added with one irrigation.

c) Number of irrigation - obtained by dividing the irrigation rate by the irrigation rate.

d) The moment of irrigation - today it is most often determined by measuring soil moisture with a tensiometer.

e) Duration of irrigation - depends on the amount of water that we want to add through irrigation, on the intensity of irrigation, and on the stage of plant development. It is important because of the coordination with the intensity of water absorption into the soil.

f) The required amount of water for irrigation - depends on the phenophase of the plant's development, the plant's water needs, the irrigation period, and the type of soil.

Irrigation can be done in different ways. Surface irrigation was common, which meant irrigation with furrows and overflowing. This type of irrigation is almost abandoned today due to the large consumption of water and the increase in the potential danger for the spread of diseases to agricultural crops. Irrigation can also be underground, common in horticultural gardens. In addition to those two methods, irrigation can be done by sprinkling with the help of self-propelled wings of different ranges (200 to 400 m) with the possibility of connecting to typhoons. In addition to self-propelled ones, there are stable and portable irrigation devices. In practice, localized irrigation is most often used, which can be drip irrigation (drop by drop) or irrigation with micro sprinklers. This type of irrigation is convenient because only part of the surface around the plants or only part of the soil volume in the root zone is moistened. Irrigation with micro-sprinklers has proven to be more effective than the drip system, because it improves the microclimate of the plantations and distributes water more

evenly within the zone of the root system. It is very important to choose the right irrigation method depending on the culture and terrain. It is important to properly design and dimension the irrigation system for proper operation and even distribution of water.
The correct selection of the irrigation system greatly affects the selected agricultural production. Some agricultural crops require more water than others, and the amount of available water depends on the time and method of cultivation, stages of growth and development, and other conditions.

2.5. Climate change and irrigation

Agriculture and food growing are important and indispensable in the sustainability and survival strategy of both rural and urban environments. It is the economic branch that suffers the greatest consequences of climate change. Extreme conditions of major droughts, floods, high and low temperature oscillations are becoming a daily occurrence and bring great economic damage. The upcoming challenges have encouraged many experts who are looking for innovative solutions and methods of growing plants and food production in controlled conditions of protected areas, as well as breeding existing species in order to obtain new varieties more resistant to existing climate changes. Uncontrolled water consumption as well as unprofessional management of agricultural areas can lead to significant natural and material losses. Challenges in agriculture through the coming climate changes are looking for sustainable solutions to provide food for future generations.

2.6. Structure of agriculture and irrigation in Zadar County

According to the data of the Agency for Payments in Agriculture, Fisheries and Rural Development (2015), the total agricultural area of Zadar County is about 30,000 ha. Of this, the largest part refers to karst pastures - about 53%, 17% to arable land, 10% is olive groves, 7% is meadows, about 5% is the area under vineyards and the same amount under orchards, while the remaining 3% is recorded under mixed permanent plantations .

From the above data, we can conclude that only a small part of agricultural production potentially needs irrigation. The Zadar County has enabled its farmers to connect to several public irrigation systems. There are 4 public systems in Zadar County that cover about 850 ha of agricultural land. They are primarily intended for vegetable growers, but also for producers of fruit and vineyards and olive groves. In addition to the mentioned public systems, some producers use irrigation in their plantations from their own wells and reservoirs. As such, they are not fully recorded, so it can only be assumed that the total part of irrigated agricultural areas is slightly larger than 1000 ha. The exact number of irrigated areas is difficult to specify.

3. University property Baštica

The University agricultural property Baštica is located in the hinterland of Zadar in the area of Suhovare, K.O. Islam Grčki (N 44.158248 | E 15.43467). The Baštica area has a Mediterranean climate with mild winters and hot summers (Csa). The average annual air temperature is around 15 °C, and the average amount of precipitation is around 900 mm. Although this is the amount of precipitation that is sufficient for agricultural production, the problem is the irregular distribution of precipitation during the growing season. For this reason, water shortages very often occur in the growing season (April-October), especially in the summer months during the phase of intensive growth and ripening of perennial crops. Late spring frosts, when the temperature can drop to -5 °C, are not uncommon in recent years.

The total gross area of the entire University property is 15 ha. There is an apple orchard and vineyards of different ages on the mentioned area, on different Arkod plots. Mixed fruit species were planted along the edges of the University property. In addition to the above, a raised vegetable bed was built on one part of the surface. The plan is to create and plant a Mediterranean garden, as a "green classroom" with various medicinal and honey-bearing plants characteristic of the Mediterranean climate.

The soil in the orchard and older vineyard is maintained by mulching, while in the herbicide zone the soil is maintained by the application of permitted herbicides in accordance with the principles of good agricultural practice. The soil in young vineyards is maintained by tilling and hoeing, without the use of herbicides. In the vineyard and orchard, the occurrence of diseases and pests is monitored with the help of pheromones, traps, but also by monitoring agrometeorological data at the station located in the plantation, and care is taken in the rational use of pesticides.

Table 1. Total used area:

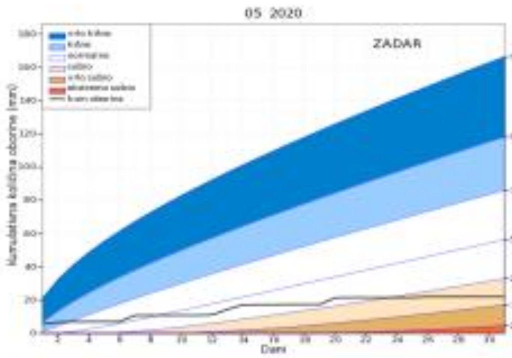
	Vineyard	Orchard	Collection vineyard	Orchard (pear, plum, pomegranate) *40 pcs*
Neto area (ha)	6,21	5,5	0,35	0,28
ARKOD Plant of land	663470 (3,22 ha) 664809 (2,99 ha)	1373606 (3,77 ha) 3830918 (1,73 ha)	3761933	3830923
	2884209 (0,32 ha)			

Table 2. Part of the surface in realization:

ARKOD ID	Area (ha)	Utilization plan
3830926	0,37	Planned for a green classroom

3.1. Weather conditions in 2021

In recent years, we have witnessed the occurrence of more and more different weather extremes during the vegetation period of the plant. These extremes are most often related to extremely high or low temperatures, stormy winds at the time of intensive growth of saplings, hail and the like. Weather conditions in 2021 were characterized by several temperature extremes, the first in early April, and the second in the third decade of May. At the beginning of April, 8/9/ and 10/4/2021. spring frost and hurricane-force winds caused damage to the entire plantation. Temperatures dropped to -7 °C. The beginning of July was characterized by precipitation. June was drier, and July was rainier, as 20 mm of precipitation fell on two occasions. During August and September there were extremely dry periods. From figure 4 to figure 14, the cumulative amount of precipitation during a particular month is shown. According to the intensity of precipitation in 2020 and 2021, each month in the specified period was characterized.



Figures 4. Precipitation Zadar, May 2020.
Normal
(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani- days)

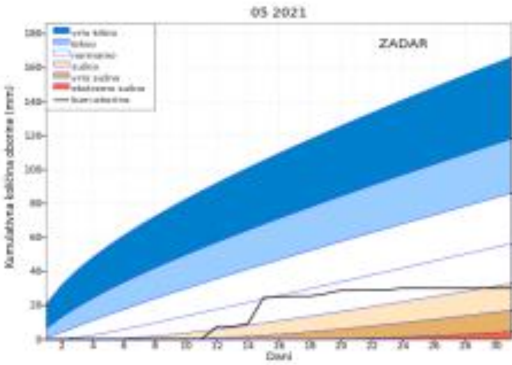


Figure 5.Precipitation Zadar , May 2021.
Dry

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

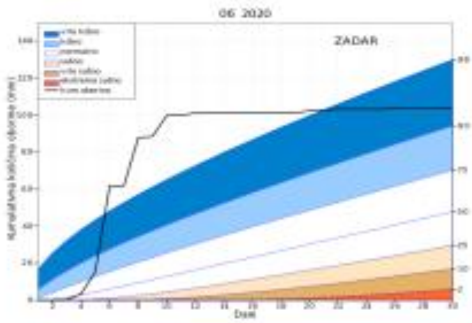


Figure 6.Precipitation Zadar , June 2020.
Very rainy

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

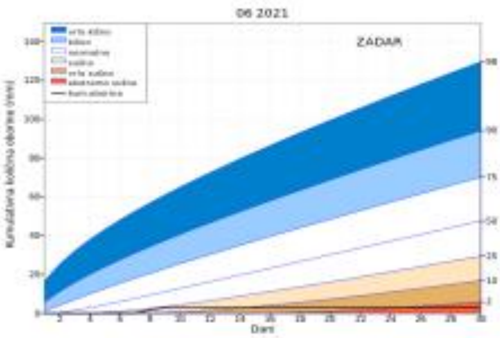


Figure 7. Precipitation Zadar , June 2021
Very dry

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

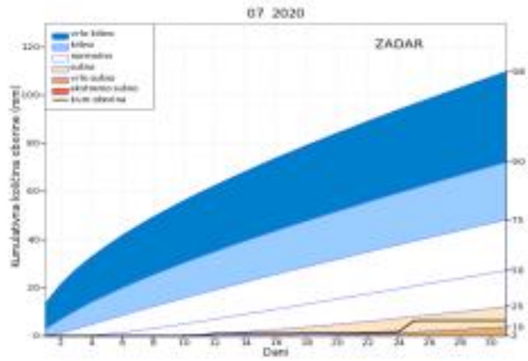


Figure 8. Precipitation Zadar , July 2020.
Very dry

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

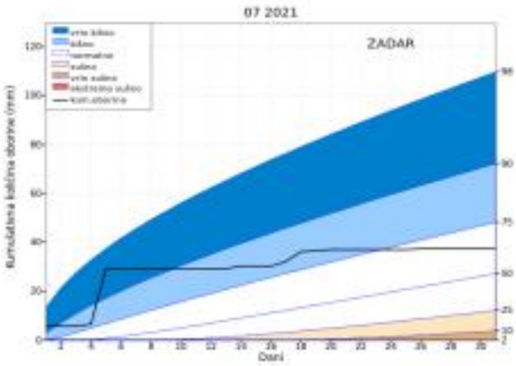


Figure 9. Precipitation Zadar , July 2021.Rainy

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

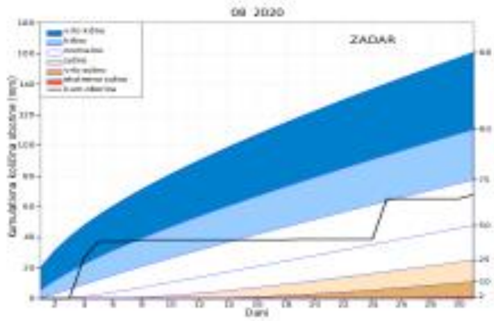


Figure 10. Precipitation Zadar, August 2020.
Rainy/ Normally

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

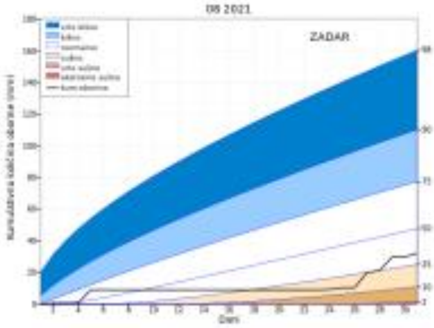


Figure 11. Precipitation Zadar, August 2021.

Dry/ Normally
(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

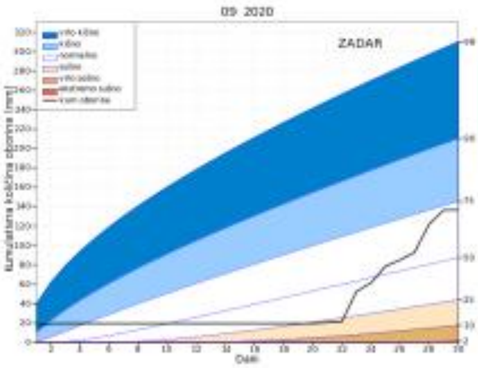


Figure 12. Precipitation Zadar, September 2020.

Normally
(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

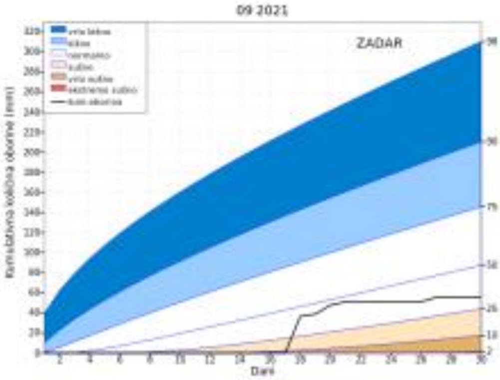


Figure 13. Precipitation Zadar, September 2021.

Dry/ Normally

(Legend: vrlo kišno-very rainy; kišno-rainy; normalno- normally; sušno- dry; vrlo sušno- very dry; ekstremno sušno- extremely dry; kum.oborine - cumulative percipitation; dani-days)

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Figure 14 shows deviations of mean daily temperatures from multi-year averages for the Zadar area.

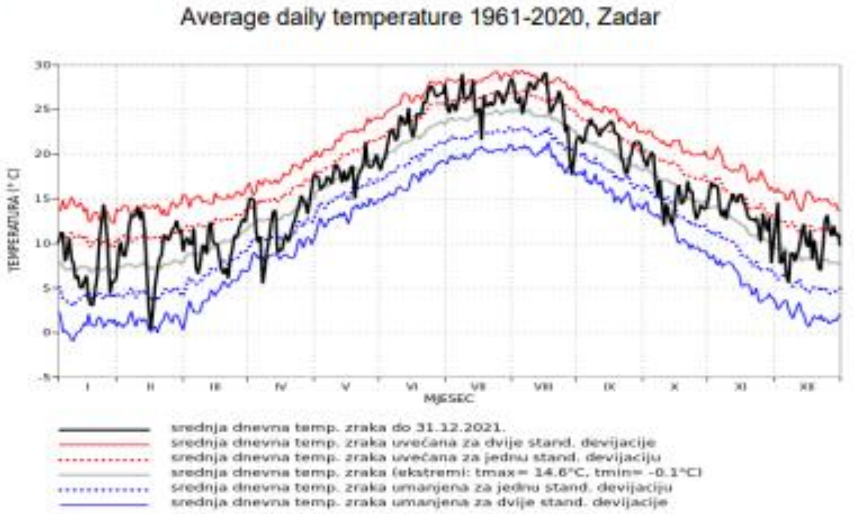

Figure 14. Multi-year deviations of the average daily temperature from the multi-year average for Zadar in 2021 (Source: DHMZ)

(Legend: srednja dnevna temperatura zraka- average daily air temp.; sr.dn.tem. zr. uvećana za dvije standardne devijacije- av.d.t. increased by two st.deviation; sr.dn.t.uvećana za jednu standardnu devijaciju- av.d.t. increased by one st. deviation; sr. dn.temp- av.d.t.; sr.dn.tem. zr. umanjena za dvije standardne devijacije- av.d.t. reduce by two st.deviation; sr.dn.t.uvećana za jednu standardnu devijaciju- av.d.t. reduced by one st. deviation)

From the attached precipitation intensity diagrams, it can be seen that the three most important months of intense vegetation, i.e. June, July and August, were respectively dry, July with precipitation on two occasions, with an average August that ended with a dry period without precipitation. During 2021, the drought had a negative impact on all agricultural crops in Baštica, both on perennial vineyards and orchards, as well as on the garden of medicinal herbs. The yield of all existing crops is reduced. The growth and development of medicinal plants was slow, there was not enough vegetative mass, the leaves were smaller,

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less developed. The pattern and amount of precipitation indicate a dry year with extremes in terms of abrupt normal/dry changes.

On the Baštica University campus, slightly heavier clay loamy soils predominate, so due to their heavier structure, they are more difficult to cultivate.
Table 3 shows the analytical parameters of the soil analysis on the University property.

Table 3. Chemical analysis of soil

Sample	Number of samples	pH - H_2O	pH -KCl	Total carbonates (% $CaCO_3$)	Activated lime (%CaO)	Humus %	P_2O_5 (mg/100g)	K_2O (mg/100g)	N Total %
HRAST	-	7,8	7,3	1	4	1,8	5	12,8	0,13
DO DNA	-	7,8	7,4	4	5	1,9	4	11,4	0,14

Table 4. Optimal values of the analyzed parameters

Parametar	Optimal parameters
pH (H_2O)	6,6 - 7,3
pH (KCl)	6,5 - 7,2
Total carbonates (% $CaCO_3$)	< 30 %
Activated lime (% CaO)	< 15 %
Humus (%)	3 – 5 %
P_2O_5 (mg/100g)	12-25 mg/100g soil

K_2O mg/100g tla	14-25 mg/100g soil
N total (%)	0,1 - 0,2 %

The results of the soil chemical analysis (Tables 3 and 4) show increased values of pH (H2O) and pH (KCl) compared to the optimal values. pH is a measure of the acidity (acidity) or alkalinity (alkalinity) of the soil suspension. Soil reaction is one of the key factors important for plant growth. For most plant species, weakly acidic to neutral soil is most suitable for cultivation. According to the obtained results, we see that the soil is alkaline. The total carbonates in the soil reduce the acidity of the soil and are a source of calcium and magnesium, they affect the structure of the soil, but also other physical and chemical characteristics of the soil. Physiological lime is an important factor in production, because the choice of substrate and selection of agrotechnical measure depends on it. In the analyzed soil, the amounts for both parameters are in optimal values, i.e. the soil is weakly carbonated, while the amount of physiologically active lime is moderate. The content of organic matter or humus in the analyzed soil is in deficit and the soil is classified as weak humus soil. The content of physiologically active, plant-accessible forms of phosphorus (expressed as P2O5) and potassium (K2O) are in deficit compared to optimal values. Plants produce phosphorus and potassium in large quantities, so fertilizing with phosphorus and potassium is a regular agrotechnical measure of agricultural production. The analyzed soil, considering the deficit of phosphorus and potassium, is classified as very weak or poorly supplied soil with the mentioned nutrients. The percentage of total nitrogen in the analyzed soil is optimal and the soil is well supplied with nitrogen. Based on the performed analysis, a fertilization recommendation is given in accordance with the rules of the profession.

4. Pilot project

As part of the Adria Clim project, with the aim of developing and improving the existing climate change monitoring systems, by encouraging the development of strategic documents and adaptation plans to current changes, an innovative solution for collecting water from moisture in the air - AquaWeb - was created at the Baštica University property Baštica.

The application of AquaWeb (Figure 15) will be monitored through a pilot project on newly planted flowerbeds with medicinal plants: *Sempervivum tectorum* L., *Rosmarinus officinalis* L., *Lavandula angustifolia* Mill., *Salvia officinalis* L., *Mentha x piperita* L., *Tanacetum cinerariifolium* (Trevir.) *Sch.Bip.*, *Helichrysum italicum* (Roth) G. Don, *Occimum basilicum* L.

Figure 15. Pilot project AquaWeb, on the agricultural University property Baštica (Source: A. Frankić)

The Biomimicry Pilot Project AquaWeb solution was installed at the Baštica University Agricultural Land. The pilot project was based on the patented design of AquaWeb, and the construction used plastic pipes, 3D hydrophobic material, i.e. patented geotextile made of recycled plastic, two smaller water storage tanks, digital hygrometer/thermometer (connected weather station), mobile pH meter for testing those medicinal plant seedlings. Examples of medicinal species of Mediterranean plants were used in the workshops so that the participants could observe and learn from nature - how nature adapts to different forms (hydrophobic and hydrophilic structures of natural materials) and to satisfy the function of absorbing water from the air now and then.

Since its first application in 2017, AquaWeb design has shown acceptable solutions for local irrigation in areas where climatic conditions had a sufficient presence of fog in the tested climates (e.g. Governor's Island and New York, an average of 1 liter of water was collected in 24 hours per one square meter of AquaWeb surface). In the area of the Baštica pilot project, the climatic conditions during the summer months of 2021 were extremely hot and dry, so the performance of AquaWeb has so far shown slightly weaker results compared to other international installations. Based on the AquaWeb pilot project, it was concluded that this design should be better adapted to individual micro-climatic conditions. The goal is to continue biomimicry research and improve this pilot project, in order to design and apply innovative materials (based on green chemistry), which will be adapted to local conditions, not only in the area of Baštica, but the entire Adriatic coast and islands.

Design and construction of AquaWeb is a key part of D.5.11.1 Zadar County Adaptation Plan. The business entity CROdelicious j.d.o.o., Gradusa Posavska 85, 44120 Sunja, Croatia, was selected to provide external professional services for the innovative water collection solution AQUAWEB.

Through workshops and lectures, the participants successfully acquired knowledge and practical skills in the field of biomimicry science, with a special emphasis on water, its unique properties, and how we can learn from nature and apply its solutions in collecting water from the air in situ. Inspired by the project, the young participants founded BiMiCro – Biomimicry Croatia, a non-governmental organization for the promotion of solutions from nature in Croatia.

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The prototype AquaWeb (Figure 16) design was developed by Team NexLoop, which received the world award for the best biomimicry design (Biomimicry Global Design Challenge) in 2017. The goal was to design a solution that would help urban and rural areas to self-sustainably collect water for local food production. How did nature conceive and design the self-sustaining connection between water, energy and food? We learn from many species, habitats and ecosystems. One species of spider, Uloborus spp., taught us how to collect mist from the air; plant species such as Mesembryanthemum crystallinum have adapted to dry periods by storing water in special so-called storage cells that are spread throughout the plant; we were particularly inspired by the mycorrhizae of fungi, which passively collect and share water with the surrounding plants, thereby contributing to communication between species, habitats and ecosystems. The shape of the hexagon is inspired by the golden ratio in nature (described by Leonardo Fibonacci), which is also used by honeybees in the construction of their honey stores (honeycombs), a solid form that can withstand the weight of honey, as well as water in AquaWeb. This design was patented in 2018.

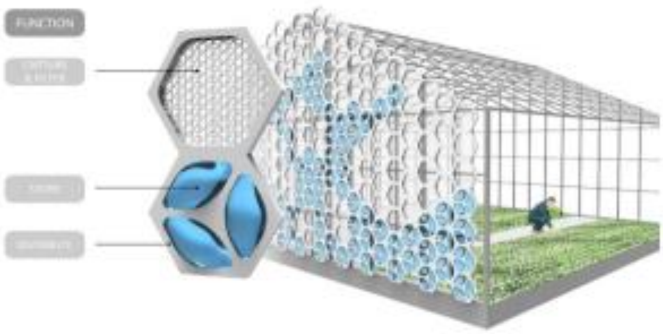

Figure 16. AquaWeb prototype design
(source: A. Frankić)

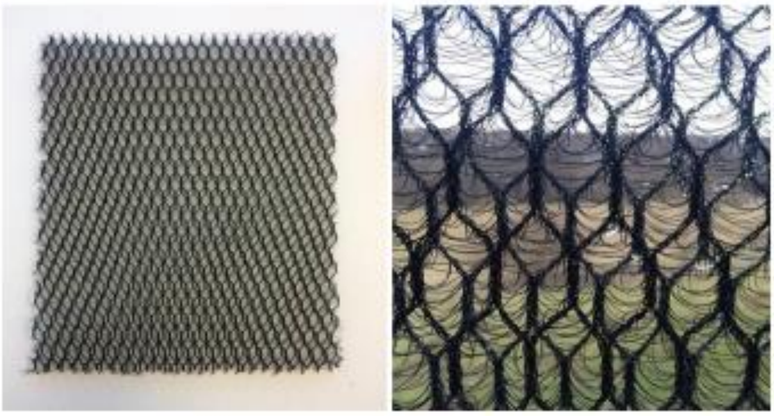

Figure 17. Detail of the AquaWeb prototype design, inspired by a spider's web
(source: A. Frankić)

As part of the Adria Clim project, according to Decree 5.11.2, in February 2022, a truck with a tank for drinking water was purchased for the area of Zadar County. The supplier of the drinking water tank truck is M.G.S. Grupa d.o.o., Žlibina 2, 51262 Kraljevica, Croatia. As part of its pilot activity, the Zadar County Development Agency ZADRA NOVA acquired a truck that will be used to supply rural areas of Zadar County with drinking water in the summer months. In most of the rural settlements of Zadar County, summer brings a lack of supply of drinking water to the inhabitants. The purchased truck will affect the satisfaction of human needs for drinking water and thus improve the quality of life in these areas. For the next 5 years, the truck will be owned by the Zadar County Development Agency, ZADRA NOVA, and given to the Zadar County Fire Brigade for use, as it belongs to its scope of work.

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Figure 18. Water tanker truck
(source: ZADRA NOVA)

5. Conclusion and monitoring

Water is an invaluable resource that we must preserve because our health and all life on Earth depend on it. The quality of water and its availability are reduced daily by climate change, various pollutions and excessive and irresponsible exploitation.

Agricultural production is related to sustainable water management, so it is impossible to imagine serious agricultural production without sufficient water.

The AquaWeb project represents an innovative solution in agricultural production, which could partially reduce the negative impact of climate change.

Many rural areas in the summer months do not have sufficient quantities of drinking water, which is necessary for our life and human health. The acquired tanker truck will facilitate the supply of drinking water to the residents of these areas.

Monitoring of the AquaWeb project will be carried out through students' final and graduate research papers. Measurements will be carried out on a weekly basis with simultaneous monitoring of weather conditions at the Baštica digital meteorological station. In doing so, analyzes and comparisons of the amount of water obtained per m^2 of AquaWeb will be carried out in relation to air humidity and rainfall in the same period.

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3. Conclusion

Handbook provides a comprehensive analysis of soil, hydrological cycle, climate change, irrigation, etc. Manual serves as a valuable reference for future efforts and informs decision-making processes to minimize the impacts of climate change. Challenges in agriculture through the coming climate changes are looking for sustainable solutions to provide food for future generations.