Col·legi
Mare de Déu del Carme
Pares Carmelites

Water scarcity

Anna Gras, Maialen Arques, Rubén Miño, Berta Palet, Martí Gómez
Col·legi Mare de Déu del Carme, Spain, smunozma@a.carmelitans.org

Abstract

In March we decided to start a project about water scarcity. We wanted to research the best way to end this problem all around the world so that everyone could be able to have quality water to drink, grow, and cover basic necessities.

During this project we have noticed that water scarcity has several origins. In fact, it has surprised us to see that some of the reasons for this problem with water aren't natural problems, though it has a major importance too.

Social issues also take part in increasing water scarcity. Furthermore, the main cause of water scarcity nowadays is climate change. This produces extreme meteorological phenomenons, reduces the availability of hydro resources, decreases the quality of water and puts in danger biodiversity.

So we believe that as a society we need to make a change and raise awareness about the water we waste everyday if we want to solve this problem.

We have learned a lot about the importance of water in multiple scenarios: industrial, biological, social, etc. and what would happen without it.

So we started thinking about solutions to end water scarcity.

Keywords

Water scarcity, solutions, climate change, plants, dew.

1. Introduction

Almost exactly one year ago, a controversy exploded between The UN and Elon Musk on Twitter. On the 30th of October, 2021 Dr. Eli David tweeted an incredible article previously published by CNN. The UN's director, David Basely affirmed that with just 2% of Elon Musk's fortune, (6 billion dollars) it would be possible to eradicate world hunger.

It is commonly known that Elon Musk is extremely active in this social network and usually instigates controversy amongst his followers. Then, of course, he was expected to answer. He was clear and concise; "If the WFP can describe on this Twitter thread exactly how $6B will solve world hunger, I will sell Tesla stock right now and do it" he further added: "But it must be open source accounting, so the public sees precisely how the money is spent".

The WFP never answered. However, we should mention, Elon Musk kept collaborating with organizations, helping and making donations.

That is how we came up with the idea of our project. We had a similar inquisitiveness, what we wanted to discover was how we could end world hunger. How would we make that happen and most important of all, is water essential to achieve our objective?

However, those were extremely broad questions. We could carry out thousands of projects. What we decided was to research the reasons for water's high importance, for all of humanity as well as for plants or animals. Moreover, we wanted to know in which countries or regions are the most affected by water scarcity and why. We were highly intrigued to think up a possible general solution and its cost. [1,2]

Figure 1: Dr Eli David. [1]

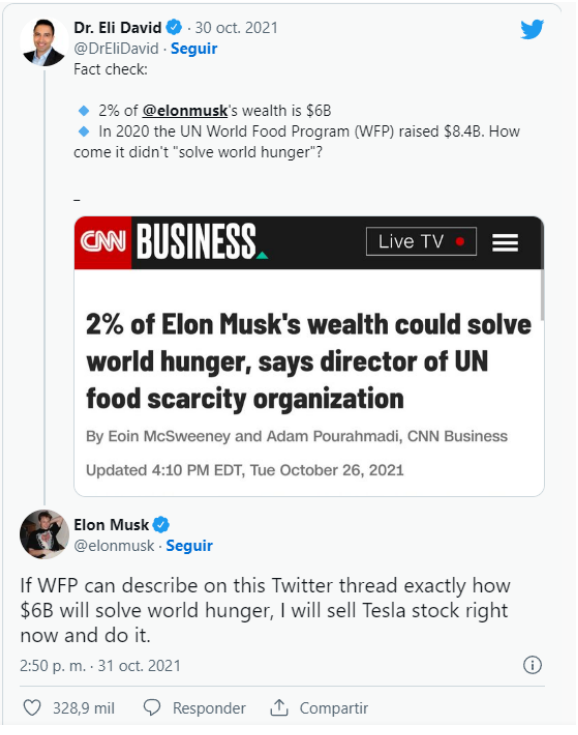


Figure 2: The answer of Elon Musk to Dr Eli David on Twitter. [2]

2. The importance of water in all areas

2.1. Importance of water for plants

Water is essential for the survival of plants and vegetables, as it is involved in numerous biochemical, metabolic and physiological processes. Therefore, we can say that biological activity is directly linked to the presence of water. The water contained in a plant is found in the cell cytoplasm, roots, vessels, etc. creating a continuous liquid phase. This extends to the soil via the roots and to the atmosphere via the leaves and through transpiration, creating the plant-atmosphere relationship. A decrease in the amount of water a plant receives can lead to growth arrest and various metabolic and structural disturbances. [3]

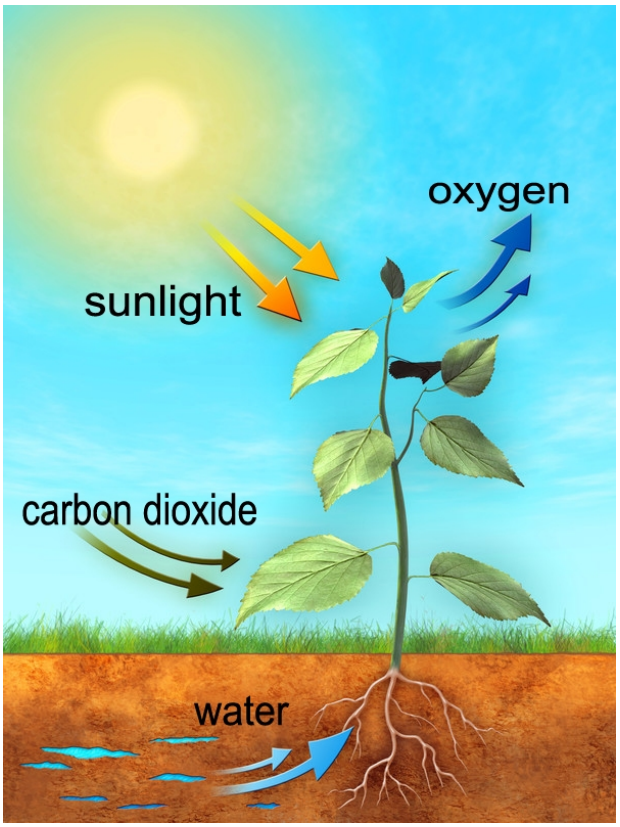


Figure 3: The photosynthesis process. [4]

Photosynthesis, transpiration and turgor are some examples of processes for those water is essential:

Photosynthesis is the process used by plants, algae and certain bacteria to turn sunlight, carbon dioxide (CO_2) and water into food (sugars) and oxygen. []

There are two different processes:

Oxygenic photosynthesis: in this process, the energy from the sun transfers electrons from H_2O, that had been absorbed by the roots of the plants, to CO_2 to produce carbohydrates.

During this process, the CO_2 "reduces" (gains electrons) and H_2O "oxides" (loses electrons). []

Anoxygenic photosynthesis: in this process electron donors that are not water and do not produce oxygen, are used. This typically happens in bacteria such as green sulfur bacteria and phototrophic purple bacteria. [3]

Plants absorb CO_2 from the environment air and release water and oxygen via microscopic pores on their leaves called stomata. Stomata are the guards of gas exchange between the inside of plants and the external environment.

When the stomata opens, CO_2 can go in, meanwhile, it remains open and it releases oxygen and lets water vapor escape. To reduce the amount of water lost, the stomata close, but that means the plant can't gain CO_2 for photosynthesis. [3]

Plants absorb the light energy needed from the sun by some special pigments. The primary pigment used for photosynthesis is chlorophyll and gives plants their green color. Chlorophyll absorbs red and blue light to use it in photosynthesis and reflects green light. [3]

Photosynthesis takes place in chloroplasts, a type of plastid that contains chlorophyll and it's found in plant leaves. Chloroplasts are similar to mitochondria, the energy centers of cells, in that they both have their own genome, or collection of genes. These genes encode proteins that are essential for photosynthesis. [3]

The pigments and proteins that convert light energy to chemical energy and begin the process of electron transfer are known as reaction centers. [3]

Photorespiration is a process based on when rubisco (a plant enzyme which catalyzes atmospheric carbon dioxide) fixes oxygen instead of CO_2, which wastes energy. Photorespiration is a big problem when plants have their stomata closed to conserve water and aren't taking in any more CO_2. Rubisco has no other choice but to fix oxygen instead, which lowers the photosynthetic efficiency of the plant. [3]

Transpiration is the process in which water is constantly evaporating from the surface of leaf cells exposed to air. This water is replaced by additional absorption of water from the soil. Liquid water extends through the plant from the soil water to the leaf surface where it is converted from a liquid into a gas through the process of evaporation. The cohesive properties of water (hydrogen bonding between adjacent water molecules) allow the column of water to be 'pulled' up through the plant as water molecules are evaporating at the surfaces of leaf cells. This process has been termed the Cohesion Theory of Sap Ascent in plants. [5]

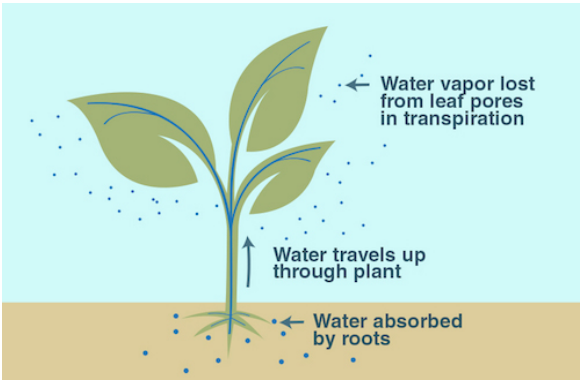


Figure 4: The process of transpiration. [6]

Why do plants transpire?

As water evaporates or converts from a liquid to a gas at the leaf cell and atmosphere interface, energy is released. This exothermic process uses energy to break the strong hydrogen bonds between liquid water molecules; the energy used to do so is taken from the leaf and given to the water molecules that have converted to highly energetic gas molecules. These gas molecules and their associated energy are released into the atmosphere, cooling the plant in which part of this water leaves through the microscopic pores in the leaves. The amount of water lost depends on the air temperature. When the air is more hot and dry, the plant loses more water, because it will evaporate more quickly as it leaves the plant, and this will cause more water to leave. At the same time as the water leaves the plant, CO_2 also enters, even though the amount of water that is expelled is greater than the amount of carbon dioxide that enters. Carbon dioxide is vital because photosynthesis can take place and this process controls the temperature of the plant. [7]

Turgor allows the plant to stand upright without a rigid structure, which is another process that requires water. The action of water is to swell the cells, increasing the volume, pushing the cell walls and keeping the plant rigid. [8]

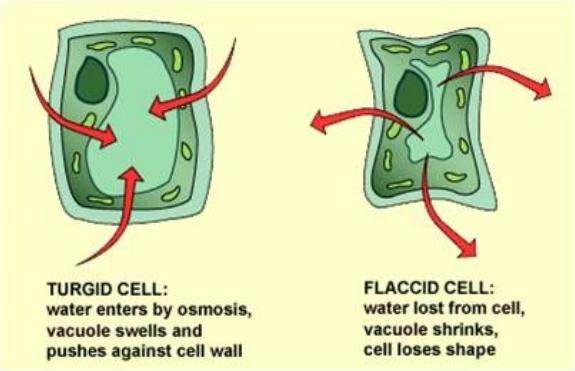


Figure 5: A turgid and a flaccid cell. [9]

It is also vital for the assimilation of nutrients in crops and is the most important of all the resources that plant species use to grow and develop. [8]

The first sign of lack of water that the plant will show can be detected with just looking at it, in the leaves or stems and trunk, among others. The leaves will start to wrinkle or even fall. On the other hand, we can also notice a change of color or dryness at the tips of the plants.

The lack of water causes the loss of turgor in the plants and those formed by stems will fall more easily than cacti or trunks. In the case of the former, they will consume the stored water and shrivel up. [8]

A decrease in production in fruit trees or plants producing vegetables will also decrease the overall yield during the growing season. It will also cause fewer buds to grow on flowering trees and shrubs, resulting in fewer flowers. Soil water deficit is the main factor that prevents crops from achieving their productivity potential, it alters many cellular processes involved in dry matter accumulation and, as a consequence, in crop productivity. [8]

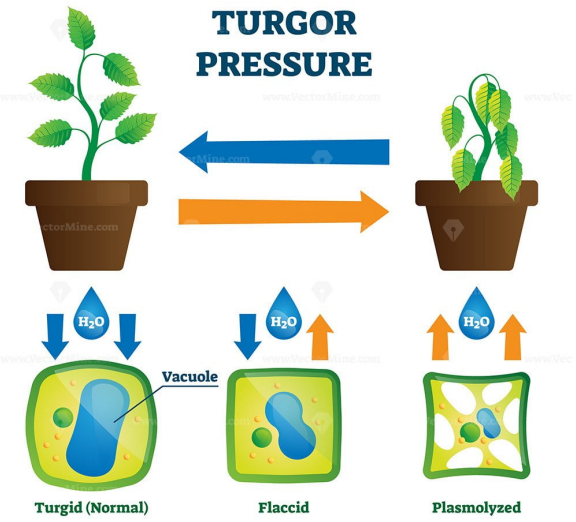


Figure 6: Turgor effects in plants. [10]

According to researcher Lucrecia Brutti, a technician at the Solo Research Institute, even though the nutrients necessary for a plant are in the soil where it is growing, if there is no water to dissolve them, the plants will not be able to absorb them or transport them to where they would be metabolised. This happens when the volume of water, from rainfall or irrigation, is less than the crop's requirement, or when there is little water available at times of peak demand, in combination with soils with low capacity to retain moisture in available form. Soil moisture deficit decreases the availability of nutrients, even though they are present in sufficient quantities, since plants require nutrients to be dissolved in the soil solution so that they can be absorbed. [8]

Therefore, if water and nutrients are limited during the growth process, the cell size will decrease. This will lead to less and smaller leaves, less fruit… [8]

The lack of water has important consequences for the survival and vitality of plants, causing, sooner or later, a decrease in water conductivity, as well as an increase in abscisic acid synthesis. This leads to a decrease in stomatal conductance and total leaf area, as well as to metabolic changes caused by a decrease in water concentration in the cells. In this context, the limitations of photosynthetic processes caused by water deficit are not only limitations to the diffusion of CO_2 into the stroma, but also to photochemical reactions, in the Calvin cycle and in the transport of assimilates (H_2O and CO_2 transformed into sugars thanks to solar energy). [8]

Water deficit causes a loss of cell turgor in the leaves which, together with the action of abscisic acid (ABA), with which synthesis in the roots increases in drought, is responsible for the closure of the stomata, which logically increases stomatal resistance to the diffusion of CO_2 into the stroma. Although it is widely accepted that stomatal closure occurs in response to

water deficit, there is currently no consensus on the relative importance of this fact, so that there is evidence both suggesting the presence of non-stomatal limitations of photosynthesis from the onset of water deficit, and others suggesting that stomatal limitations predominate at the beginning of the stress, and non-stomatal limitations predominate in the later stages of this stress. In any case, stomatal closure also results in reduced transpiration rate and thus increased water use efficiency. In Mediterranean sclerophyll species, this type of response is predominant in the early stages of water stress, during the beginning of the dry season. [8]

When this stomatal blockage appears, there is a decrease in CO2. Under these circumstances, an excessive accumulation of reducing power may happen. Reducing power is the capacity of certain biomolecules to act as electron donors or proton acceptors in metabolic reduction-oxidation reactions (NADPH). This can lead to an over-accumulation of intermediates in the electron transport chain, which can cause photo-inhibition and photo-oxidation. [8]

Other processes that may be affected are the phosphorylation or Calvin cycle, the accumulation of starch or the transport of assimilates to the roots, among others. However, the extent to which these processes are affected by a lack of water is not known, so neither are the mechanisms or adaptations of the plant related to these processes, nor their efficiency, known with certainty. [8]

In summary, water deficit, in addition to producing adjustments in growth and water relations, causes important modifications in the set of processes that lead to CO_2 assimilation. Together with the effects related to stomatal closure, non-stomatal limitations appear, affecting various photosynthetic processes. The consequences are, on one hand, a reduction in water expenditure and an increase in water use efficiency, and secondly, a reduction in CO_2 assimilation, and thus in growth and production. [8]

Long periods without irrigation: irremediable consequences.

Prolonged periods without sufficient water can cause more serious damage to plants. In other words, instead of simply wilting, the leaves eventually begin to die and fall off the plant. In addition, the cutting becomes more susceptible to insect and disease damage. [8]

Lack of irrigation can quickly turn plants into wilted and unhealthy vegetation. The severity of the damage depends on several factors, including the duration of the lack of irrigation, soil conditions and plant species. While a plant may recover from moisture loss in the short term, persistent lack of water often results in long-term damage, including stunting, weakness and dieback. [8]

Plants that do not receive enough water show a slowdown in growth, but when watering is resumed the plant is likely to resume growth as well. Long-term lack of watering can cause your plant to stop growing altogether or the leaves to grow smaller than usual. In trees and shrubs, some branches may die or fall off. [8]

Figure 7: A plant with not enough water. [11]

Lack of watering kills photosynthesi. On hot afternoons, plants may wilt temporarily but revive again during the cool of the evening. If, on the other hand, prolonged water deprivation continues, physiological changes occur in the plant, such as loss of water through transpiration. This also reduces the uptake of carbon dioxide and disturbs photosynthesis. As a result, the plant produces fewer carbohydrates, proteins and enzymes, which are necessary for plant growth and resistance to diseases and pests. [8]

Moreover, plants weakened by lack of water are more vulnerable to insects, bacteria and fungi. Pests, such as spider mites and beetles, are attracted to dry plants. This, coupled with the fact that weakened plants are less resistant to fungi and bacteria, which are often carried by insect pests, makes a lack of watering a determining factor for a plant. Absorb or be able to fight off nuisance pests. [8]

Despite being the main impediment to plant growth, lack of water is quite common in plant life. In climates where plants and plants do not always have sufficient water, they have developed adaptation mechanisms in response to this deficit in order to ensure the survival of the species. It is difficult to generalise the response of plants to water shortages, given that droughts are not always of the same duration or intensity and that there is a great variety and typology of plants. Even so, different models of behavior have been established according to the characteristics of these responses. There are three that are based on avoiding, tolerating or escaping the lack of water and fundamentally delaying or reducing the effects of the water deficit. [12]

The first consists of avoiding drought, the plants will carry out their biological life cycle in the months when there is more water available before the water shortage arrives. Among the plants that carry out this strategy, we must also include those that enter into a partial vegetative state that will bear the lack of water (*Cistus*, *Stipa*, *Lygeum*...) In the case of the second, the plant learns to tolerate desiccation, this consists in the fact that the plant carries out different physiological modifications that

allow it to withstand a greater degree of dehydration without this drastically affecting its vital activity. [12]

To avoid dehydration is the third strategy, in this case it increases the plant's ability to supply itself with water, increase the efficiency of water use and reduce water expenditure. Species following this strategy will either maximise water uptake or minimise water loss. This increases the plant's chances of survival during drought. [12]

In a situation of water scarcity, it is also important to limit the amount of light energy captured. To achieve this, one mechanism is to change the position of the plants.

The complete or partial loss of leaves during a dry period is considered an extreme mechanism to reduce energy harvesting. Others reduce energy uptake with reflective structures such as hairs, thorns or layers of wax. Species in arid or semi-arid climates follow this adaptation. [12]

Species of the Cactaceae family are the most clearly adapted. Most cactus species have lost their leaves and their photosynthetic organs are cylindrical or spherical stems with a low surface/volume ratio. [12]

Plants are covered by a thick cuticle of waxes and in some cases have hairs and other reflective structures. All the mechanisms described previously, in addition to reducing the amount of light intercepted, reduce the loss of water by the plant, constituting an adaptation to the lack of water and the consequent excess of light, which are closely linked, especially in Mediterranean ecosystems. [12]

Consequences of water excess

Figure 8: Consequences of water excess in plants. [13]

Since there is water scarcity, we don't usually talk about the effects of the excess of water. Are there any possible consequences if a plant receives too many nutrients from water? Curiously plants which are less watered than they should generally live longer than the ones overwatered. How is that possible? [14]

On the one hand, roots need to receive CO_2. When overwatering a plant, it can not correctly exchange gas as nitrogen or potassium. It also leads to the plant not being able to absorb nutrients. And that is called root asphyxia. [14]

On the other hand, as a consequence of water excess and lack of respiration, fungus can appear in the roots. It is extremely difficult to recuperate a plant once it has achieved these conditions. When those are detected it is usually too late. [14]

Possible symptoms when there is presence of fungus are:

Absence of growth on the plant, debilitation of the plant, leaves that hardly grow at all or that grow in brown tones, yellowing of lower leaves, falling of leaves and flowers, compacted or even greenish soil, narrowing of the stem base.

Curiously those symptoms can easily be confused with symptoms of water scarcity. To distinguish one from the other you have to watch the tierra humidity, you can touch it to feel it. [14]

2.2. Usage of water of the human body

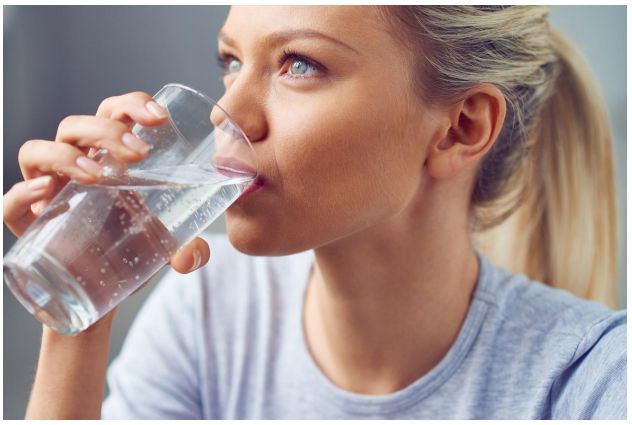


Figure 9: A woman drinking water. [15]

Keeping properly hydrated is essential for human's survival. We can survive without other nutrients for weeks or even months, but not without water. Water is mostly found in cells, with the exception of fat cells. It is also found in the brain as a lubricant, in the joints, in the intercellular space, in the blood plasma... Total body water is approximately 60-80%. 30-40% of which is usually intercellular fluid and 20-25% extracellular fluid. [16]

The balance between water loss and intake is controlled by mechanisms that control excretory pathways and stimulate consumption. When water deficiency occurs, sensors from the hypothalamus to the brain, where specialised cells called osmoreceptors are located, detect the decrease in water and initiate the process of water research and intake, thirst, and the release of the antidiuretic hormone (ADH). There are also factors such as sweating or breathing water-saturated air. [16]

When our body's H_2O levels are low, sensors from the hypothalamus in our brain order the release of an anti-diuretic hormone, which when it reaches the kidneys creates aquaporins, special channels that allow the blood to absorb and retain more water. High dehydration can have serious health consequences: it affects energy levels, mood, blood pressure and skin hydration. [16]

It also has negative effects on cognitive performance. A dehydrated brain has to work harder to achieve the same results as under normal circumstances, and may even be temporarily reduced. [16]

The human body has no provision for water storage and about two and a half litres of water are lost every day. Water loss takes place via 4 routes, via the kidneys, through excrement, sweat and respiration. Therefore, the amount of water that is eliminated every 24 hours has to be replenished to keep the body highly hydrated. [16]

Functions and benefits of water

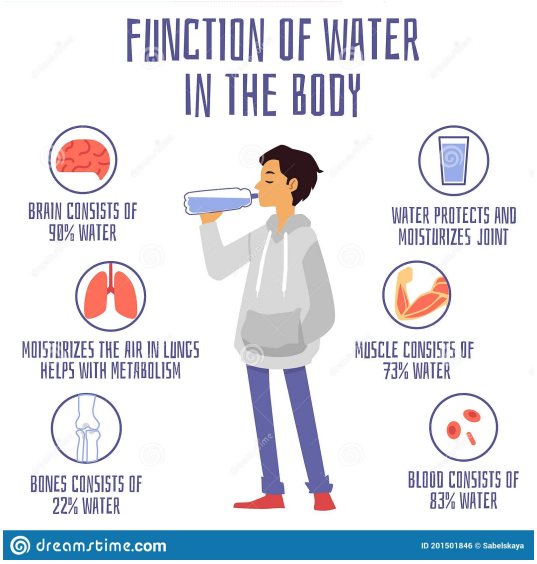


Figure 10: The functions of water in the body. [17]

Many of our body's functions are carried out specifically due to the presence of water. It transports nutrients to the body's cells and removes waste products from them. It also helps regulate temperature by redistributing heat from active tissues to the skin and by cooling the body from sweat. Another important function of good hydration may also be the correct functions of the brain. Brain cells receive oxygenated blood when we are properly hydrated, so the brain stays alert, and we also find benefits in the digestion of food, in the dissolution of nutrients, so that they can be absorbed and transported by blood. In the case of the chorus, for example, fluids are also essential to keep blood pressure within healthy limits. The kidneys of a well-hydrated person filter approximately 180 litres of fluid in a day. Some of this is reabsorbed to prevent the body from losing large amounts of fluid. Water plays an essential role in enabling the kidneys to carry out their function properly and, by filtering these fluids, to eliminate waste and unnecessary nutrients through urine. Water also acts as a lubricant in the joints and muscles and is essential for the proper functioning of these. Among many other examples. [16]

Consequences of lack of water in the human body

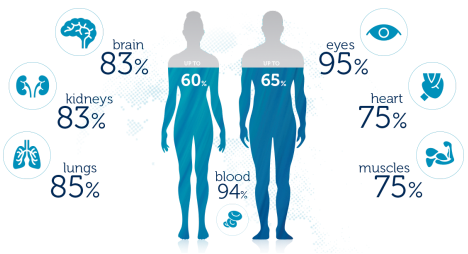


Figure 11: Water level in the body. [18]

Not hydrating our body enough will cause our body to be unable to carry out certain processes and, therefore, various consequences appear. Although it is an approximation, a human being can survive between three and five days without water, depending on the conditions. Mild, moderate and mild dehydration are classified according to the amount of weight lost. Mild dehydration means the loss of about 1-5% (approx.) of body weight and does not cause severe symptoms, only thirst. Moderate dehydration is 5-10/30% (approx.), in this case other symptoms such as dry skin, nausea or vomiting may appear. And if it is higher than 10/30% (approx.), severe, this leads to an intensification of the previously mentioned symptoms. It can also be classified according to the balance between water and solutes, hypertonic, hypotonic or isotonic dehydration. Hypertonic dehydration, common in people suffering from diabetes and children, is characterised by a greater loss of water than sodium due to lack of water intake or osmotic diuresis, among others. Hypotonic or extracellular dehydration is the opposite, there is a greater loss of salts than water. It is characterised by an osmotic exchange of fluid from the extracellular to the intracellular region. It is usually caused by excessive sweating or by drinking beverages with a high water content and low salt content. And finally, isotonic is the most common in young children, usually caused by vomiting, diarrhoea or not drinking enough water. It is characterised by the fact that there is the same lack of solutes as there is of water, i.e. proportionally identical quantities of water and solutes are lost. There is no osmotic exchange of water between the intracellular and extracellular space. [16]

Functions of water in the body

Water lubricates our joints, regulates temperature and it provides nourishment to our brain and spinal cord.

It is part of our blood, our organs (lungs are 83% water and brain and chorus are nearly 75% water), and our bones (which are 31% water).

Even though we are essentially water, our body loses fluid in various ways. Every day we can lose between two and three litres through sweat, urine, bowel movements and even breathing, so we need to replenish it if we don't want to become dehydrated. [19]

Insufficient hydration will slow down the digestive process and chronic poor hydration can lead to constipation, as it slows down the rate of passage of faeces through the intestinal tract.

However, overhydration is not good either. When our body has too much water, the release of the antidiuretic hormone in the blood slows down or stops, sodium electrolytes are diluted and cells swell, causing headaches, vomiting and, in rare cases, convulsions or even death. The amount of water we should drink per day depends on our weight and environment. The recommended daily intake varies between 2.5 and 3.7 litres for men, and between 2 and 2.7 litres for women, depending on health status, activity, age or the heat of the environment. [20]

2.3. Social importance of water

Apart from being related to an economic issue, water has a great importance in societies and people. Water has always played a big role in the creation and prosperity of civilisations. Since prehistoric times, humans have organised themselves in the way to have a constant supply of water, locating themselves near rivers or lakes in order to survive. Later, in, for example, Roman society, the construction of aqueducts and water distribution networks allowed the Romans to advance their technology and learn new construction techniques that allowed the civilisation to prosper. This demonstrates the great importance that water has had socially throughout history and evidently continues to have. [21]

Figure 12: An aqueduct in Rome, Italy. [22]

In modern societies, water is only seen as a hydraulic resource, separating it from its territorial context and removing its relationship with ecosystems and the hydrological cycle, as well as its interconnections with people who live and depend on ecosystems. This vision of water as an appropriated resource creates a relationship of human domination over nature and over others, facilitated by technological progress and the commercialisation of water to serve the interests of groups that hold economic and political power and that define the objectives of society in order to maintain power relations. [21]

Figure 13: An aquatic ecosystem. [23]

Although water currently provides us with life, it creates social conflicts such as the way in which it is distributed, giving rise to the debate of whether or not it is fair how it is distributed and whether or not it would really be easy to put an end to the lack of water in certain places of the planet. It also creates thousands of demonstrations and social movements demanding clean and quality water for everyone everywhere in the world. [21]

In the 18th century, Adam Smith posed a paradox comparing diamonds to water, asking and reflecting on the value we place on both. Diamonds, on one side, have a lot of economic value even though they have no real use beyond shining on pendants and rings, but they do not give us anything without we cannot live with. On the other side, water, although it is fundamental for our survival and is found in many parts of our daily routine (showering, washing our hands, brushing our teeth, etc.), has much less economic value than diamonds, for example. Moreover, socially we waste a lot of water, such as when we brush our teeth and leave the tap running, or when we turn on the water 5 minutes before we have to use it before getting into the shower. And we do all this despite the fact that we know that in some parts of the world the lack of water is a real problem and that water in these places has taken on the status of divinity. This shows us that the social price of water will always be linked to whether there is an abundance or lack of it. [24]

We need to change our mentalities in terms of how we see water, this is clear, and as such we should try to see the world in a more objective and general way. Because although in certain countries like ours it is not difficult for us to waste water, since we have it at our disposal whenever we want, but we have to think that, although the earth is made up of ¾ of water, most of it is salty, only 3% is fresh water, much of it is found at the poles in the form of glaciers, or in aquifers, rivers and lakes. But, at the very least, only 0.014% of fresh water is accessible to humans, from which we can see that it is up to us to change our social mentality if we want to have a better future, and to rescue Adam Smith's paradox, it is a matter of "renewing the value of our water and estimating it as if every drop was a diamond". [24]

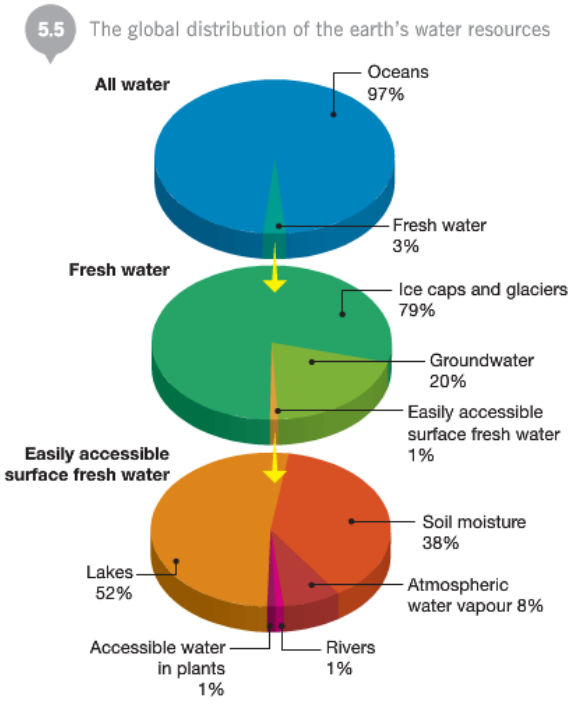


Figure 14: The distribution of water. [25]

Many experts and water distribution associations highlight the great importance and social value of water in the present and in the future, and for this reason it is increasingly necessary to make a good distribution that, apart from guaranteeing quality water, does it in a fair and equitable way. [26]

It is also necessary to have a real commitment and social awareness of responsible water consumption. They also point out the key factors for the sustainability of this vital resource, as well as the management of climate change, which plays a very important role in the lack of water, the management of infrastructures for the good distribution of water and the financial sustainability of this project (a good recovery of investments). [26]

2.4. Importance of water on an industrial level

Figure 15: The importance of water in industry. [27]

Water is a fundamental factor in most industrial processes and in the maintenance of machines used in companies and in the production of all kinds of materials, objects or products. All industrial sectors use water for industrial processes, from those that manufacture food products to those that manufacture electronic devices. [28]

Water for industry, in general, as with humans, usually needs and consumes most of the drinking water intended for humans. [28]

The proportions in which water is used vary from country to country, but we can find a similarity between countries with similar monetary incomes: In a high-income country we can observe that 59% of water is used for industrial products, 30% for agricultural cultivation and the remaining 11% is used for domestic use (heating, washing machines, personal and household hygiene, etc.). [28]

Industry is the biggest polluter, as it needs water to dilute all the pollutants that have been generated during the process and then expel them into the sea. The food industry is the biggest contributor to the load of organic pollutants, as it is the biggest polluter. [28]

Water in the food industry

Figure 16: Water in the food industry. [29]

In food and drinks processing, the purity of water will influence the quality of those. It is often used for dilution, preparation, serving, etc. For this reason, the most common type of water used in this sector is drinking water, and to consider water potable for humans it has to meet certain established parameters to be considered good for consumption. [28]

There are several methods for water purification, such as: disinfection (application of a chemical agent, usually chlorine, for the reduction or elimination of microorganisms), filtration with granular media, softening (use of ion exchange resins, which serve for the removal of salts that make water hard), reverse osmosis, ozone and sterilisation with ultraviolet light. [28]

Water in the pharmaceutical industry

In the pharmaceutical industry, high quality water is required for the production of medicines, as well as for the maintenance and cleaning of the equipment used. Catagolised water for pharmaceutical use is obtained from drinking water. The production process is similar to the one used for drinking water, but the reverse osmosis step is essential. There are three general types of water for pharmaceutical use, each for different processes:

1. Purified water

Purified water is normally used in non-sterile processes, as well as for the cleaning of used equipment and laboratory equipment.

2. Highly purified water

Highly purified water is obtained by methods such as reverse osmosis, ionisation (use of ion exchange resins) or ultrafiltration (use of membranes with high capacity to retain suspended solids and micro-organisms measuring 0.001 to 0.1 µm).

3. Injection water

Water for injection is obtained by distillation as the last stage. The difference between highly purified water and water for injection is the final stage (distillation) to obtain water for injection. [28]

Water in the mining industry

Figure 17: Water in the mining industry. [30]

In the mining industry, water is also of great importance, mainly used for the cleaning of minerals, as well as for operations carried out by some of the equipment (ground, transport of material, drying), and the cleaning of these. [28]

Water used in this industry does not need to be of high purity as in the pharmaceutical or food industry, which is of vital importance. In fact, the water that has been used in these sectors is then used by the mines. [28]

However, the big challenge in the mining industry is, without doubt, the treatment that has to be carried out on the water after it has been used. This is due to the fact that products obtained in the mining industry usually need to be washed with water and chemicals to perform certain physical separations, where the desired product is obtained from the ore, separated from the many other compounds it contains. [28]

Other industries use water for transport, as it is cheaper to travel by boat than by plane, but this creates a problem, boats pollute the seas with petroil and other substances. [28]

Other industries produce electricity from water, this is a clean form of electricity, since we get it from the seas, rivers and lakes, from their movements and tides, it is not a polluting source. [31]

At the other extreme we have the nuclear electricity industry, which uses large water reservoirs to store radioactive waste. The paper industry also pollutes large quantities of river water, and the petroil industry pollutes indirectly through the manufacture of plastics that always end up in the sea. [31]

About the use of water for industry, we have to be aware and make a more moderate use, since the levels of water pollution are very high and we can have periods of drought in which the need for water increases. But it should be noted that in the last five years we have become more aware and have reduced the use of water to make a smaller and more adequate consumption. [31]

As we see, the importance of water for industry is extremely important, since without it we won't be able to produce or provide the number of necessary and important products that we have until now. [31]

In conclusion, as water is a resource that works for all types of treatments and processes, as well as for the cleaning of equipment, materials or objects, it is considered vital for all industries and is another clear example of the importance of water in our lives and what we would do if it were not there. [31]

2.5. The importance of water during humanitarian crisis

Figure 18: Water during a humanitarian crisis. [32]

Water is not only important in our daily lives, but in the event of a humanitarian crisis it becomes essential. A humanitarian crisis resulting from a natural disaster (earthquake, flood, typhoon...) or a war, among other causes, can be aggravated when a water scarcity problem is added. In such situations, access to safe water, sanitation and hygiene are essential to avoid aggravating the crisis with disease. [32]

3. Causes of water scarcity

The Earth is 70% water, but only 3,5% is fresh and 0,025% drinkable. Approximately 2.200 million people in the world do not have access to safe drinking water service; 4.200 million do not have safe sanitation service, and 3.000 million do not have access to wash their hands. [33]

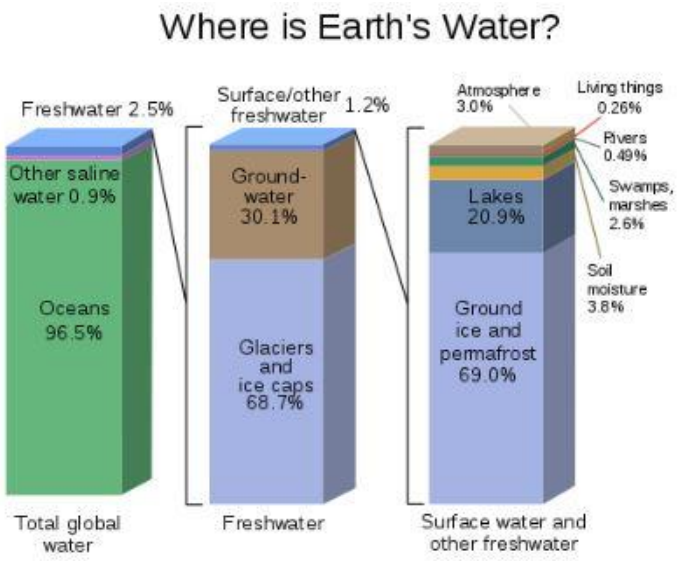


Figure 19: Distribution of water on earth. [34]

The most affected countries by water scarcity are in The Middle East and in North Africa, and they are: Kuwait, Bahrain, United Arab Emirates, Egypt and Qatar, based on information from World Resources Institute. [33]

The main causes of water scarcity are the following:

Climate change causes big weather phenomena such as hurricanes, heat waves and especially major droughts that cause water shortages, not only for human consumption, but also for crops and industry. [33]

Do you know how much water is needed to produce a kilogram of rice? Nothing less than 5000 liters. The UN says that the water footprint of world production is related to food production and agriculture by 70%. [33]

We refer to both freshwater and land or air pollution, since pollution can filter into the water and can also affect the air. Moreover, all the waste of mining operations, oil leaks, chemicals, fecal material and plastics go directly to the planet's water reserves. [33]

An increased population causes a greater demand in the first world, and a high waste of water aggravates the problem. In Spain, for example, each citizen consumes 136 liters of water per day, while in the United States the consumption of one person per day is 570 liters. [33]

The uncontrolled use of water, both on a large scale, in factories, and on a small scale, in our own homes, makes it a scarce resource. [33]

The image below (Figure 20) shows us where the world's total water comes from, the fresh water, the amount of water there is and its renovation rate.

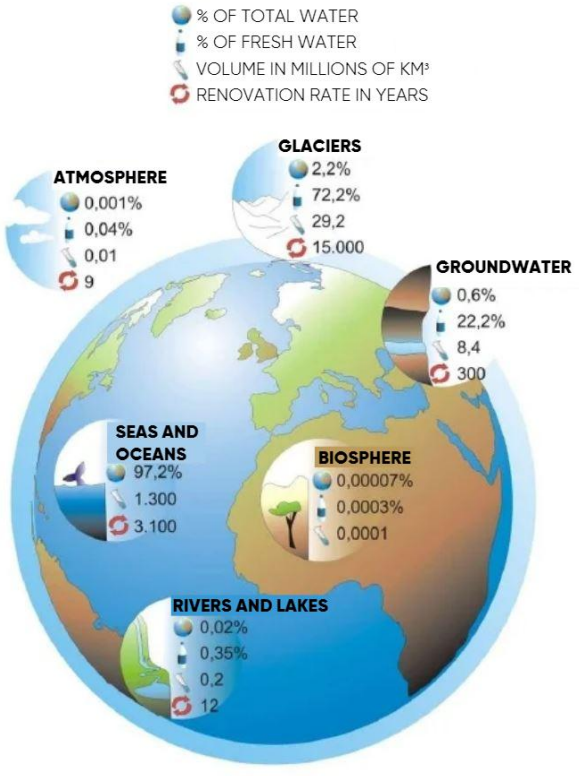


Figure 20: Where water comes from. [35]

3.1. Why is there water scarcity in Africa

Water scarcity is both a natural and a human-made phenomenon, so it is essential to divide it into two general types: economic scarcity and physical scarcity. Economic scarcity refers to the fact that finding a source of drinking water is time-consuming and expensive. However, physical scarcity is when there is not enough water in a particular region. [36]

In the category of physical scarcity we find the issue of climatology:

Africa has nine deserts, including some of the largest in the world: the Sahara and the Kalahari Desert. Besides, the progressive desertification of areas that used to be productive and good for agriculture, especially in the countries close to Lake Chad, which has been drastically reduced over the years, is another cause of poverty in Africa. Climate change and global warming are causing long and continuous episodes of drought, leaving thousands of cultivable hectares of land unusable. As a result, hunger and dehydration are perpetuated. In addition, climate change is also contributing to the evaporation of huge amounts of water in Africa's rivers and lakes (as well as contributing to forest fires). [37]

If we talk about economic scarcity, we find the following issues:

Africa is currently the scene of 25 active wars and conflicts that we hardly hear about. The damage caused by war is compounded by an added problem: the long duration of these conflicts that never end or reappear after a short period of calm. In this situation, the country's resources are depleted, millions of people have to flee to other countries and the prices of scarce goods multiply and are beyond the purchasing power of a population that has lost everything. Armed conflicts are a very important cause for understanding population movements and the existence of refugees, not only because these are people who have to flee because they fear for their lives, but also because constant wars perpetuate poorness in Africa. These are the perfect conditions for poverty, drought and hunger in Africa. [37]

Historically, Africa has been a territory colonized by different nations from other parts of the world. In the 17th century, the main European countries divided up almost all the countries of Africa. As a consequence, non-native languages, mainly French and English, are spoken nowadays in many African countries. In addition, the map of Africa is particularly impressive because of the straight-line divisions of many of its borders, which were drawn geometrically by the colonizers to facilitate their division, without keeping in mind the different cultures and tribes of the continent. [37]

The disadvantaged situation due to the lack of infrastructure in these regions and the fact that the existing water sources are highly polluted, makes the consequences of droughts especially severe on the African continent. [37]

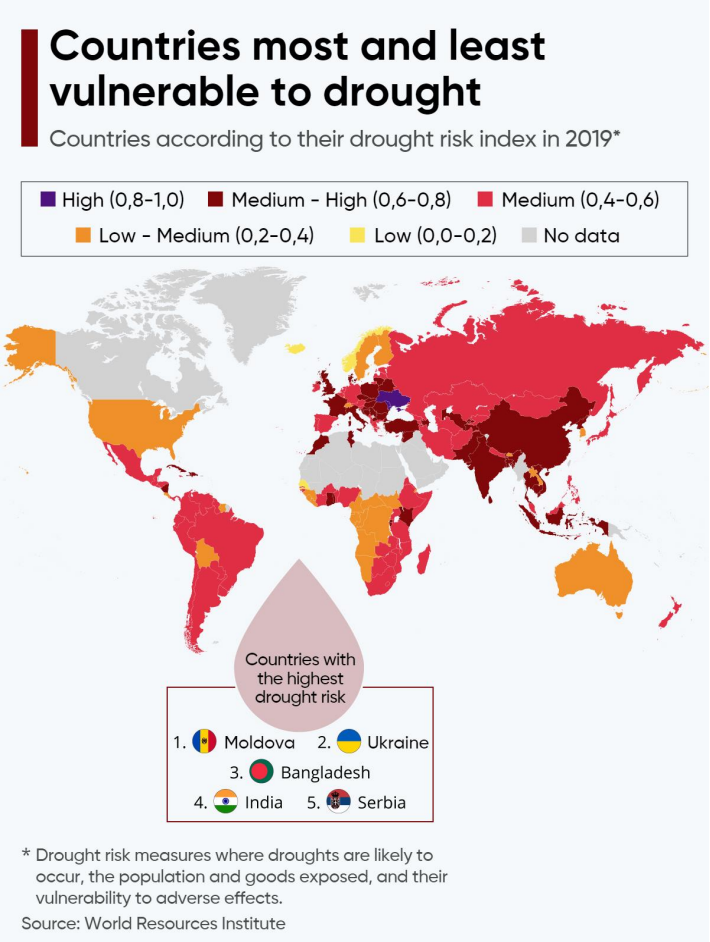


Figure 21: The most and least countries vulnerables to drought. [38]

If we look at the following table of river water distribution, we can see how North Africa has the lowest percentage of all continents. [34]

Table 1: River water distribution. [34]

Continent or region	River runoff (km³/year)	Percent of world total
Asia (excluding Middle East)	13,300	30.6
South America	12,000	27.6
North America	7,800	17.9
Oceania	6,500	14.9
Sub-Saharan Africa	4,000	9.2
Europe	2,900	6.7
Australia	440	1.0
Middle East and North Africa	140	0.3

3.2. Groundwater

Groundwater is a fundamental element of the hydrological cycle, supplying the humidity that allows plants to grow and making it possible for rivers to continue flowing when it is not raining. Groundwater can be found almost anywhere: under hills, mountains, plains and even in deserts. [39]

Some of the largest groundwater reserves, or aquifers, are the result of very different past climatic conditions, with rainfalls being the most important. Even under "normal" weather conditions, about 90 percent of precipitation is released into the atmosphere and does not flow into groundwater or rivers. For example, in North Africa, where today there is little rainfall and high evaporation, the groundwater reserves are estimated to be enormous. [39]

Overexploitation of an aquifer occurs when water is extracted from the subsoil at a rate higher than that of infiltration or natural recharge. This situation involves the progressive consumption of water that was stored in the ground, and has many negative consequences, such as: a gradual increase in the cost of production, problems in watercourses or between users, and often a degradation of water quality. If the situation of overexploitation continues, it is possible that the aquifers may even end up being depleted. [40]

The following image shows the water extracted and the recharge capacity of the aquifers in Spain. The southeast of the country is in a worrying situation, as more water is extracted than the aquifer can recharge. [40]

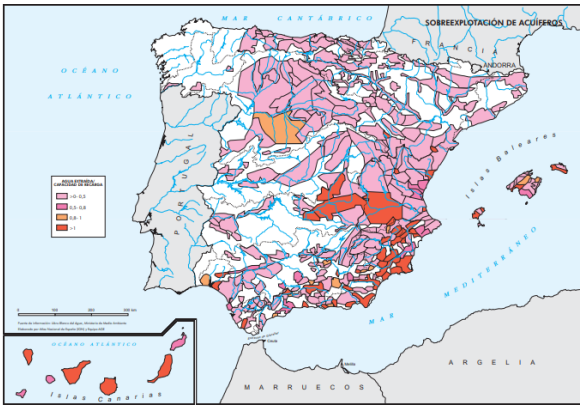


Figure 22: The aquifers in Spain. [40]

4. Consequences of water scarcity

4.1. Global conflicts

Wherever there is lack of something necessary, either food or water, there are always conflicts. Depending on the conflict causes, its impact will be higher or. Therefore, because of the worldwide importance of water, there are even global conflicts. [41]

Figure 23: Social conflict for water in Peru. [42]

To get to know more about it, we have read about Charles Iceland, director of some global and national initiatives related

to water of the World Resources Institute (WRI), who has talked about the conflicts this resource has created and how to avoid those. Getting information about him and his ideas has helped us to understand and answer some questions. [41]

Figure 24: Charles Iceland. [43]

Figure 25: World resources institute logo. [44]

What is a water conflict and how does it appear?

Water conflicts appear, evidently, from a hydric stress in a specific zone. When we think about the word “conflict”, we always think about violence, but it is not always like that. Sometimes, like in Australia or California, people use the legal system. In any case, in other sites the conflict is more serious and the resolution capacity is not well developed, so then, it is when violent ways appear. [41]

Figure 26: Illustration of a bad distribution of water. [45]

In which countries is there more inclination for these conflicts?

In Sub-Saharan Africa, for example, the population is growing very fast. Since 1960, it has quadrupled. The quantity of resources available for them, however, is the same or less than before. This leads to many violent conflicts between farmers and shepherds, who fight to survive with nothing. During those last few years, we have seen similar situations. [41]

Figure 27: An African child drinking water. [46]

In the Middle East, like Iraq, people have been protesting and they have gotten the first minister to designate. Some of the complaints about the minister's job were due to the public water scarcity. However, international conflicts for water exist but just a few of them end up involving violence. India and Pakistan fight for the Indian river water, Iraq and Turkey for the Tigris River and Euphrates water. And Egypt and Ethiopia for the hydric resource of the blue Nile's mouth. [41]

Is there any conflict at interstate level?

International conflicts over water exist but a few times they involve violence. For example, India and Pakistan fight for the water of the indian river, Iraq and Turkey for the rivers Tigris and Euphrates water, Egypt and Ethiopia for the hydrological resource of the “conca” of blue nil. [41]

Figure 28: Warriors trying to drink water. [47]

Will there be wars for water in the future?

We also should take into account what will be the future of wars because of water scarcity. Wars never start only for water, countries do not fight only for one thing. Water scarcity is just one more problem that increases threats and dangers. It is more about funds. If there already exist problems between regions, the water fight will be another thing at the big bowl. [41]

What is "Water, Peace and security?

The WPS (Water, Peace and Security) nine organizations are distributed between E.E.U.U. and Europe and have an objective, to identify the most critical sites which suffer water scarcity. The goal is to help as many people as possible inside and outside the involved communities. And in order to achieve their objectives they have developed a tool which pretends to predict where there could be a water conflict in the next 12 months. [41]

Water, Peace and Security

Figure 29: Water, peace and security logo. [48]

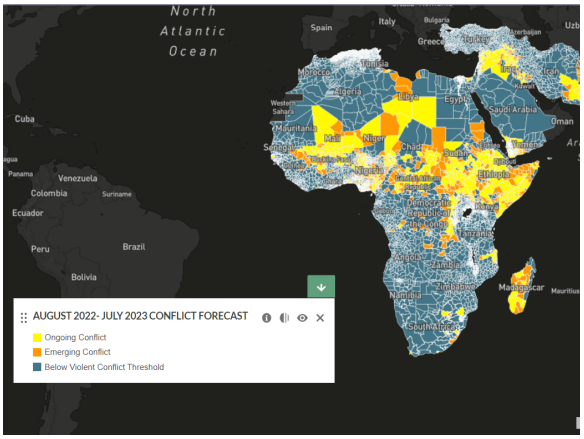


Figure 30: Map of water conflicts around Africa. [49]

How could a water conflict be solved?

Many times, whenever there is an International or subinternational conflict, mediatos appear. Those are meant to join both representative sides in the conflict. An example could be the India and Pakistan treatise (1960), for the Indian river distribution, which lately has been under pressure yet it has avoided many confrontations. [41]

Figure 31: Representative photo of mediation. [50]

Straightaway we have 5 more examples, out of many more, of actual water conflicts. [51]

Israel & Palestine

Some time ago, Palestine had the control of Jordas river water and all the aquifers of the localities Gaza and Cisjordania. Nevertheless, Israel wanted to control that service source, because it was a fundamental geostrategic matter. [51]

Figure 32: Jordan river. [52]

In 1967, after the total occupation of Cidjordania and Franja de Gaza, Israel declared of its property all the hydric resources. Since then, Palestinian people, need a licence from the Israelite army before doing anything related with water. [51]

Figure 33: Israel growth. [53]

Palestinians that are in Israeli territory, are forced to face a terrible crisis, due to the Israeli government. They block provision of water services and use that as a method of subjecting them to additional hardships. [51]

From the Nigerian perspective, half of the population don't have access to potable water and their residents have to walk countless hours to get it. [51]

Figure 34: Israel and Palestina fighting for the water. [54]

The mouth of Zimbabwe river

Countries around this hydrological source are Zambia, the Congo, Angola, Namibia and Zimbabwe. This conca in the south of Africa is one of the more overused hydrological systems of the earth. The nations negotiated, and more countries are in a conflict, almost starting a war. [51]

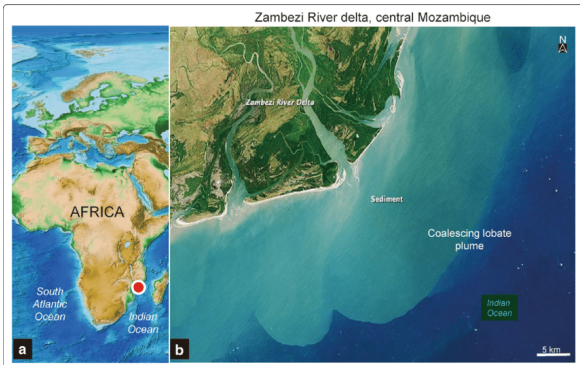


Figure 35: End of Zambezi river. [55]

Occidental Africa

In this zone of the planet, many of the rivers are losing their flow and the countries around are near to suffer a crisis. The Akosombo dam of the Volta river has created the biggest artificial lake in the world. [51]

Figure 36: Akosombo prey.[56]

Water scarcity has developed wars between people from the same ethnic group in Mali. The fight for water is added to the delicate political situation. The population's alimentation depends on the Niger river as well as their transport, but it is at the edge of a ambiental catastrophe. [51]

Figure 37: Niger river and its near countries. [57]

China

The three rivers in south china are highly contaminated and therefore cause frequent health problems to the people who consume their water. It also limits the irrigation of crops. Northern China, for example, is home to two thirds of the country's cultivation, yet only one fifth of hydraulic resources.

Between 1991 and 1996 the volume of water in the subterranean water reserves in Northern China reduced by 1,5 m/year. [51]

Figure 38: China rivers. [58]

India

Some conflicts around the Indian rivers, like the Kaveri river, are of a religious and spiritual nature. They are considered sacred rivers. [51]

Figure 39: Kaveri river. [59]

4.2. Water stress

Nowadays, water stress is a popular and well-known topic. It comes about when the water demand is higher than the amount of available water during a specific period of time. Sometimes, water usage can also be restricted by its quality. [60]

Water stress consequences

There has been a gradual growing trend of water stress across the world throughout these last twenty years, according to the FAO. Who state that the situation is progressively worsening due to the impact of climate change and it can not be balanced out by other zones in the world where water stress is not such an issue. [60]

It is predicted that by 2025, 1.9 billion people will be living in countries or regions which will be tackling an absolute scarcity of water. And two thirds of the global population could be suffering from water shortages. [60]

Overexploited aquifers, dry rivers, contaminated organic matter and many more are also consequences, consequences related to nature, of water shortage. [60]

Also, one of the features the ground gains when suffering water scarcity is the inability of absorbing water. This can lead to the roots not receiving enough water, moreover it can cause water accumulation and on a broad scale, floods or inundations. [60]

Water stress in spain

In Spain, for example, taking into account that water demand has increased between 50 and 70% over these last 40 years. There is a high possibility that the quality of the water will decrease. It is believed that in 2023, 65% of the population will suffer the consequences of the lack of water. [61]

Our society is not aware of the huge amount of problems water scarcity could imply, and its disproportionate use in the domestic area won't help when trying to avoid those. Spain is the European country with the highest amount of water used for domestic chores. Its average is approximately 250L per person a day. A more responsible use of water and the use of more efficient systems could avoid the worsening of the situation and that's why encouraging awareness and education is fundamental. [61]

4.3. Health

Drinking contaminated water could cause the apparition of some grave illnesses such as Leptospirosis, Cholera, Hepatitis A… These diseases are much more common in kids, between 1 and 6 years old, pregnant women or elderly people due to the alterations in the immune system. This could well be considered a serious public health problem. [62]

Figure 40: Contaminated water. [63]

Figure 41: Child drinking contaminated water. [64]

The responsible of this problem are some microorganisms which can easily develop themselves in water. Even though it is easier for it to happen in rivers and lakes, the water which comes out of fountains can also contain some type of bacteria, parasites or viruses. Those only appear when water does not go through any cleaning or purifying treatments which eliminate those organisms. [62]

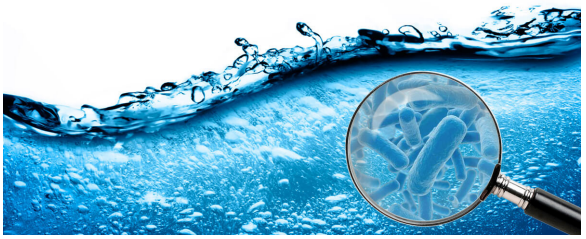


Figure 42: Microorganisms in water. [65]

Hepatitis A

It is a liver highly contagious sickness which although is not always dangerous, if it is not treated the right way it could lead to resultar fatal. Hepatitis A is transmitted by contact with infected excrements or when microorganisms get into your digestive system after drinking water which contains those. [62]

Symptoms: Dark urine, light excrements, yellowish skin and sclera, fever, nauseas, loss of appetite and fatigue… [62]

Treatment: Our body is supposed to fight for itself however symptoms are evaluated and observed. [62]

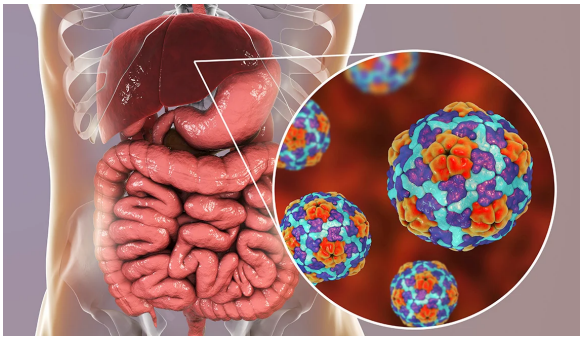


Figure 43: Microorganism in the liver. [66]

Giardiasis

It is an infection which affects the digestive system caused by the microscopic parasite *Giardia duodenalis*. It is an infectious disease, transmitted by consuming water or food which has been in contact with infected excrements. [62]

Symptoms: Abdominal pain, diarrhoea, fever, nauseas, feebleness or loss of weight. [62]

Treatment: Doctors prescribe medication which will fight the parasite. Besides, it is recommended to drink a considerable amount of water throughout the day or administer it through the intravenous route in extreme situations. [62]

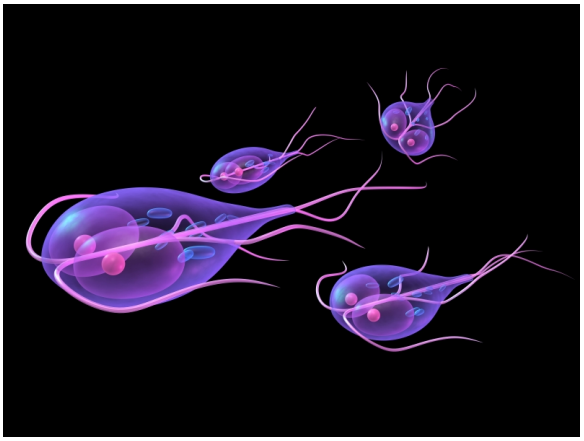


Figure 44: Parasite giardiasis. [67]

Amebiasis

Protozoan Entamoeba histolytica causes this disease, it stays in the intestine and stops or difficulties the absorption of very important nutrients for our body. [62]

Symptoms: Abdominal pain, diarrhoea, fever, shivers. In some cases excrements can contain blood. In more serious ones, the infection could spread to other organs like the liver or even the cerevel. [62]

Treatment: Anti-parasitic medication is usually used to cope with this disease, like Secnidazol, Metronidazol… However, the quantity and duration of the medication will be decided by the doctor who visits you depending on your situation. [62]

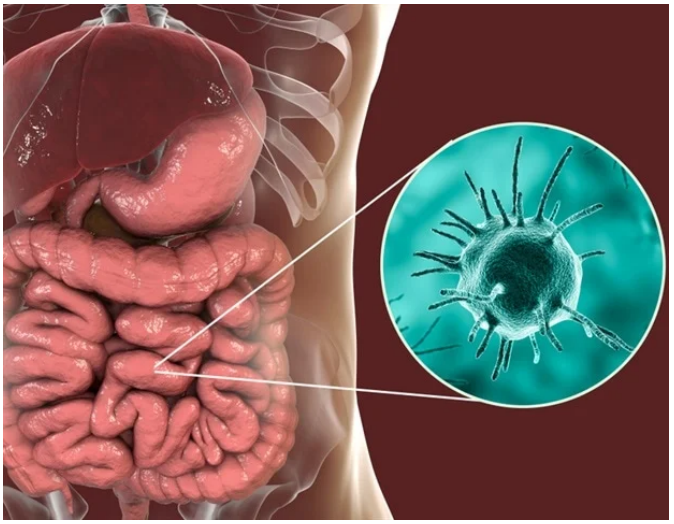


Figure 45: Protozoan *Entamoeba histolytica*. [68]

Typhoid fever

This illness is infectious and it is caused by the bacteria *Salmonella serotype* typhi. [62]

Symptoms: High fever,gastric juices, abdominal pain, constipation, diarrhoea, headache, loss of hunger, loss of weight and red spots on the skin. [62]

Treatment: Antibiotics are usually used, resting and keeping your body well hydrated is essential during recovery. A vaccine against this illness is disponible. [62]

Cholera

Infection in the intestine caused by a bacteria which can be found in contaminated water. Toxins are produced and symptoms appear. [62]

Symptoms: Intense diarrhoea and gastric juices that could lead to grave dehydration. [62]

Treatment: Antibiotics and administration of solution to reduce the dehydration or of saline drip through the intravenous route. [62]

Ascariasis

Parasitosis caused by *Ascaris Lumbricoide*, a parasitic. It stays and multiplies in our intestine. [62]

This illness is transmitted when you consume water or ailments which have been in contact with the eggs of the parasitic. [62]

Symptoms: Abdominal pain, dizziness or troubles when defecating. [62]

Treatment: Anti-parasitic medication. [62]

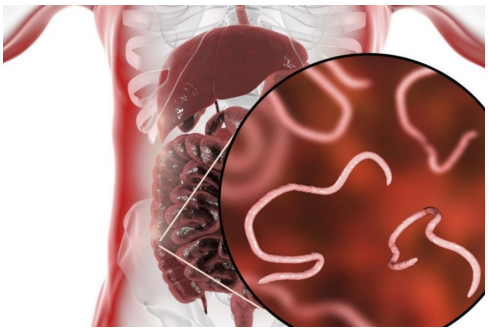


Figure 46: Parasitic Ascaris Lumbricoide. [69]

Leptospirosis

A disease caused by a bacteria present in the rats urine from the sewage system or other infected animals such as dogs or cats. This bacteria penetrates via a wound, the eyes, the nose or saliva. [62]

Symptoms: High fever, headache, general discomfort, loss of hunger, gastric juices, diarrhoea or shivers.[62]

Treatment: Antibiotics and paracetamol for the fever and pain. It is not recommended to consume medication, such as aspirin, to reduce inflammation. [62]

How to avoid these infections

It is essential to not have any contact with water coming from the sewage system or contaminated water as well as water from swimming pools that haven't been treated with chlorine. You should also avoid drinking water from rivers, not treated water, water from the rain and stagnated water. [62]

We must be careful, sometimes water can seem to be potable and be contaminated anyway. [62]

Lack of treatments or of a proper sewage system, even though it affects the whole population, especially kids from 1 to 6 years old. It also increases the possibility of a fetus dying. [62]

4.4. Hunger

Water scarcity also has an impact in other fields like agriculture, ranching and industry, that can provoke a shortage of ailments, therefore, hunger.

Figure 46: Plants with no water. [70]

4.5. Disappearance of vegetal species

Humans are far from being the only species requiring water for survival. There are an infinite number of other species with the same necessity. Especially vegetable species.

4.6. School neglect

A very challenging trek to get potable water is the norm in many regions. Sometimes, that is the child's task in order to help their families. As a consequence children reach school late, after an arduous and exhausting walk. And that is when the risk of kids permanently leaving school gets higher. [71]

4.7. Social discrimination

People who do not have access to water can not take showers or clean themselves. Of course, they can't clean their clothes and that could be humiliating or it could even be the reason they end up becoming society outsiders. This especially affects women and girls. [71]

4.8. Gender inequality and exploitation

Violence between family members and the selling off of children into pre-arranged marriages, is increasing owing to the lack of water. Families in a tough financial situation, arrange marriages between their daughters and members of better off families in the hope of their child being maintained into the future. [71]

5. Solutions

5.1.Environmental education

Every 26 of January is celebrated the World Day of Environmental Education, whose origin dates back to 1975.

Education is not only limited to informing or raising awareness about a specific problem, it also proposes to take action and invites change. [72]

It is said that solving environmental problems or, better yet, preventing them implies the need to change each action, so that the effects of our individual and collective activity are modified, to obtain a new mosaic of forces directed in a different direction: sustainability. [72]

In this sense, education is important to promote sustainable development and increase citizen capacity. [72]

So to speak of an environmental education for a sustainable use of water is to speak of a transformative education, which pushes us to change the way in which we use water resources in which we are aware that "without achieving access to water, it will be difficult to achieve the other objectives. It is important to reconnect people with the physical, chemical and socioeconomic reality, which is to have aquatic ecosystems for our development. [72]

Educating for the change of consumption models and lifestyles is very important for our teaching and for our own training. Coping with the next water shortage requires major changes in all forms of consumption, from individual use to that of large corporations. The initial factor is knowledge and consideration of the problem to be faced. [72]

For example, in some countries such as Singapore, they have made important advances in the reuse of water for different uses, including also the use of drinking water thus reducing water consumption and improving self-sufficiency. [72]

How do we educate?

The presence of water and its problems, as one of the resources most affected by climate change, has increased in school education over the last few years. In the environmental education activities developed by educational centers, water usually has an important position when it comes to developing content and sensitizing students. These children and young people will in the future be responsible for taking care of water resources and, in some cases, those responsible for water governance, distribution and research. [72]

But not only is it important to raise awareness among children and young people, it is also crucial that education is present in higher education. [72]

Water education also involves working with media professionals, in order to improve their abilities to communicate water issues clearly and effectively. [72]

Education in Spain

In Spain there are environmental education projects focused on high quality water. Among them stands out a program called, EDUCASSA. It has been sensitizing the students of the city for 35 years about the importance of taking care of the resource, and that has had exact results in the consumption of water in Sabadell. [72]

Aqualogy

An approach based on the care of the environment, the sustainability of resources and action on climate change, Aqualogy discovers to children the integral cycle of water, how it reaches our homes and what treatments are necessary for its consumption and return to the natural environment. [72]

5.2.Conservation technologies

Rainwater pipe

The rainwater pipe network transports the harvested water on roofs and channels it to a storage point. The objective of this system is the efficient transport and removal of impurities before reaching the storage point. In the project "Safe water benefits us all, these types of systems were installed, improving the efficiency and quality in the harvest of rainwater. [73]

Table 2: Rainwater pipe for and against (own preparation)

Advantages	Disadvantages
Flexible design and adaptability to various contexts	Requires constant attention during the rainy season
No required electrical power for its operation	The correct sizing of the gutters requires some specialized knowledge
Relatively low cost installation	The first rainfall diversion system doesn't remove compounds dissolved in water or chemicals, such as pesticides

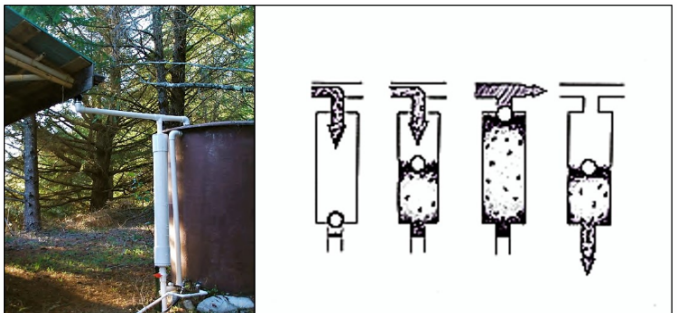


Figure 47: rainwater pipe

Figure 48: rainwater pipe

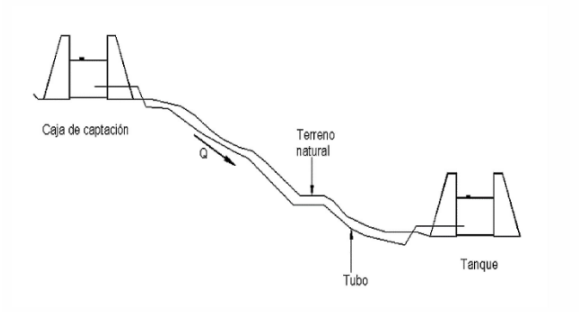
Gravity Driving

A gravity conduction system is one that allows water to be transported from the source collection point to the storage tank, without mechanized pumping and in safe and hygienic conditions; in case the source does not meet the requirements, a treatment plant is included. The main feature of these systems is that the source is located in a higher position than the one where the community that will make use of the captured water is. [73]

Table 3: Gravity driving for and against (own preparation based on information source [74])

Advantages	Disadvantages
Minimal operation and maintenance, resulting in low costs	There is not always availability of adequate water sources that are located upstream of the community
Provides safe water to the population	Construction costs are more expensive than those for wells in the community

No pumps are needed, so no additional or external power is needed for their operation	The relief and quality of the terrain can make it impossible to place pipes
You can have a constant service since the maintenance needs are low	System performance can be affected during periods of extreme drought
Water sources that are relatively far from the community can be used, due to the ease of connection with PVC pipes	In hard water areas pipe washing is required
Few pressure changes are created	



Esquema de una línea de conducción por gravedad. Fuente: SAGARPA s.f., p.8

Figure 49: gravity driving [74]

Manual water pumping

Pumping by human force is an active system, which requires the strength of the human being to raise and extract water from a low point to a high one. It can be used with surface water, groundwater and deposits to distribution systems. Pumping devices are easy to install, operate and capable of lifting water in quantities suitable for small communities and provide faster and easier access to water. [73]

Table 4: Manual water pumping for and against [75]

Advantages	Disadvantages
Independence of energy sources	Frequent maintenance is important and requires trained personnel
Water discharge capacity suitable for domestic use or for small rural communities	Limitation of human energy to perform pumping
Low-cost options available	Low water discharge capacity for large communities
Simple, low-cost components for operation and maintenance by people in the community	Disproportionate increase in the effort to lift the water, by increasing the depth
Can be used independently by women, children, boys and small farmers	
Increased safety in water handling	
Can be used almost anywhere in Mexico	

Figure 50: Manual Water Pumping https://engineer.decorexpro.com/ca/vodosnab/nasosy/ruchnoy-nasos-dlya-skvazhiny.html [73]

Motorized water pumping

Mechanized pumping systems are devices for raising and extracting water from a low point to an elevated point, from surface water, groundwater or from reservoirs to distribution systems. These types of pumps can be driven by various energy sources. This type of technology requires technical knowledge to define the type of installation, operation and maintenance, as well as economic resources. [73]

Table 5: Motorized water pumping for and against [75]

Advantages	Disadvantages
High performance: sufficient discharge capacity to meet water requirements in different contexts	High costs in procurement, operation and maintenance
With a storage tank the liquid is guaranteed where there is no continuity of energy supply	A qualified technician is required to ensure operation and maintenance
Independent operation in isolated or dispersed communities	High yield causes excessive use of water that can lead to shortages in the source of supply

Less physical labor effort and time spent for the activity	Fuel systems can produce fumes and noises harmful to health and can contaminate groundwater and the environment
Quick access to drinking water	Requires frequent maintenance for proper operation
Low risk of contamination during transport	

Sistema de bombeo, San Martin Tilcajete, Oaxaca. Fuente: SARAR 2018 [archivo del autor]

Figure 51: Motorized water pumping. [75]

5.3. Sewage

To realize the problem posed by the contamination of water waste, it is estimated that almost a third of the population consumes water in poor conditions due to the presence of pathogens and harmful chemicals. [73]

Specifically, it is based on the elimination of the polluting agents contained for subsequent reuse for other purposes, without generating derived environmental problems. [73]

How can water be reused?

First of all, you have to filter the water to remove solid waste or larger volume in it. Once the garbage of different sizes has been removed, the water passes through pipes to the purification chambers and goes to sedimentation tanks, so that the waste settles at the bottom. [73]

After eliminating them, a series of biological procedures are carried out that purify the water, promoting the disintegration of any polluting material that exists. After being purified, it is transferred to chambers where the last residues that may still remain in the water are eliminated and then to other tanks where a chemical treatment is carried out to leave it in perfect condition for future uses. [73]

In which areas can water be reused?

It is surprising the large amount of useIt is surprising the large number of uses that can be given to wastewater once it has been properly treated. In fact, this is not a new practice that can be given to wastewater once it has been properly treated. In fact, this is not a new practice. [73]

Here are some examples of uses that can be given to wastewater once it has been properly treated for purification:

- Agricultural irrigation. In many cases, the soil can be nourished by waste from sewage. It is frequently used in seedbeds and crops.
- Industrial field. Wastewater can also be used for cooling tanks and tanks, as well as for feeding boilers.
- Irrigation of green areas. Something similar happens with agricultural irrigation. Cemeteries, golf courses or urban forests can take advantage of this type of water.
- Aquifer recharge. When these are emptied, it is important to fill them with water so that the soil remains stable.
- Other uses. In addition, wastewater can be used in firefighting, in car wash centers, in air conditioning refills or in street cleaning, for example. It is also very useful in the field of construction, for the cleaning of livestock or for the melting of snow in places where there are very low temperatures. [73]

5.4. Improve agricultural practices

What are sustainable irrigation strategies?

The sustainable irrigation strategy is one that is drawn up when we have different crops with different consumption needs. That is, we use an irrigation technique for one crop and a different one for other plantations. [76]

The usual irrigation pumps and other systems to achieve good harvest results and even to generate sustainable irrigation require electricity. That is why it is so important to focus on sustainable solutions from both perspectives. Energy efficiency has become key to both our economy and the planet. [76]

Drip Irrigation

Drip irrigation, also known under the name of "drop-by-drop irrigation", is an irrigation method used in arid areas because it allows the optimal use of water and fertilizers.

The water applied by this irrigation method infiltrates the roots of the plants directly, irrigating the area of influence of the roots through a system of pipes and emitters, which increase productivity and yield per unit area. This technique is the most important innovation in agriculture since the invention of sprinklers in the 1930s.

Drip irrigation consists of watering the plants by means of water droplets which are filtered by a hose, tube, etc.

In Spain there are already people who use drip irrigation and it is giving them very good results. [76, 77]

Figure 52: Sprinkler [78]

What is the best technique?

Finding the best sustainable irrigation technique involves studying the terrain, the type of plantations, where the main water supplier is located, what pressure it comes out with, etc. Different parameters that escape us to those who 'only understand each other with our plants'. In this sense, there is not much to think about: if you want to make your water and electricity bill go down, get in touch with professionals who can study your case and provide you with the best tools. [76]

5.5 Desalination plants

How does it work?

At the level of planning and engineering, the development of a desalination plant requires taking care of many aspects of organization, design, and location of the different phases and processes through which seawater has to pass to be converted into drinking water. [79]

1. Water catchment

It is the starting point of the whole process, and it is the point where all the water that comes from the sea is received so that it can be conducted and driven by pipes to the treatment plant itself. [79]

2. Pretreatment

Already within the plant, an area is designated where a first sieve of the water that enters the sea is made, this can vary according to the quality of the water and the type of treatment that will be applied. But normally, it is based on separating the biological load, pollution, or aggregates that seawater can bring so that its subsequent treatment is more effective and does not damage the machinery. [79]

3. Treatment and purification

Each of the desalination methods requires different membranes, machines, ducts and installation, so this space (or spaces) houses all the necessary equipment to desalinate the water brought from the sea, including the necessary ducts to take it to the next, and last, area. [79]

4. Post-treatment

It is a storage area where the water that has been treated is separated according to the type of final application it will have, in some cases it requires to be remineralized to comply with local consumption regulations. Finally it is distributed throughout the supply network. [79]

5.6. Improve water distribution

Pressure management has proven to be an effective tool to reduce non-revenue water leakage, improve energy efficiency and reduce operating and maintenance costs.
It is an optimal management of the pressure in the network, ensuring that the water reaches the end users while reducing excess pressure, totally unnecessary, also bearing in mind that both the scarcity and the quality of the water are problems of interest. which can even condition the growth of cities and countries around the world. [80]

5.7 Fight against pollution

The main solutions are:

- Reduce the greenhouse effect and the temperature of the planet. In order to restore the balance and oxygen level of the seas. This means accelerating all measures to combat climate change: increased recycling, electrification of transport, promotion of renewables, etc.
- Reduction of the use of plastic and microplastics already in the water. We must reduce plastic (especially single-use) to reduce waste that ends up in the sea. In the same way, you have to eliminate the one that is already in the water. Unfortunately, no solution we have now is 100% effective,
- Responsible management of fisheries and the use of marine resources. In order not to deplete ecosystems already very damaged.
- A more sustainable agriculture. Reduce the use of pesticides that end up reaching the water.
- Improve waste management. Eliminating once and for all discharges to water currents.
- Responsible freshwater management. That it avoids scarcity and the tensions it produces.
- Extend better sanitation services and new technologies in this field. This machine, for example, funded by Bill Gates' foundation, makes it possible to convert fecal water into drinking water. [81]

6. Plants and drought

6.1. Introduction

In this experiment we wanted to investigate what happens to a plant which suffers water scarcity but also to one which is receiving an excess of water. Analyze how the type of plant affects the results of this experimentation. Besides, one of our objectives was to see if the climate conditions, like if it is sunny or not, is a factor which has an important impact on the plants survival.

For this, we've chosen two different types of plants and we have kept them in different conditions, essential for the experiment. Firstly we chose a breed of cactus, blue Echeveria, a type of plant that doesn't need a big quantity of water to survive. As all the other succulent plants, Echeveria has a specialized organ which accumulates major quantities of water than other plants. Then, we went for the Basil, which needs a lot of water. The total of plants was 36:

Table 6: Distribution of Basil and Echeveria. (Own preparation)

IN THE SHADE

	WATER SCARCITY	WATER EXCESS	CONTROL GROUP
Echeveria	3	3	3
Basil	3	3	3

IN THE SUN

	WATER SCARCITY	WATER EXCESS	CONTROL GROUP
Echeveria	3	3	3
Basil	3	3	3

6.2. Method

To start, the control group of plants will receive the general recommended quantity of water according to their features. The approximate quantity of water each plant needs to survive. The other two groups will receive more water than necessary and the other won't be watered at all.

According to our research on these plants, Basil needs to be frequently watered but not to receive big quantities of water. We decided to water Basil everyday, 10 ml. Blue Echeveria needs to be watered when its soil is dry. So we watered the control group every two days, 5ml.

Basil which was supposed to receive more water than they should have received 20 ml/day. And the Echeverias have received 5 ml/day. 50% of the Basil was in the shade and 50% in the sun as well as the Echeveria. Then, a group of Basil receiving no water will be in the sun and another in the shade. Half of the Basil receiving too much water will be in the sun and the other half in the shade as well as the ones receiving the proper quantity of water and the Echeverias.

Table 7: Basil and Echeveria water. (Own preparation)

IN THE SHADE

	WATER SCARCITY	WATER EXCESS	CONTROL GROUP
Echeveria	0ml	5 ml/day	5 ml (every 2 days)
Basil	0ml	20 ml/day	10 ml/day

IN THE SUN

	WATER SCARCITY	WATER EXCESS	CONTROL GROUP
Echeveria	0 ml	5 ml/day	5 ml (every two days)
Basil	0 ml	20 ml/day	10 ml/day

6.3. Hypothesis

With reference to the Basil plants of the control group, we assume they aren't going to change that much during these 2 weeks. Although the possible different climates, we also reckon these groups of plants will be the ones which will end in best conditions.

Our predictions for the Echeveria are similar. However, we believe there will be a difference between the ones in the shade and the ones in the sun.

On the one hand, we have a group of plants which will be suffering from water scarcity. We won't water them, none of them it doesn't matter if they are in the sun or in the shade. We think that the Echeveria will survive longer in both cases, furthermore, they won't barely have any notable physical change. At the same time, Basils with water scarcity will experience the usual changes in these situations: their leaves will dry and fall, even the plant itself will start to dry up.

On the other hand we have the group of plants which will receive an excess of water, we aren't that sure about how the Echeveria will reaccionate, but we believe it will affect the plant, as its organism is prepared to live in very different climate conditions. The Basil, a more delicate plant, will probably suffer notable changes especially the ones in the shade. And it's probably the appearance of fungus in the roots or changes of color of the leaves.

Since the experiment won't last more than a month, we aren't sure about the differences there will be between the plants at the beginning and the end, in view of the fact that changes in plants are slower than in other organisms.

6.4. Observations

After only nine days, we can tell there is a huge difference between the appearance of the plants now and in the beginning. We can notice the control groups have survived, however, the leaves of the Basil group which have been in the sun have suffered a color change. Some of them have turned yellow. Also, the outer edge of the cladodes on the Echeverias have dried out and turned brown. The ones in the shade have turned so soft that they are easily damaged.

Basil plants which have been excessively watered and have been in the sun have grown taller and stronger. On the contrary, black dots have appeared in the ones in the shade. Echeverias haven't changed much even though their cladode (stem) are more soft and fragile now.

Last, Basil, which hasn't received water, no matter if they were in the sun or in the shade, has totally dried. However, the ones in the shade did survive longer. And the Echeverias in the sun have slightly started to dry and crease, the other ones haven't shown any physical change.

We can see the progression of these plants throughout the images that we will find in the appendix.

6.5. Conclusion

To conclude, we can tell that the Basil leaves, which have turned yellow, may have not received enough water even though it is the recommended quantity for this type of plant due to the sun. Also, the ones in the shade have survived without showing any evidence of dehydration. That means the sun has had an important impact.

Since Basil, which has received too much water and has been in the sun, has grown healthier than any other plant, we can tell sun is essential as long as the plant receives a bigger amount of water than it is recommended too.

Plants which haven't been exposed to the sun have barely grown and don't look healthy. In some plants, fungi have even appeared.

As Echeverias from these two groups have barely changed, we can tell they are more capable of resisting climatological stresses than other plants.

Water and sun in excess can be damaging to plants.

It is necessary to reach de valence between the hours that the plant is exposed to the sun and the quantity of water that the plant receives.

When analyzing Echeverias, the ones which haven't received any water, have dried out, and wrinkled. However, not as much as the Basil. That proves the action of the already mentioned organ of succulent plants which accumulates water.

7. Water catchment method

7.1. Introduction

One of our objectives of this project was to see if it was possible to end water scarcity all over the world. For this, we have managed an interview with Jose Maria Nacenta, a teacher, investigator, technical director and company's collaborator.

Some years ago, in 2013 Jose Maria, invented a mechanism that took water from dew and humidity and turned it to liquid water.

The most important thing in life for Jose is his way of seeing things. He says that failing is part of life and it's good to fail; if you don't, you won't learn about your mistakes so you will end up doing them again.

"When trying to find solutions there is a high possibility of failure, but don't be afraid, I've failed a lot of times during my investigations but I've learned a lot and it has been useful to solve other problems. Failure isn't important; what is important is what you learn."

He believes trying to solve a problem with different technologies or techniques every time it's essential.

"You have to fall in love with the problem you are trying to solve, not with one possible solution you think of."

Although his experiment is not completed, he is looking forward to confirming its efficiency whenever he has time to do it. His objective would be to implement this technology to help cope with water scarcity.

He created a mechanism which captured water from the dew and humidity and turned it to liquid water. It was similar to a box, it was made with glass and solar panels. And it used calcium chloride that acts as a dehydrating compost. At night, he opened the solar panel so the air could enter inside the box. Then, the calcium chloride absorbed the water vapor from it.

When using this technology we must take into account the relative humidity. It is the relation between the temperature and the absolute humidity. To calculate this we use a psychrometric

The percentage represents the relative humidity. For example, at 30ºC (x) and with an absolute humidity of 8g/air (y) the relative humidity will be 30% and for 40ºC and the value of 14 g/air, the relative humidity percentage will be the same.

Taking this into account, we can understand how the mechanism works; The moment of the day when the percentage of humidity is higher is between 5am, 6am and 7am, when the temperature is lower. The main idea of the project was to leave the panel open during the night (when there's more humidity) and close it at sunrise. Throughout the day the humidity of the air is captured inside the panel, absorbed by the calcium chloride and then starts the evaporating process. After, some tubes with cold water would pass under the shelves where calcium chloride would be and condense the water. At the end of this process we could have 1L of water for each panel.

This is a very good method to catch water since it doesn't pollute, it is eco-friendly because it doesn't use non-renewable energies and although solar panels can be a little expensive, once you buy some you just have to invest in maintenance.

Also, it could help those areas where there aren't any rivers or lakes nearby to provide fresh water to the population. This mechanism can be installed in any place where there's a minimum of humidity at night so those places where water isn't available would have a solution to water their plants and crops or to have a shower.

7.2. Interview

Where did you make your project?

- I did my internship of the mechanism in Hospitalet de Llobregat, Spain.

Which materials did you use?

- Glass to make the cover, metal for the "little shelves"and calcium chloride, as the dehydrating agent.

How much did it cost to create one panel?

- I'm not really sure because the experimentation is still not finished, but the cost of a solar panel ($5,500 and $14,000), multiplied by 1,5 would be the cost of this type of water panel.

Did you do this project alone or with more people?

- First I started with a friend, then I went with another group, and finally I took it to a company that I made by myself. There more people took part and the product was perfected.

How does the panel work?

- First, we can find the isolator that stops water from escaping. Here I put a type of shelving (1 cm thick) with calcium chloride that acts like a dehydrating compost. All of that, at night was open, so the air could enter and the calcium chloride could absorb the humidity, increasing the weight.

Later at sunrise, a piece of glass covered all the panels, when the sun was very hot, in order to increase the temperature inside the panel (80ºC, 90ºC, 100ºC). Consequently, the humidity inside the panel began to rise because there wasn't any flow of air to make the temperature decrease.

Next, a circuit of cold water passed under the tiny shelves, and, as they were metallic, they got cold really fast so the water vapor that the calcium chloride absorbed condensed thus producing liquid water.

Do you think that if this project became a global reality it could end water scarcity, or maybe ensure there is sufficient water for agriculture?

- I tell you, that when I do have time I will apply this device to my work on ending water scarcity, but currently I don't think so.

Although you have to think that when you are finding solutions, you always have a high probability of failure, but don't be put off. I 've failed a lot of times in my investigations, but I've learned a lot and it has been useful to solve other problems. Failure is not important, what is important is what you learn. And when a thing doesn't work, you have to know the way to redo it and improve. It's weird if the invention or the idea is right the first time around, it's really difficult, it's like winning the lottery. However, don't forget that the most important thing is to fall in love with the problem, not with your solution.

Why does the calcium chloride absorb the water in air?

- As the air is really humid, the calcium chloride absorbs the water vapor. If you want you can try it at home, you pick a plate and 50 g of calcium chloride and you distribute it all over the plate. You have to leave this at room temperature. Then at 4 pm or 5 pm, you weigh it to see how many grams it has increased due to humidity. Later, at 6 am you weigh it again and you will see that it's colder than before and it has more water.

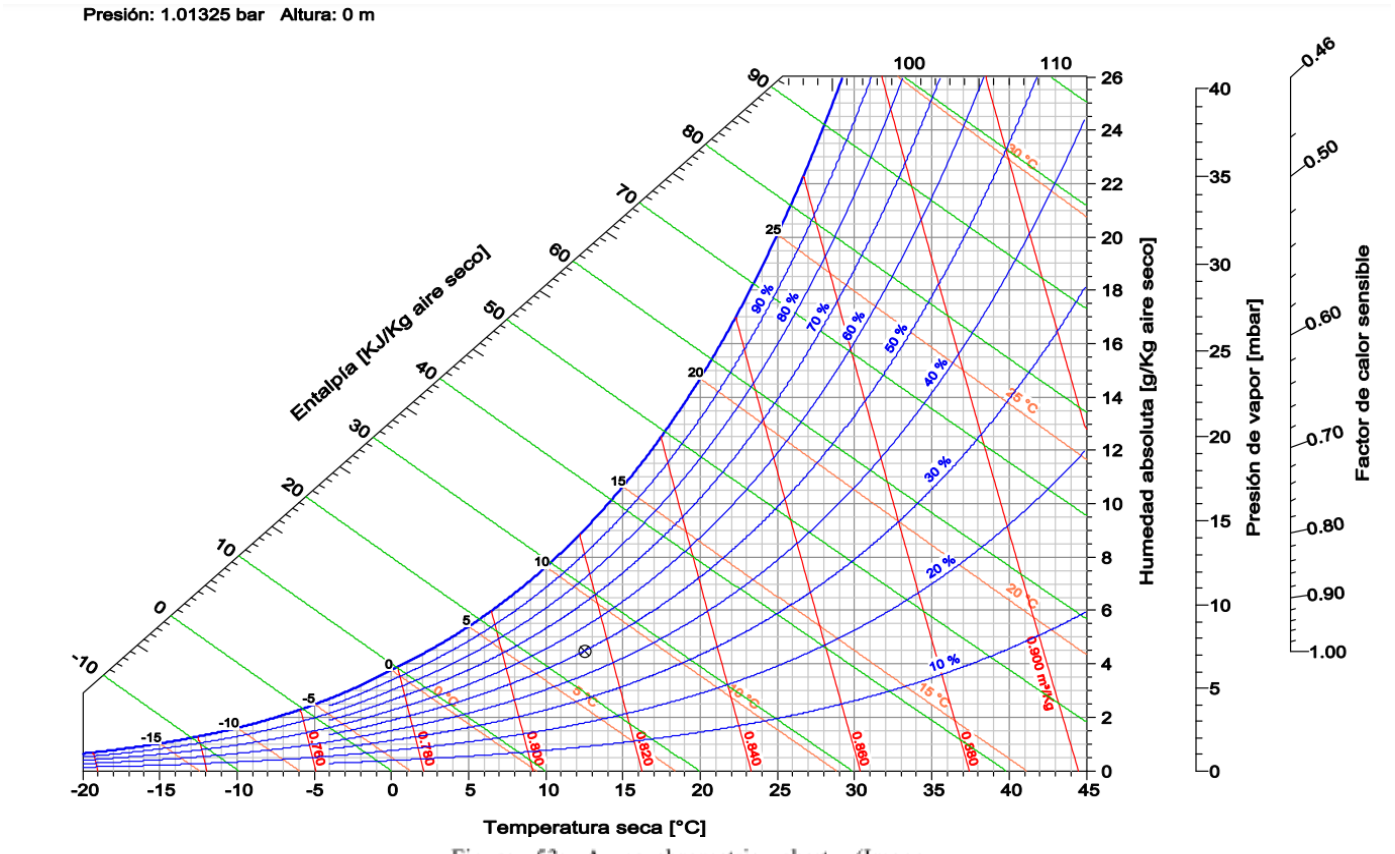


Figure 53: A psychrometric chart. (Image provided by José María Nacenta).

(x= temperature y= absolute humidity)

When is there more humidity in the air?

- At 5 am, 6 am and 7 am there's more relative humidity, but the temperature is lower. On the other hand, at 3 pm, 4 pm and 5 pm there's less relative humidity and the temperature is higher.

It is often said that the consequences of water scarcity are worrisome. What we wanted to discover was how we could do our bit.There are so many consequences of the lack of water But, how could we help to avoid this amount of misfortune? Well with a mix of scientific studies, technological advances and the ingenuity necessary to bring together this culmination, we have found the way to do our bit.

As the numbers show, a high percentage of the water is used for cultivation, which squeezes the few hydrological resources in certain regions. Because of that, we wanted to use a method to pick up water from dew and its evaporation.

Talking to relatives and friends we found an engineering project from a few years ago and we talked to the inventor to ask if we could make an interview.

On the other hand, also essential in this practical part has been discovering what happens to plants when they are exposed to water scarcity or water excess and if the species of the plant makes changes or not in the final results. This will help to have an idea of how much water needs a plant used for humans to consume it, like basil.

Mixing these two experiments, we can imagine how much water a population needs with a concrete number of people and obviously how many mechanisms to trap water we will need and also the budget that it will require.

7.3. Prototype

This model represents a solar water panel, where you can see some drawers where the chloride is put. What this panel does is not let out the evaporation that forms during the night and this transforms it into water. We've done it with an app called sketchup.

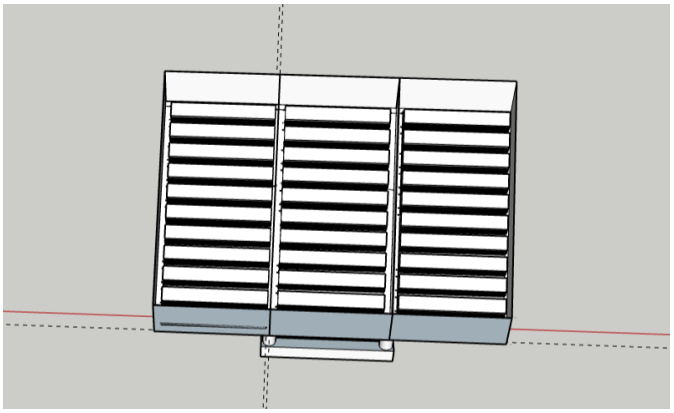


Figure 54: Solar water panel. (own preparation)

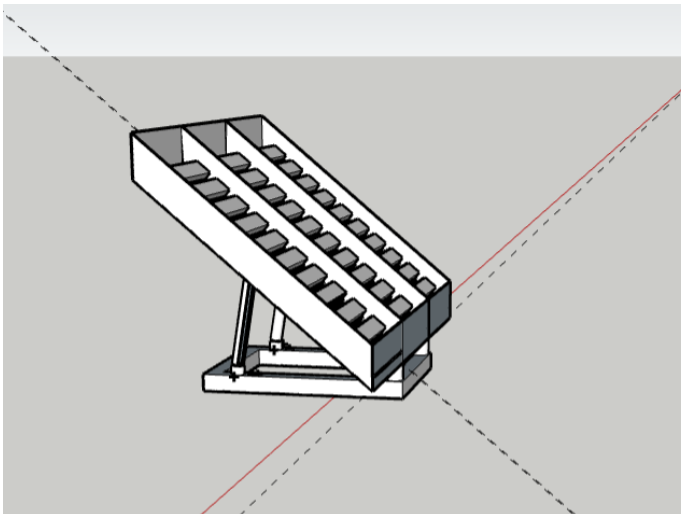


Figure 55: Solar water panel. (own preparation)

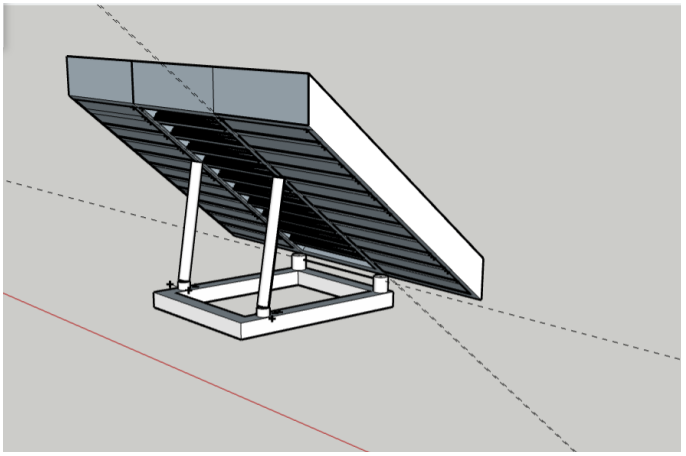


Figure 56: Solar water panel. (own preparation)

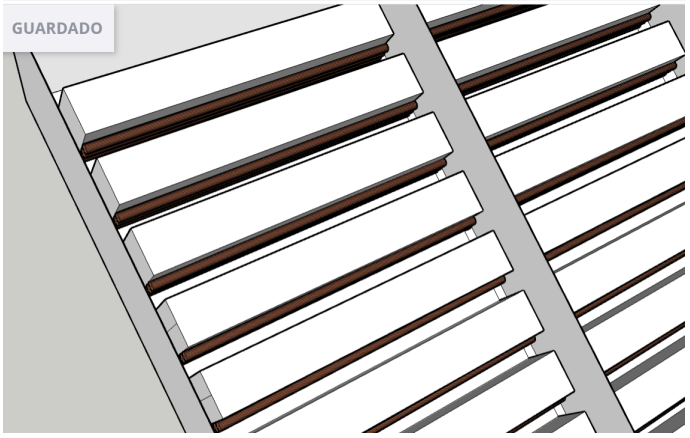


Figure 57: Solar water panel. (own preparation)

8. Mixture

To combine the two experiments, we wanted to propose a test showing how the system will work at a socioeconomic level. That's why we've found a region that we could use as an example: Tunisia.

Tunisia is a country of contrast. So despite its relatively high tourism in some areas, there are a lot of places where there is water scarcity and they can't cultivate properly. Furthermore,

its climate is Mediterranean, so the results agree with the tests that have been done in Catalonia.

In the hypothetical case that there was a small population in need of water, how much water and how many panels would we need?

The basil is a low-consumption plant with which we have made experiments and we have checked how much water it needs (20cL/day).

With the necessary calculations, a cultivated field of basil would need 14 L of water/day. The water harvesting machines could contribute 50% of that water consumption, that is 7 L. Taking into account that every panel provides 1,5 L per day, we would need 5 panels. The estimate of this project would be between 41.250 € and 105.000 €.

9. Appendix

These are the photos of the experiment plants and drought:

https://drive.google.com/file/d/1WCr-z9JIxIVNQCCkEJzkDsd-UeJNm0mi/view?usp=sharing

Acknowledgements

We would like to thank Jose Maria Nacenta for his collaboration, essential knowledge and the provided material.

Moreover we would like to mention Paul Allyn Tompkins for his help with the language. Also thanks to our guiding teacher Sara Muñoz for assisting us throughout all the project.

References

[1] Flor, M. F. (2022). Elon Musk donó $5,7 mil millones para combatir el hambre en el mundo. PanAm Post. Recovered October 13th 2022, from https://panampost.com/mamela-fiallo/2022/02/16/elon-musk-dono-millones-hambre/

[2] Manzano, C. B. (2021). Elon Musk, dispuesto a acabar con el hambre en el mundo. Confidencial Digital. Recovered October 13th 2022, from https://www.elconfidencialdigital.com/articulo/actualidad/elon-musk-ha-aceptado-reto-onu-donar-parte-fortuna-acabar-hambre-mundo/20211103184742299130.html

[3] Dobrijevic, D. (2021). What is photosynthesis? Livescience. Recovered October 13th 2022, from https://www.livescience.com/51720-photosynthesis.html

[4] Photosynthesis in Plants. (2019). Photosynthesis Education. Recovered October 13th 2022, from https://photosynthesiseducation.com/photosynthesis-in-plants/

[5] 2.2-Els vegetals i l'aigua - L'aigua. (n. d.). Recovered October 13th 2022, from https://sites.google.com/site/aiguaunbeimprenscindible/2-2-els-vegetals-i-l-aigua

[6] Shomrat, A. (2020). Transpiration Mechanism in Plant Body. Plantlet. Recovered October 13th 2022, from https://plantlet.org/transpiration-mechanism-in-plant-body/

[7] Water Science School. (2018). Evapotranspiration and the Water Cycle. U.S. Geological Survey. Recovered October 13th 2022, from https://www.usgs.gov/special-topics/water-science-school/science/evapotranspiration-and-water-cycle

[8] Suelos: la falta de humedad afecta la absorción de nutrientes. (2018). INTA Informa. Recovered October 13th 2022, from https://intainforma.inta.gob.ar/suelos-la-falta-de-humedad-afecta-la-absorcion-de-nutrientes/

[9] Carrmisty. (2022). Plants, Photosynthesis Terms Plants, Tropism, Tropisms, Turgor Pressure, & Stomata. Quizlet. Recovered October 15th 2022, from https://quizlet.com/320275321/plants-photosynthesis-terms-plants-tropism-tropisms-turgor-pressure-stomata-diagram/

[10] Turgor pressure vector illustration. (n. d.). VectorMine. Recovered October 13th 2022, from https://vectormine.com/item/turgor-pressure-vector-illustration-labeled-hydrostatic-force-explain-scheme/

[11] France in midst of 4th heat wave amid historic drought. (2022). The Hamilton Spectator. Recovered October 13th 2022, from https://www.thespec.com/ts/news/world/europe/2022/08/08/france-in-midst-of-4th-heat-wave-amid-historic-drought.html

[12] Valladares, F. et al. (2004). Estrés hídrico: ecofisiología y escalas de la sequía. Ecología del bosque mediterráneo en un mundo cambiante. pp. 163 - 190. Recovered October 13th 2022, from https://www.researchgate.net/profile/Eustaquio-Pelegrin/publication/267260569_Estres_hidrico_ecofisiologia_y_escalas_de_la_sequia/links/544e1b570cf29473161a164d/Estres-hidrico-ecofisiologia-y-escalas-de-la-sequia.pdf

[13] Excess Water Damage on Flowers. (2021). College of Agriculture and Natural Resources. University of Maryland Extension. Recovered October 13th 2022, from https://extension.umd.edu/resource/excess-water-damage-flowers

[14] Vandegehuchte, M. L., Izquierdo, J. L., De la Rosa, A. (2021). ¿Cómo afectan a las plantas la sequía y los enemigos naturales? Sierra de Guadarrama. Recovered

October 13th 2022, from https://www.parquenacionalsierraguadarrama.es/es/parque/blogs/blog-centro/item/510-plantas-sequia-enemigos

[15] O'Neill, M. (2022). Water: Do You Really Need 8 Glasses a Day? SciTechDaily. Recovered October 13th 2022, from https://scitechdaily.com/water-do-you-really-need-8-glasses-a-day/

[16] Hidratación. (n.d.). Cátedra Internacional de Estudios Avanzados en Hidratación. Recovered October 13th 2022, from https://cieah.ulpgc.es/es/hidratacion-humana/hidratacion

[17] Vector banner with functions and benefits of water for human body. (2020). Dreamstime. Recovered October 13th 2022, from https://www.dreamstime.com/vector-banner-functions-benefits-water-human-body-medical-information-function-man-drinking-bottle-image201501846

[18] 9 amazing benefits of ionized alkaline water produced by HydrogenX. (2018). HydrogenX Better Health Delivered. Recovered October 13th 2022, from https://www.hydrogenx.com/9-amazing-benefits-of-hydrogen-water/

[19] Arteaga, S. (2018). ¿Qué pasa en tu cuerpo cuando no bebes agua? ComputerHoy. Recovered October 13th 2022, from https://computerhoy.com/noticias/life/que-pasa-tu-cuerpo-cuando-no-bebes-agua-79719

[20] Bidault, O. (2021). ¿Cuánto tiempo podemos vivir sin beber agua? Waterlogic. Recovered October 13th 2022, from https://www.waterlogic.es/blog/cuanto-tiempo-podemos-vivir-sin-beber-agua/

[21] Molina, R. (2021). Importancia del agua y las problemáticas socio-ambientales. Educación Ambiental. Gobierno de México. Recovered October 13th 2022, from https://www.gob.mx/semarnat/educacionambiental/es/articulos/importancia-del-agua-y-las-problematicas-socio-ambientales?idiom=es

[22] Brooke, K. L., Quinn, Z. G. (2017). Aqueducts of Rome, Italy. Building the World. Recovered October 13th 2022, from https://blogs.umb.edu/buildingtheworld/waterworks/aqueducts-of-rome-italy/

[23] Aquatic Ecosystem - Definition and its Types. (n. d.). Toppr. Recovered October 13th 2022, from https://www.toppr.com/guides/science/nature/ecosystem/aquatic-ecosystem-definition-and-its-types/

[24] Rodríguez, L. (2014). La importancia del valor económico y social del agua. Fundación Aquae. Recovered October 13th 2022, from https://www.fundacionaquae.org/el-valor-del-agua-y-su-vinculacion-social-y-economica/

[25] Distribution of Water. (n. d.). Year 7 Geography. Recovered October 13th 2022, from http://sncyear7geography.weebly.com/distribution-of-water.html

[26] La importancia del valor social del agua y la sostenibilidad del sector. (2019). RETEMA. Recovered October 13th 2022, from https://www.retema.es/actualidad/importancia-del-valor-social-del-agua-sostenibilidad-del-sector

[27] Manganello, K. (2019). Which Industries Use the Most Water? Thomas. Recovered October 13th 2022, from https://www.thomasnet.com/insights/which-industries-use-the-most-water/

[28] Agua para procesos industriales. (2022). Carbotecnia. Recovered October 13th 2022, from https://www.carbotecnia.info/aprendizaje/tratamiento-de-agua/agua-para-procesos-industriales/

[29] Harveston, K. (2019). How does water treatment in the food and beverage industry work? New Food Magazine. Recovered October 13th 2022, from https://www.newfoodmagazine.com/article/89676/water-treatment-industry-work/

[30] Maverick, T. (2014). The Well Runs Dry for Mining Industry. Trefis. Recovered October 13th 2022, from https://www.trefis.com/stock/spy/articles/251428/the-well-runs-dry-for-mining-industry/2014-08-12

[31] Miarco. (2015) ¿Cómo de importante es el agua para la industria? Blog de bricolaje y material industrial. Recovered October 13th 2022, from https://www.miarco.com/blog/como-de-importante-es-el-agua-para-la-industria/

[32] La importancia del agua en nuestra vida cotidiana. (2021). Oxfam Intermón. Recovered October 13th 2022, from https://blog.oxfamintermon.org/la-importancia-del-agua-en-nuestra-vida-cotidiana/

[33] Causas de la escasez de agua. (2022). BBVA noticias. Recovered October 13th 2022, from https://www.bbva.com/es/sostenibilidad/causas-de-la-escasez-de-agua/

[34] Distribución mundial de los recursos hídricos. (2022). Wikipedia. Recovered October 13th 2022, from https://es.wikipedia.org/w/index.php?title=Distribuci%C3%B3n_mundial_de_los_recursos_h%C3%ADdricos&oldid=143022012

[35] Bermúdez, J. A. (n. d.) Distribución del agua en la tierra. Instituto Nacional de Tecnologías Educativas y de Formación del Profesorado. Ministerio de Educación y Formación Profesional. Gobierno de España. Recovered October 13th 2022, from http://recursostic.educacion.es/bancoimagenes/web/

[36] Escasez de agua en África. (2022). Wikipedia. Recovered October 13th 2022, from https://es.wikipedia.org/w/index.php?title=Escasez_de_agua_en_%C3%81frica&oldid=145004311

[37] Causas de la pobreza en África. (2017). ANHCR. Recovered October 13th 2022, from https://eacnur.org/es/actualidad/noticias/emergencias/pobreza-en-africa-analizamos-las-principales-causas

[38] Mena, A. (2021). ¿Qué países corren más riesgo de padecer sequía? Statista Infografías. Recovered October 13th 2022, from https://es.statista.com/grafico/25092/paises-segun-su-indice-de-riesgo-de-sequia/

[39] Origen y formación del agua subterránea. (2021). Fundación Aquae. Recovered October 13th 2022, from https://www.fundacionaquae.org/wiki/como-se-forma-agua-subterranea/

[40] Sobreexplotación y contaminación de acuíferos. (2009). Instituto Geográfico Nacional. Ministerio de Fomento. Gobierno es España. Recovered October 13th 2022, from https://www.ign.es/espmap/mapas_conta_bach/pdf/Contam%20_mapa_03_texto.pdf

[41] Crece la amenaza de conflictos por el agua en el mundo. (2020). Semana. Recovered October 15th 2022, from https://www.semana.com/medio-ambiente/articulo/crece-la-amenaza-de-conflictos-por-el-agua-en-el-mundo/49122/

[42] Talledo, J. (2015). Conflictos sociales: casi la tercera parte son por el agua. El Comercio. Perú. Recovered October 13th 2022, from https://elcomercio.pe/peru/conflictos-sociales-tercera-parte-son-agua-246820-noticia/

[43] Charles Iceland. (n. d.). WRI Ross Center for Sustainable Cities. Recovered October 13th 2022, from https://wrirosscities.org/profile/charles-iceland

[44] World Resources Institute (WRI). (2018). EAT. Recovered October 13th 2022, from https://eatforum.org/partner/world-resources-institute-wri/

[45] Fayanás, E. (2015). SOS por el agua en el conflicto judeo palestino. Nuevatribuna. Recovered October 13th 2022, from https://www.nuevatribuna.es/articulo/medio-ambiente/sos-agua-conflicto-judeo-palestino/20150811144437118997.html

[46] Martínez, G. (2022). El eterno problema del agua en África (y las iniciativas que tratan de paliarlo). El Confidencial. Recovered October 13th 2022, from https://www.elconfidencial.com/arcadia/2022-05-09/problema-agua-en-africa-arcadia_3420227/

[47] Rojas, A. (2020). Las guerras del agua, los conflictos del siglo XXI. El Mundo. Recovered October 15th 2022, from https://www.elmundo.es/internacional/2020/08/08/5f2d956721efa042338b4633.html

[48] Water, Peace and Security. (n. d. a). Recuperado 13 de octubre de 2022, de Recovered October 13th 2022, from https://www.linkedin.com/company/water-peace-security

[49] Water, Peace and Security. (n. d. b). Recovered October 13th 2022, from https://waterpeacesecurity.org/map

[50] Corella, M., Arias, F. (2022). Cómo comunicar la mediación. Legal Today. Recovered October 15th 2022, from https://www.legaltoday.com/opinion/blogs/civil-blogs/blog-de-co-mediacion/como-comunicar-la-medicion-2022-01-21/

[51] Ollantay, I. (2017). Conoce los 8 conflictos que podría causar el agua. https://www.telesurtv.net/foros/colombia-violencia-policial-manifestaciones-paro-nacional-foro-20210603-0001.html. Recovered October 13th 2022, from https://www.telesurtv.net/news/Conoce-los-8-conflictos-que-podria-causar-el-agua-20160321-0038.html

[52] Río Jordán. (2022). Wikipedia. Recovered October 13th 2022, from https://es.wikipedia.org/w/index.php?title=R%C3%ADo_Jord%C3%A1n&oldid=143020417

[53] Makluf, S. (2014). Mapa de Palestina. PalestinaLibre. Recovered October 13th 2022, from https://palestinalibre.org/articulo.php?a=49848

[54] Ruvalcaba, E. (2022). Implicaciones culturales del conflicto palestino - israelí. The Global World. Recovered October 15th 2022, from https://theglobalworld.es/magreb-y-oriente-medio/implicaciones-culturales-del-conflicto-palestino-israeli/

[55] Shanmugam, G. (2013). Zambezi River delta, central Mozambique. ResearchGate. Recovered October 13th 2022, from https://www.researchgate.net/figure/Zambezi-River-delta-a-Location-of-the-Zambezi-River-delta-red-filled-circle-Image_fig19_326782148

[56] Cándido. (2016). Central hidroeléctrica de Akosombo. Alma de Herrero. Recovered October 15th 2022, from http://almadeherrero.blogspot.com/2016/06/central-hidroelectrica-de-akosombo.html

[57] Río Níger. (2022). Wikipedia. Recovered October 15th 2022, from https://es.wikipedia.org/w/index.php?title=R%C3%ADo_N%C3%ADger&oldid=144068921

[58] Hoffmann, M. (n. d.). Mapa Físico de China: Montañas, Ríos, Desiertos y Mesetas. China Family Adventure.com. Recovered October 13th 2022, from https://www.china-family-adventure.com/es-mapa-fisico-de-china.html

[59] Río Kaveri. (2020). Wikipedia. Recovered October 13th 2022, from https://es.wikipedia.org/wiki/R%C3%ADo_Kaveri

[60] Zarza, L. F. (2021). ¿Qué es el estrés hídrico? iAgua. Recovered October 13th 2022, from https://www.iagua.es/respuestas/que-es-estres-hidrico

[61] Borràs, C. (2017). Estrés hídrico: agua en peligro. EcologíaVerde. Recovered October 13th 2022, from https://www.ecologiaverde.com/estres-hidrico-agua-en-peligro-46.html

[62] Hinrichsen, S. (2022). 7 enfermedades causadas por el agua contaminada. Tua Saúde. Recovered October 13th 2022, from https://www.tuasaude.com/es/consecuencias-de-beber-agua-contaminada/

[63] Portillo, G. (2021). Contaminación hídrica. Renovables Verdes. Recovered October 13th 2022, from https://www.renovablesverdes.com/contaminacion-hidrica/

[64] Falta de l'accés a l'aigua. (n. d.) Els nens d'Àfrica. Recovered October 15th 2022, from https://sites.google.com/site/elsnensdafrica/cos-de-treball/falta-d-acces-a-l-aigua-al-sud-d-africa

[65] ¿Bacterias en el agua de nuestro grifo? ¿Es posible? (2022). Hydrohealth. Recovered October 15th 2022, from https://hydrohealth.es/blog/bacterias-en-el-agua-de-nuestro-grifo-es-posible

[66] Hepatitis A. (2022). School of medicine. TECH Universidad Tecnológica España. Recovered October 13th 2022, from https://www.techtitute.com/medicina/blog/hepatitis-a

[67] Infección por Giardia. (2013). En familia AEP. Recovered October 15th 2022 from https://enfamilia.aeped.es/temas-salud/infeccion-por-giardia

[68] Montes, L. (2021). Amebiasis (disentería amebiana). Análisis, estudios e información. Recovered October 13th 2022, from https://aeinoticias.com/amebiasis-disenteria-amebiana/

[69] Sánchez, S. A. (2022). Ascariasis: causas, síntomas y tratamiento. MédicoPlus. Recovered October 13th 2022, from https://medicoplus.com/medicina-general/ascariasis

[70] Hermida, Á. (2022). Un 80% menos de agua en los cultivos mundiales ¿eso no es un problema? El Confidencial. Recovered October 13th 2022, from https://www.elconfidencial.com/medioambiente/agua/2022-05-08/agricultura-sequia-agua-escasez-cultivos_3420275/

[71] González-Cebrián, P. (2018). ¿Cuáles son las consecuencias de la falta de acceso al agua? iAgua. Recovered October 13th 2022, from https://www.iagua.es/blogs/pablo-gonzalez-cebrian/cuales-son-consecuencias-falta-acceso-al-agua

[72] Lara, S. (2022). Educación ambiental: aprender a ser responsables con el agua y el planeta. El Ágora Diario. Recovered October 15th 2022, from https://www.elagoradiario.com/agua/educacion-ambiental-responsables-planeta-agua/

[73] Aguas residuales: cómo se reutilizan y cuál es su importancia. (2021). Veolia. Recovered October 15th 2022, from https://golatam.veoliawatertechnologies.com/es/blog/aguas-residuales-como-se-reutilizan-y-cual-es-su-importancia

[74] Roberti, L. (n. d.). Conducción por gravedad. Sustainable Sanitation and Water Management Toolbox. Recovered October 15th 2022, from https://sswm.info/es/gass-perspective-es/tecnologias-de-agua-y-saneamiento/tecnologias-de-abastecimiento-de-agua/conducci%C3%B3n-por-gravedad

[75] Tecnologías de abastecimiento de agua. (n. d.). Sustainable Sanitation and Water Management Toolbox. Recovered October 15th 2022, from https://sswm.info/es/gass-perspective-es/tecnologias-de/tecnologias-de-abastecimiento-de-agua

[76] Técnica de riego sostenible ¿Estás usando la más eficiente? (2021). Mundoriego. Recovered October 13th 2022, from https://mundoriego.es/tecnica-de-riego-sostenible-estas-usando-la-mas-eficiente/

[77] Sigfito. (2020). Riego sostenible. Cultivando el medio ambiente. Recovered October 13th 2022, from http://cultivandoelmedioambiente.es/riego-sostenible/ https://www.elagoradiario.com/agua/educacion-ambiental-responsables-planeta-agua/

[78] Mejores aspersores de riego. (2021). Recovered October 15th 2022, from bing.com/images/search?view=detailV2&ccid=1%2brjLcW3&id=1CA8E9829E9A9727399A28B7D5AF4D5C52D99917&thid=OIP.1-rjLcW3OPvH5CCuRlcfVwHaH3&mediaurl=https%3a%2f%2fwww.misterherramientas.com%2fwp-content%2fuploads%2f2020%2f01%2faspersores-de-riego.jpg&cdnurl=https%3a%2f%2fth.bing.com%2fth%2fid%2fR.d7eae32dc5b738fbc7e420ae46571f57%3frik%3dF5nZUlxNr9W3KA%26pid%3dImgRaw%26r%3d0&exph=850&expw=800&q=aspersores&simid=608023866185366654&FORM=IRPRST&ck=C527AA3A952BEB3466AA47FAEFF0B85D&selectedIndex=3&ajaxhist=0&ajaxserp=0

[79] Plantas desalinizadoras: ¿Qué son y cómo funcionan? (2021). Structuralia. Recovered October 13th 2022, from https://blog.structuralia.com/plantas-desalinizadoras

[80] Strategies to increase water supply. (2019). Internet Geography. Recovered October 13th 2022, from https://www.internetgeography.net/topics/strategies-to-increase-water-supply/

[81] Lucha contra la contaminación. (n. d.). Medio Ambiente. Ministerio de Defensa. Gobierno de España. Recovered October 13th 2022, from https://www.defensa.gob.es/medioambiente/luchacontaminacion/