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Review

Why there is water scarcity

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Abstract: During the Neolithic period very few humans (3 to 5 million) lived on Planet Earth. As described in this review, there was an excess of water to support the life of these people. After the advent of agricultural practices, the number of people, as well as the production of food, increased very much and, as a consequence, large amounts of water became necessary to support this development. The availability of water is still in large excess as compared to the needs. The lack of water is the consequence of the lack of the appropriate infrastructures required to transport water to the places where it is needed. People need water in the right places at the right moment. They ask their governments to provide it, but the answers are not satisfactory. The actions needed are at the level of improving the irrigation, the distribution of water, the growth of more efficient vegetables and many similar initiatives. What is needed is a plethora of concerted actions that require national and international initiatives. The answer is an "international" action, not an "intergovernmental" one.

Keywords: hydrological cycle; number of people; contagious diseases; irrigation; Green Revolution; water transportation; freshwater for everybody

Abbreviations: CGIAR: Consultative Group for International Agricultural Research; FAO: Food and Agriculture Organization of the UN; GR: Green Revolution; ICID: International Commission on Irrigation and Drainage; ICOLD: International Commission on Large Dams; OECD: Organization for Economic Co-operation and Development; UNESCO: United Nations Education Culture Science

Organization; WHO: World Health Organization; WWDR: World Water Development Report 2017; WWDR: World Water Development Report 2021; WWC: World Water Council

1. Introduction

Plenty of water is present on our planet. Most of it (97.5%) is the saltwater of the oceans, while the remaining 2.5% is freshwater, found either in glaciers and underground in the aquifers, or in rivers, lakes and swamps. Freshwater, through evaporation, returns to the oceans, thus giving rise to the hydrological cycle [1,2]. The relative amounts of the components of this cycle are considered to be stable during the years; but recently different parameters have been analyzed in different zones of the planet Earth during the course of many years (2002–2016); in this way different trends of interannual variability were discovered, perhaps influenced by the climate change [3]; these data are considered with attention because of a possible prediction of future changes that might affect water security.

The amount of rain that falls every year on the emerged lands is approximately 100,000 km^3. Part of this water, about 60%, called "green water", is stored in the soil and it is the primary source of water that feeds agriculture; then it returns to the atmosphere. The remaining part of rain, approximately 40%, called "blue water", is the renewable resource used by the human beings. It flows towards the oceans, but along this path it helps to supply rivers (which contain a total of approximately 2,100 km^3 of water), lakes (containing 91,100 km^3 of water) and aquifers (containing 10,530,000 km^3 of water) [4–8]. The aquifers, located underground, represent a major reservoir and provide almost 20% of the total water presently used by mankind [9]. Water from aquifers is sometimes interrupted because the wells from where it comes are not enough deep [10]. Aquifers often cover large distances underground and cross national borders [11].

Human beings need to drink a few liters of water per day and survive only few days in its absence. The need for water has influenced human behavior since ancient times and, indeed, the oldest human settlements have been found mainly on the banks of rivers or lakes [12]. Rivers were used for drinking and refreshment, but they were also places where food could be obtained by fishing or hunting, because animals used them for the same purpose [13].

In this review we point out that the presence of water has been crucial for the expansion of humans on the planet. Agricultural activities were important for the production of food, thus permitting a very relevant increase in the number of inhabitants, who interacted in a novel way, giving rise to important cultural and political developments. The main factors influencing the life of the new farmers were: (1) water was necessary to produce the food needed by the growing population; (2) the population growth led to an increased need for water; (3) people realized that it was important to have the control of this important resource.

The construction of infrastructures (like channels, canals, or dams), to import abundant quantities of water has been crucial for the establishment of specific populations that occupied certain geographical areas. However, an important question is: why people did not organize themselves in order to have a constant amount of water sufficient for them? Or, if we look at the problem from a different point of view, why some governments have been so inefficient in the procurement of water?

We will show that lack of water caused problems in certain geographical areas; on the other hand the provision of appropriate structures was instrumental for the well-being of some other regions of the world. It is certainly true that some populations are more efficient in the procurement of water as compared to others. Overall, the number of people on the planet is constantly growing and it is becoming urgent to produce more freshwater.

Plenty of water is present on our planet: why is it not available for human beings?

2. The demographic increase

The transition from foraging to food production took place during the Neolithic period. At this time hunter-gatherers lived predominantly near the borders of rivers or lakes. Archaeological findings [14–16], suggest that in the Neolithic period the total population of the Earth's globe was about 3 to 5 million people, and probably this number did not increase because of lack of resources and the occurrence of high mortality. Hunter-gatherers moved to different places, probably because they followed the tracks of animals [17]. The situation changed drastically for those groups of individuals who settled in areas made fertile by frequent floods: since they had the water necessary for irrigation they could start agricultural activities, which changed the lifestyle of the human species and greatly influenced, although to different degrees, the demographic development of the various populations [18–21]. The use of water for agriculture, as well as the domestication of animals, allowed a more comfortable life and led to a spectacular increase in the number of inhabitants [22]: they are now on the planet about 7,700 million and are expected to become 9,800 million in the year 2050, with a 27% increase compared to the current situation (data from the Population Division of the United Nations). At the same time, total water consumption has grown much more than the level of population growth: part of this increment is due to irrigation, part is due to the discovery of the convenience of the use of domestic animals.

It should be pointed out however, that, when people live in a crowded space, often shared with domesticated animals and frequently contaminated with waste water, contagious diseases appear [23] and the high level of mortality causes a reduction in the rate of increase of the number of individuals [24,25]. Only when people understood the importance of using an appropriate amount of water for personal hygiene the mortality rate decreased and the rate of increase of individuals started to rise again. Therefore, water has become a strategic resource that serves not only to produce food, but also to limit the spread of contagious diseases. The paradox is that the availability of water has caused not only an increase in the number of individuals, but also a greater consumption of water, due to the increased need of water for the production of food, as well as an increased need of water for personal hygiene [26].

It is remarkable to note that the total amount of water used by humans in the Neolithic was negligible (namely less than 0.02 km^3 per year), while the total water consumption used by the present-day population is now estimated to be about 3,500 km^3 per year [27]. About 70–75% of this amount is necessary for irrigation and to feed domestic animals; 10–12% is used for direct human needs, mainly for hygiene and food cooking [7]. Finally, an increasing amount of water is used for industrial activities (up to 15% of the total). It is worth stressing that the amount of water needed by the human beings today (3,500 km^3 per year) is much less than the 100,000 km^3 of rain falling each year on the emerged lands of the planet (see above).

In conclusion, a cultivated land may develop in different ways according to the presence of different factors: water (present for a good part of the year or for short periods); different plants and their genetic traits; domesticated animals; farming techniques, etc.

There are areas of the planet where water is in excess and so it remains for a good part of the year, while elsewhere there is a more or less serious and extensive water shortage. About three quarters of the annual rainfall takes place in specific areas of the world and about 80% of fresh water is found in a few basins, such as the Great Lakes of North America, Lake Tanganyika in Africa and Lake Baikal in Siberia; or in five main river systems: the Amazon River, the Ganges with the Brahmaputra, the Congo, the Yangtze and the Orinoco [4]. In addition, the rain that precipitates on the planet can move at very different speeds, depending on the characteristics of the soil: in some cases, it stagnates while in other cases it evaporates very quickly, or it flows on the surface without penetrating in it. Often, the quantity of water is not sufficient to provide to the human needs and the struggles for its hoarding can generate episodes of violence, in some cases of considerable severity.

As mentioned above, agriculture permitted a relevant increase in the number of people on the planet. As a consequence, it became necessary to produce food for them, which means to use huge amounts of water for irrigation. The irrigated areas of the planet are very large: according to the International Commission on Irrigation and Drainage (ICID) [28] in the year 2018 a total of about 300,000 million hectares were cultivated. More detailed data are found in a document edited by FAO [29]. Note that water for irrigation is needed in specific places (where farms are present) and at specific times (when plant growth and ripening are occurring), thus making this requirement more stringent. A problem caused by the water used for irrigation is the salt contained in it: although the concentration of salt in freshwater is usually low and part of it is used by the plants growing in the irrigated field, a portion remains in the soil, and evaporation causes an increase of the salt concentration that prevents future plant growth. In some cases, in low-income countries, farmers use wastewater for irrigation because it is abundant and less expensive; however, this causes significant health hazards, especially if people eat raw vegetables that have been irrigated with the polluted water.

In some parts of the planet water is not only abundant, but also rich in nutrients useful to feed the growth of plants for agriculture: for example this happens in Mesopotamia, in the Fertile Crescent (located in a region corresponding to the Middle East of today) and in Egypt, were the river Nile brings every year water full of nutrients. During the Neolithic period farmers in Mesopotamia often used the floods of the local rivers to obtain water: they channeled it at the right time towards poorly irrigated pieces of land. The same was done in Egypt where farmers used (and still use now) the main flood of the Nile River to create deposits of water to be used when and where necessary. Later on, these structures were excavated to increase their volume and efficiency, were used regularly and their embankments became fixed. Irrigation required the organization of a large number of workers for the construction of structures for collective use, while the abundance of crops made it necessary to organize protection forces against nomads, or invaders. It is therefore thought, as proposed by Wittfogel in 1957 [30], that the management of water for irrigation has led to the birth of urban agglomerations and to the foundation of state systems for the administration of common resources.

3. Irrigation

The easiest way to obtain water for irrigation is to take it either from a nearby river, or from a lake, or from an aquifer. In some cases, when the water source is not close, it is necessary to build important artifacts. However, the extensive use of water has caused cases of river depletion (for example the Yellow River, the Indus, the Colorado, the Nile), or a serious decrease in the volume of some lakes, as in the case of the Aral Sea [31]. A serious case is the probable upcoming depletion of the Ogallala aquifer: this is one of the world's largest groundwater sources extending under eight States of the USA. Farmers are pulling water out of the Ogallala faster than the incoming rain and snow can recharge it: the expectations are that the Ogallala aquifer will be 70% depleted within 50 years.

Many cities are found close to rivers. At the beginning the nomadic people found it convenient to establish themselves and to become sedentary; then they started new activities and their number increased (the city of Rome started with a few hundred people, who became almost a million at the time of maximum expansion). Of course, the high concentration of people favored the appearance of contagious diseases [24]; the inhabitants of Rome, having understood the danger, built a complex network of small canals (the Cloaca Maxima) that received the wastewater from the the city and poured it into the river far from the city.

Quite often a river was chosen as the line of separation between two countries: for example, portions of the Rhine and Danube rivers were used as the northern limit of the Roman Empire: the river was used for defense from attacks, but also for the use of water, for fishing and for navigation. Finally, in the year 1815 the countries established on the borders recognized the advantages of collaboration and set up a Commission for the regulation of its use.

As already pointed out above, water is used not only for irrigation, but also for other reasons: drinking, cooking, hygienic purposes etc. In this case water should not be contaminated and should have good taste. It is analogous to the drinking water that is received by citizens in their town apartments (see below). In modern aqueducts, water is subjected to potabilization processes (flocculation, filtration, disinfection) and is made colorless, tasteless, odorless, clear, fresh and free of pathogenic germs. Before distribution, water is analyzed to exclude the presence of microorganisms or toxic substances, in accordance with the legislative provisions of the State where the aqueduct is located (see below).

4. The "Green Revolution"

The increased activities in agriculture caused an increase in the number of people and, as a consequence, an increased need of land for cultivation and of water for irrigation. In the years 1950s there were discussions concerning the possibility of a crisis and how to prevent it. A wide number of scientists, managers and organizations set up a collaboration to select high yielding varieties of cereals. The Ford Foundation and the Rockfeller Foundation were strongly involved, as well as many scientists, like Norman Borlaug, who received the Nobel Peace Prize in 1970 [32]. These activities started in the 1960s and were named Green Revolution [33]. The aim of this initiative was to search for new varieties of cereals, or other plants, like the dwarf grain, the IR8 rice, the hybrid corn and other very productive strains. These new varieties showed a shortening of the crop growing period,

and were able to use better fertilizers and pesticides. These concerted actions caused a relevant increase in yields per hectare, thus achieving more production and making it possible to use more efficiently irrigation water; at the same time the new varieties made it possible to decrease the conversion of land to agricultural cultivation. These activities were supported by the foundation and setting up of a Consultative Group on International Agricultural Research, CGIAR, *cgiar-org*), an international organization supporting 15 top-class Research Centers, which organize activities in 108 countries and keep a collection of more than 700,000 seeds.

Thus, the Green Revolution contributed to poverty reduction, averted hunger for millions of people, and avoided the conversion of many hectares of land into agricultural cultivation, while at the same time using less water for irrigation. The efforts to find new strains of plants, or better growth conditions, also aiming at a lower use of irrigation water (through the so-called drip irrigation) are continuing in the CGIAR Research Centers. In fact, as discussed in the previous chapter, the population size is again growing at a high rate and therefore the efforts in improving the production of food are becoming of crucial importance. On the other hand the public opinion appears to be more interested in the impressive disasters caused by the environmental problems, such as the climate change. It is hard to understand these attitudes, unless we realize that people struck by hurricanes or wild storms usually have higher incomes as compared to those that lack water for their immediate needs. If we agree with this statement a consequence is that people struck by hurricanes and storms may be more efficient in asking their governments to become active, as compared to the poor people that need water for daily needs.

Perhaps it should be clear that the discussions on Environmental Problems should be intergovernmental, while the discussions on a renewed "Green Revolution" do not require agreements among States and actually might be more efficient if they are discussed by means of a collaboration among international, non-governmental institutions.

Apparently, what is missing is a concerted effort of many States of the world to set up new managerial structures in order to obtain more water and more food without increasing the extension of land necessary for cultivation. As quoted above, 7,700 million people live now on our planet and they are expected to become 9,800 million in the year 2050, with a 27% increase compared to now. The production of food for these people will need water for irrigation and land for cultivation.

It is clear that we need a second "Green Revolution": less water per km^2, more efficient irrigation, a higher yield per plant. We need new ways to approach the problem of water management and agricultural production [34].

5. How to get water

The number of people on the planet will continue to increase, especially in some areas, and therefore it is necessary to be prepared to provide enough water, especially for those regions where it is presumed that the expansion will be more pronounced. As mentioned above, about three quarters of the annual rainfall occur in specific areas of the planet and about 80% of freshwater is found in a few basins, such as the Great Lakes of North America, Lake Tanganyika in Africa and Lake Baikal in Siberia; or in five main river systems: the Amazon River, the Ganges with the Brahmaputra, the Congo, the Yangtze and the Orinoco. In addition, the rain precipitated on the planet can move at very

different speed, depending on the characteristics of the soil: in some cases it stagnates, while in other cases it evaporates very quickly, or it flows on the surface without penetrating it. For these reasons there are areas of the planet where water is in excess and so they will remain for a good part of the year, while elsewhere there is a more or less serious and extensive water shortage [25] Often, the quantity of water is not enough to cover the local human needs and the struggles for its hoarding can generate episodes of violence, in some cases of considerable severity. As reported in the World Water Development Report of 2021 [35], over two billion people live in countries experiencing water stress; in fact, about four billion people live in areas that suffer from severe physical water scarcity for at least one month per year [36].

Humankind needs to increase the availability of water in the zones where the population is abundant, especially where land fertility may be improved by irrigation. Water is moved through open air canals (sometimes made more efficient through the presence of dams), or through closed structures, the aqueducts. Many canals were built in modern times and today the irrigated areas of the planet are very large: according to ICID, the 2008 estimate was about 3 million km^2, almost 70% of which are located in Asia, 15% in America and the rest distributed between Europe, Africa and Oceania. Appropriate canals were constructed already a long time ago and ruins of them, dating approximately from the 6th millennium BCE, can be seen in Iran; others, built at least three millennia BCE, are found in India or China; and others, built one or two millennia BCE, have been found in Africa, departing from the Niger river. Quite often water moved through small canals that were constructed in order to control the water coming from the flooding of a more important watercourse. Other times these canals were of considerable flow and length: for example, the Assur canal, built about 10 centuries BC, 400 km long, connects the Tigris and Euphrates rivers and it was dug to rationalize the flows of the marshes between these two rivers. The Great Canal of China, built in the 7th century AD, connects the Yellow River with the Blue River and is 1,800 km long. The following are few examples of modern structures: the Arizona Canal, 540 km long, was built to irrigate 400,000 hectares of land with water from the Colorado River; the California Canal, 1,100 km long, brings water from the Sierra Nevada and Northern California to Southern California. In Libya, the Great Man-Made River was built to transport water extracted from more than 1,300 wells located in the South of the country in order to distribute it to the cities of Tripoli, Sirte and Benghazi [37].

Dams are used to manage and furnish water for irrigation. The oldest ones, (called "wadi") were built on rivers that are dry most time of the year; they were useful to retain water coming from rainfall, which passes through the wadis intermittently. Later on, dams were built to handle water from the Tigris/Euphrates, or from the Nile. Important dams, built in modern times, are the Hoover Dam on the Colorado River (completed in 1936); the Aswan Dam on the Nile (completed in 1960) and the Three Gorges Dam on the Yangtze River in China (completed in 2006). In 1997 the International Commission on Large Dams (ICOLD) [38] estimated that 800,000 dams are present in the world, 40,000 of which are more than 15 meters high. The water they keep is used for irrigation and it contributes to 12–16% of the global agricultural production. Quite often dams cause problems to the many people that have to move in order to leave space to the lake that accumulates because of the dam; they also interrupt the links that were present in the different sections of the river and cause difficulties of interactions between States located upstream or downstream, because of their effect on ecology, and their contribution to the availability of water and of energy [39].

Rivers, lakes or groundwater aquifers are often shared by different States. This situation is rather frequent (it involves 153 States) and usually leads to the necessity of international agreements [40]. The competition for these sources of water has caused considerable friction between different countries: we have news of many international disputes for the use of transboundary waters, in which usually the subject of the dispute is the water of a river coming from a state located upstream. The contenders refer to the doctrine of Harmon [41], according to which a State is the owner of the water originating in its territory and has no duties towards the States located downstream. Instead, downstream States claim that they are entitled to receive the same amount of water as they have received in the past.

Aqueducts serve to transfer water, moving in a closed space, to the site of use. The Qanats (or Kariz) are underground tunnels that use water originating from the aquifers; the flow of water is continuous because it moves on an inclined plane and therefore there is no need for pumps. The Qanats have been crucial for the development of the agricultural practices in the Iranian plateau since the first millennium BC, and then spread as a means of water supply throughout the Middle East, the Mediterranean basin and Central and South Asia. In the Roman Empire there were about 600 aqueducts whose main function was to provide drinking water. The Ostrogoths in the year 537 A.D. destroyed the aqueducts that arrived to Rome, in order to prevent the supply of water to the city. Later on, many aqueducts were built in the Islamic world, while in Europe their construction on a large scale resumed only around the 19th century to feed the rapidly growing cities. Modern aqueducts receive water from a source (for example an aquifer, a river, or a canal) and distribute it in a detailed and comprehensive way to the reception points (apartments, in most cases). In modern aqueducts, water is subjected to potabilization processes (flocculation, flotation, filtration, disinfection) and is made colorless, tasteless, odorless, clear, fresh and free of pathogenic germs. Before distribution, water is analyzed to exclude the presence of microorganisms or toxic substances, in accordance with the legislative provisions of the State where the aqueduct is located. Water networks are generally public property and often their sale to private subjects is prohibited; however, their management is sometimes entrusted to private subjects. A serious problem, present in many aqueducts (especially in large cities), is that of the lack, insufficiency or obsolescence of transport networks and infrastructures, too often ancient and inadequate. This causes the waste of enormous quantities of water, depleting the resource and exposing these territories to chronic inefficiencies.

The main source of water used by mankind arrives to the point of utilization by means of canals or rivers, or aquifers. There are however small quantities of freshwater obtained through desalination, namely the separation of salts from marine water, using the method or reverse osmosis, namely the application of pressure on one side of polymeric membranes. Although this method is energy expensive and produces brine that must be carefully disposed of to avoid environmental damage, in 2019 there were about 16,000 desalination plants all over the world, half of them being located in the Middle East and North Africa, producing 95 million m^3 of fresh water per day [42]. Efforts are underway to increase the efficiency of these plants through the use of membranes that are permeable to water due to the presence of aquaporins (cell membrane proteins that allow water permeability) [43].

Another method is drip irrigation; it consists in administering water slowly and directing it towards the root of the plant, thus reducing not only water consumption, but also the growth of unwanted grasses and pests and the evaporation of water from the soil.

One problem that is occurring with an increased frequency is the contamination of freshwater with polluted water. This phenomenon, due to population growth and urbanization, has increased over the years and is expected to continue to increase, despite the approval of several legislative measures aiming at water protection. Polluted waters pose a serious threat to both health and livelihoods. More and more people will have difficulty accessing healthy water and as a result we should find new ways to manage the needs that often compete with each other. In fact, the water available, as described in this article, may be sufficient to meet growing needs globally, but only in the face of a radical change in the way this resource is used, managed and shared. Water recycling allows to obtain water suitable for new uses and in this way to save water in areas affected by shortage. In Windhoek, the capital of Namibia, recycled water has been used as drinking water for about 50 years. Water is also recycled elsewhere, such as in the town of Cuxhaven in Germany and in the International Space Station.

Other mechanisms, not described here, have been proposed: for example, the transfer of icebergs to places where their water can be used; the filling of ships with water from river estuaries; the production of rain obtained by bombarding clouds with silver iodide; etc.

In conclusion, there is plenty of water on the planet to meet the needs of the current population but it should be available in the right place and at the right time.

6. A better management is needed

The description of the present status of the water resources clearly shows the necessity of a better management. It is not acceptable to see that so many sources are underutilized, that many structures built to transport freshwater do not function properly (and sometimes cause disasters), that so many persons lack freshwater and try to emigrate to places where water is abundant. Finally, it is a shame to force women, and sometimes children, to transport every day a small, but essential, part of the water necessary at home for cooking and for hygiene.

It is not acceptable to note that 100,000 km^3 of water fall every year on the emerged lands and that aquifers contain an enormous quantity of freshwater, while there is scarcity of water in many regions of the world. Why the States all over the world have not invested in structures able to furnish water where it is needed? Enormous sums of money are needed, but nothing will take place if discussions do not begin.

The policy “business as usual” generates unrest, unhappiness, poverty, desire to emigrate, wars. Thus, the tremendous amount of work needed to provide freshwater to the poors should be considered a priority in each State, finalized to give more rights to the people that until now have been discriminated. It is not possibile to build the appropriate structures in a short time, but it is a must to begin to do it in an efficient way, in order to give hope for a better future to the many people who do not have enough freshwater. Water is essential for life, it is essential for each of the many cells that make our body. It should be regarded as a special substance as it was in many ancient cultures [44]. The problem of valuing water has been extensively and efficiently analyzed in the 2021 edition of the World Water Development Report. There is no life without water: should we conclude that water is extremely precious? Planet Earth is covered with an immense quantity of water: should we conclude that water has no value?

This article shows that much of the work needed is the transfer of freshwater to the places where it is used. Much of this transfer takes place through channels or rivers (often supported by the presence of dams). This water is either used for field irrigation or distributed to family apartments. Most water for irrigation arrives to the site of utilization through channels. In this case the State should pay for the construction of the channels, while the utilizers should pay for their maintenance.

A high percentage of freshwater for human use comes from aquifers. These were filled with water in the past millennia and continue to be recharged, although very slowly. The underground extension of most aquifers does not follow the political limits existing overground between different States and therefore the use of many of them follows the rules agreed in an international agreement. Each State covering an international aquifer in principle has free access to an agreed percentage of the water of the aquifers. All the structures necessary to extract and transport water are normally paid by the State using it.

More complex is the management of the water distributed to the single utilizers through aqueducts. As described elsewhere in this article, this water should be analyzed to determine if it can be distributed. The analyses should be repeated at prefixed time intervals on samples taken from a detailed list of sites. The distribution of water should be continuously inspected for maintenance in order to avoid undesirable losses that might cause damages to the environment. The amount of water received by each receiver should be measured and paid for. Consumers should pay a low rate on a fixed part of their use while rich people should pay more per cubic meter for the amount of water in excess.

In recent years many urbanized areas started accumulating large amounts of wastewater, which lowers the quality of freshwater. It is essential to avoid the mixing of the two and the necessary devices for treatment should be ready to function. This is not an easy job, but it is an important investment for the future.

Large parts of the globe do not have enough water for human use and as a consequence less people live in these zones. However, the total population of the globe will continue to increase and therefore it is necessary to be prepared to increase the availability of water, especially in those places where it is presumed that the expansion will be more pronounced. It is essential to start building or renovating the structures necessary for the transport and distribution of freshwater. According to the World Water Development Report of 2021 [35] the financial support to be invested is enormous; but we should understand that this work has to begin.

In this review we describe why water is important for the humankind. Water is essential for life: cells of all organisms need macromolecules to propagate themselves and these are kept in solution because they interact with water molecules. Biological membranes are impermeable to water, which can enter cells only through binding to special proteins, called aquaporins [45]. These are part of the mechanism that participates in the regulation of the intracellular concentration of water, so that multicellular organisms are kept alive. Therefore, we may conclude that life on Earth is dependent on water.

There is an excess of water on planet Earth; most of it is in the oceans and it contains too much salt to be useful for the propagation of life of many organisms. Water moves continuously from the oceans to rivers and back to the oceans. According to the hydrological cycle [46] water evaporates from the seas and from the surface of the emerged lands and it then precipitates in the form of rain on

the Earth's surface (including both the emerged lands and the oceans). The salinity of the oceans comes in part from erosion and transport from the mainland of salts dissolved in the water of the rivers.

We mention at the beginning of this manuscript that each year about 100,000 km^3 of rain fall on the planet emerged lands, but only 3,500 km^3 are used by humans. This shows that there is a large excess of water; and that the appropriate structures should be built to avoid water shortage. What is missing is the organization of water structures all over the world. The building of these structures is certainly costly, but the water they transport should not be charged. In other words what is needed is to transport to the right place a material of very little cost (water) and most of the price to be charged is needed to build the infrastructures that are necessary for water use.

Conflict of interest

The author declares no conflict of interest.

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