

REVIEW

Climatic Changes and the Earth's Water Resources

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Abstract

Climate change and especially the Earth global warming affects and will continue to affect one of the principal Earth's natural resources – the water. If in a previous paper we referred to the melting of polar ice caps and glaciers due to global warming, in this paper we refer to the extension of the world dryland and the effects of the reduction of water sources either surface or underground on agriculture and human nutrition. Furthermore it shows that water penury and the irrational management of the existing water resources can lead to disputes and conflicts between neighboring states, which sometimes may reach to armed conflicts as well.

Key words: agriculture, climate changes, nutrition, state conflicts, water

Introduction

The climatic changes, especially the temperature rises, affects water resources which are important for society, biodiversity and human health (the need of drinking water). Water is the main source for agriculture, energy production and navigations as well. In addition, rising temperatures are melting glacial ice at an unprecedented rate. Glaciers are an important source of freshwater worldwide, and some of them, are in great danger of disappearing within the 21st century. Once these glaciers have melted away, they can't be restored. Areas that previously depended on glaciers for freshwater will then have to seek other sources. In addition, the temperature rises are leading to the advancing of deserts in numerous parts of the world. The water shortages and the

problem of drinking water resources and their use will create conflicts all over the world between neighboring countries.

In this paper we will refer only to the effects of global warming on Earth's water resources, and how this phenomenon put pressure on water resources, stresses that are likely to be exacerbated by climate change. The paper include some reparation measures to be taken to meet this challenger.

Discussions

The climatic changes we are witnessing today, and especially the temperature rises, are leading to the advancing of deserts in numerous parts of the world. Thus, the advancing of the Sahara desert forces millions of people from Tunisia, Morocco and Algeria to migrate, either towards the south, or towards Northern Africa (most of them), to the Mediterranean area. At the 2006 UN conference regarding desertification, it was estimated that approximately 60 million people would migrate from sub-Saharan Africa towards the Mediterranean area or Europe by 2020, something that is more and more obvious at the moment (Fig. 1) (Brown, 2011a).

Scientists appreciate that the Sahara has extended over the last hundred years by a million km² and over the last 20 years by 200 km². Our country too has areas with a high degree of desertification (south of Oltenia, Moldavian plateau etc.) (Fig. 2) (Bavaru and Bercu, 2014).



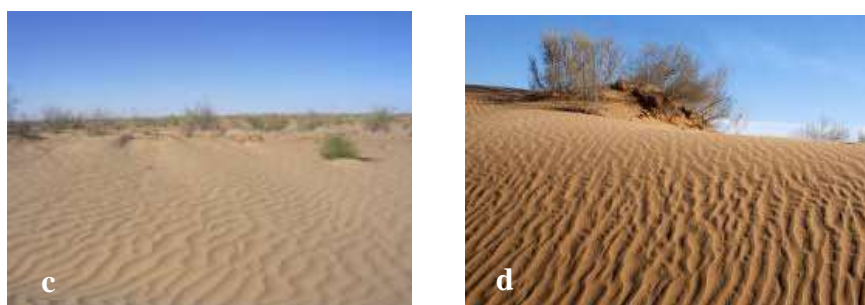


Figure 1. Images from the Kara-Kum desert (a, b) and Kyzyl-Kum desert (c, b), in the Turan Basin, Central Asia (from Bavaru and Bercu, 2014).



Figure 2. Ten counties of Romania in danger of desertification due to drought (from Bavaru and Bercu, 2014).

In Iran, due to the lack of water and the desert advancing, dozens of villages were abandoned and millions of people migrated to other zones. The same thing happens in Latin America. Approximately 60 million ha (in Brazil) and 59 million ha (in Mexico) are affected by desertification. Such aspects are present in the USA as well, due to the advancing of the south-west deserts, which led to the displacement of approximately three million people, while in China, desert expansion would lead to the displacement of tens of millions of people (Brown, 2011a). A study of the International Organization for Migration (IMO) shows that the number of “climatic” refugees will reach 200 million people by 2020 (Fig. 2) (Web 2).

A team of American specialists from the National Center of Atmospheric Research (NCAR) from Colorado demonstrated that the surface affected by drought increased from 15% in the 1970s to approximately 30% in 2002 (it

doubled). This is firstly due to the temperature increases and rainfall reduction. Other American researchers have shown that if atmospheric carbon dioxide increases from 385 ppm to 450-600 ppm, rainfall would drastically decrease in many regions of the world. Moreover, it was demonstrated that a temperature increase by 1.6°C during summer would double the number of wilderness fires.

Apart from the water we need to drink and wash, let's see how things are with water in agriculture, the one needed to produce food. In order to have an exact image of the water consumption in various sectors, we will present a table belonging to Suzanne D. Grivet and also used by other authors (Bavaru and Bercu, 2014; Brown, 2011a).

This table presents the large variations of water consumption according to various activities and geographical areas of the world. If there is some resemblance between Africa and Asia from this point of view, the same thing applies for Europe and North America. For other geographical areas, the differences are obvious. As a whole, we can see that agriculture has the highest water consumption (70%), followed by industry (20%), while domestic consumption is estimated to only 10% of the total. In agriculture, 17% of farmland is irrigated, producing approximately 40% of the world production. Thus, agriculture is the champion of both water use and water waste. Of the 80% withdrawn, 50% evaporate, a quantity lost in the atmosphere (Brown, 2011a; Brown 2011b; Lacoste 2010).

The specialists mention (Guilhem Soutou, 2013) that the entire irrigated surface of the world was almost double compared to 1960-2000, reaching 280 ha in 2008, compared to 190 million ha in 1980.

We must also specify that the geographical distribution of irrigation does not depend on the development of the countries, but mainly on climate (François Neron, 2011).

It is normal for arid zones, permanently affected by drought (Northern Africa, the Middle East, Central Asia and the Mediterranean countries) to take over 80% of the water withdrawn. For India and China, irrigations are absolutely necessary if we realize that they must provide food for billions of people. In the equatorial countries of the world, irrigations are not a necessity as it rains daily (Congo, Indonesia etc.).

It is known that the increase of food production is not possible without the increase of water consumption. It is estimated that by 2050, according to the demographic growth in the world, an increase of approximately 5000 km³ of water would be required (Mășu, 2014).

Table 1. Water collection on sector and region (by Grivet D. Suzane, 2011).

Continent/Regiune	Agricole	Industriale	Casnice
In the world	70	20	10
Africa	86	4	10
Asia	81	11	7
Latin America	71	10	19
Caribbean	64	9	27
North America	39	47	14
Oceania	72	10	18
Europe	29	55	16

Table 2. The amount of water needed for food production (liters/kg) (by Ghislain de Marsily, 2009)

Continent/Regiune	Agricole	Industriale	Casnice
Vegetable oil	5.000	Beef	13.000
Rice	15.000-2.000	Domestic fowl	4.100
Wheat	1.000	Eggs	2.700
Maize	700	Milk	800
Vegetables	200-400		
Potatoes	100		



Figure 3. African children and the shortage of drinking water(*foto*: Hannah Mcneish / AFP / Getty Images; *sursa*: “The Epoch Time-Romania”, 24.05.2012) (Web 3).

If the daily needs of a person are estimated to a few liters, for the production of bread and of other daily foods, the water needed ranges from 1.5 to 5 tons. In the civilized countries, it varies from 4 to 5 tons for the daily needs of a person.

There are in the world areas with water shortages. It is estimated that a sixth of the world population does not have access to water. Approximately two billion people live with “water stress”, meaning their resources are below 1700 m³/person/year. There are countries in the Middle East, North Africa and sub-Saharan Africa with only 1000 m³/person/an (Brown, 2011a). Unfortunately, there is also a bad water management that leads to shortages (Fig. 3).

Here is, for example, the case of Saudi Arabia. Due to food insecurity, the Saudis have bought or rented for years farmland in other countries (Ethiopia and Sudan). They produce their own resources by using land and water from other countries (Brown, 2011a; Mășu, 2014).

In Yemen, the situation is even more serious. Groundwater and the deep fossil water table were pumped and exhausted. The level of groundwater, as a whole, decreases yearly by two meters. In Sana’a, the capital of Yemen, with two million inhabitants, tap water is supplied once every four days, while in Taiz, a different city in the south, water is supplied once every 20 days. The Yemenite

tribes have been constantly fighting over water for years. Today, they import 80% of the grains they need. Without industry, with small oil resources and exploitations, Yemen is one of the poorest countries in the world (Brown, 2011a; Mășu, 2014).

Currently, there are numerous countries dealing with a large water shortage. The level of groundwater decreases as it is used more and more intensely. We remarked previously that 70% of the world's water is used for irrigation, while water shortages rapidly turn into food shortages.

Unfortunately, the increasing reduction of the level of groundwater also occurs in China, India or the USA, all three producing about half of the world cereal production. In order to better understand the danger of overdrafting, we must remember that 4/5 of the cereal crop in China is obtained from irrigated lands, 3/5 in India and 1/5 in the USA (Brown, 2011a; Mășu, 2014).

For those who are not aware, here is another important element: the largest amount of groundwater comes from the water table which is regularly supplied by rain and, as long as the rain regimen is positive everything is alright. But part of the water table is fossil – water deposited during the distant geological ages. These cannot be resupplied by rain, being located at great depths, and consequently are exposed to exhaustion (the Great Plains in the USA, Saudi Arabia, the north plain in China etc.). As a result, in the American states Arizona, Colorado and Florida, the irrigated surfaces are smaller and smaller. It is estimated that there will be a 10% reduction between 2000 and 2030 as a result of the exhaustion of the water table and the deviation of a part of it (used for irrigation) towards large urban centers, also very “thirsty” (Brown, 2011a; Mășu, 2014).

In Mexico, the water demand exceeds the supply. The capital, Mexico City, has been having problems with the water supply for years. Located like the whole country, in a droughty area, it is over 50% supplied with water from deep water tables (down to 150 m), and overdrafting will exhaust this water in the future.

Jordan and Israel do not have a better situation either. In 2010 Jordan imported approximately 90% of the cereal production yearly, while Israel imports

about 98% of the required cereal production. Numerous Arab countries are also in a bad situation (Iran, Iraq, Syria, Afghanistan etc).

As can be estimated, the insufficient amount of water at global level generates economic competition between agriculture – specifically farmers – and urban centers which are ever increasing, in number and surface. The farmers are disadvantaged in this competition because they need considerable water to produce food. Here is a telling example: the production of a ton of wheat requires 1000 tons of water, while the gain is 150-160 euro/ton. However, a ton of steel requires only 14 tons of water, while the gain is approximately 650-700 euro/ton. Not to mention that industry is the one that offers more jobs.

The problem of drinking water resources and their use has been creating conflicts all over the world between neighboring countries.

We will mention here a recent study performed by two American researchers from the University of Iowa and published by the “Association for Psychological Science” from the USA in February 2017 (popularized in our mass-media as well). The title is enough to understand the content “Global Warming and the Violent Behavior”. In short, high temperatures and global warming generally cause a violence surge. These climatic changes and especially the temperature increases cause major problems in terms of food security in various countries, enhancing poverty and malnutrition (Fig. 4). There are phenomena of instability, conflicts, incertitude. There are disputes over resources, water being one of the major causes (Unteanu, 2017).



Figure 4. Climatic changes enhance poverty, malnutrition, and affect people's health. *Photo* "Sleeping on the river bed" by Nimai Chandra Ghosh was awarded at the WHO photography competition "Images of the health of the environment 2007" (from Bavaru și Bercu, 2014).

We will shortly dwell on some of these disputes that can, at any moment, generate violent conflicts

Thus, China has an internal imbalance between the north and the south. The north is experiencing an acute water shortage, as it has an arid and semi-arid climate, with 45% of the country's population and only 15% of the water resources. The south has 50% of the population and 80% of the water resources (the two rivers and the annual input from the monsoon etc.). It shares the hydrological resources with its neighbors in the north (Russia and Kazakhstan) that criticize China for the building of too many dams and the pirating and pollution of these waters. As collateral information, China has 22000 large dams of the 45000 dams existing in the world. In the south, it has obvious economic conflicts with India related to water resources, apart from those related to frontiers in the Himalaya region. The Brahmaputra is very important for India, but China wants to build several dams in the superior sector of the river located on the Chinese territory in order to develop agriculture and hydroelectric activity in the Chinese Tibet, affecting thus 27% of the river flow. Similar disputes are between China and Thailand, Laos, Cambodia and Vietnam because of China's desire to build dams on the superior sector of the Mekong. These dams are a menace to the climatic balance in the region, as well as to the socio-political one (Mârșu, 2014).

A similar situation is in Egypt in terms of the ten countries crossed by the Nile, the longest river in the world. Its basin has 3 million km³. Egypt, and not

only, owes its existence and the existence of its people to the Nile. Compared to its neighbors, Egypt has a rather rigid attitude when it comes to this river. Firstly, Ethiopia, with a similar population to Egypt and an impressive birth rate (it is estimated to reach 129 million inhabitants by 2025) has a similarly arid climate and its economy is based on agriculture. In order to provide food for such a large population, agriculture needs irrigation (for approximately two million ha), based on micro-dams and an economic development based on hydroelectricity (only 2% of the population has access to electricity). These dams would reduce the flow of the Nile by 4-8 billion m³/year, a river which is entirely navigable.

In terms of the Nile, Egypt also has serious disagreements with Sudan, a country in which agriculture represents approximately 35% of the Gross National Product (GNP) and 70% of the water withdrawal. Sudan split in two recently, into South and North Sudan (the driest and poorest, without oil resources). The two states joined efforts to collaborate in order to use the waters of the Blue Nile (one of the two Nile tributaries) without consulting Egypt and causing an adverse reaction from it (Fig. 5).



Figure 5. SLA-MinniMinnawidin fighters in north Darfur (Sudanese region) that fight for gold and water. *Photo from the UNAMID archive (photo: Ronan O'Kelly; source: vice.com, 23.09.2013 (Web 4).*

Such conflicts also occur between Mexico and the USA in regard to the use of the Colorado which reaches Mexico with a low flow of only 4% and is

extremely polluted with chemical pesticides and fertilizers, which causes permanent protests from Mexico. Similar water conflicts occur in the Jordan basin (between Israel, Jordan and Palestine), in Spain among its regions, in Western Africa between Senegal and Mauritania and others (Mășu, 2014).

All these examples show us the international and trans-border dimension of the water resources which have often started conflicts and even wars in the 21st century. Over the past 50 years, approximately 37 wars broke out between neighboring countries. Still, the recent studies (like the one from Oregon's State University) established a positive element: the cooperation between countries occurred twice as often as conflicts (Mășu, 2014).

The Danube could be a cooperation laboratory, even though some people consider it a crisis topic, as it crosses 17 countries that signed a Convention in 1994, a year when a common institution for the management of its waters was also established.

The Danube, also a navigable river, ensures navigation from the North Sea (the Rhine-Main-Danube canal) to the Black Sea and has some pollution problems.

Through careful monitoring, 50-80% of its waters have a "good ecological situation." The situation of the Danube Delta is a problem shared by Romania and Ukraine. We delayed action in the discussions with Ukraine regarding the Bystroye canal (Mășu, 2014).

Added to the decrease of water resources linked to global warming, which can always lead to tensions and conflicts between countries, is bad management and handling of these resources, due to our negligence.

Consequently, around the years 2005-2006, a plan was elaborated to include the reparation measures. These are mentioned by Yvette Vyret and Jacqueline Jalta in "Développements durables" (2010) and which, in short, refers to the following aspects:

- the reduction of water loss, similar to the energy problems to secure the recorded losses;
- rationing of water use in agriculture (there are, however, reservations about this);
- recycling of water and the careful treatment of sewage;

- the desalinizing of seawater – the only safe solution for the countries that no longer have water resources, despite the high costs;
- transfer of drinking water to a distance – where possible;
- the use of the water table where there are still large resources (the case of Lybia);
- recovering of rainwater in dams and large reservoirs and their use especially for irrigations in agriculture.

In 2012, the European Parliament adopted a resolution through which the member states must reduce to half food waste by 2025 (Mășu, 2014). Such measures were adopted by the Chinese, as well. But the most important measures consist in the change of mentality for some of us who do not care about wasting water.

Conclusions

As Noah Hall et al. reported in 2008 “Expected increases in water demand due to higher temperatures will compound the problem of how to meet increased demand from population growth and economic development. New, widespread conservation and allocation policies will be essential to meet this challenge”.

References

- [1] Bavaru A., Bercu R. (2014) - Protecția mediului, a resurselor sale – o șansă pentru viață. Ed, Arhiepiscopia Tomisului, Constanța.
- [2] Brown L.R. (2011a), Lumea pe marginea prapastiei. Cum să prevenim colapsul economic și ecologic, Edit. Tehnică, București.
- [3] Brown L.R., 2011b, Planul B. 4.0. Mobilizarea generală pentru salvarea civilizației, Academia Română, Centrul Român de Economie comparată și Consens, București.
- [4] De Marsily G., 2009, L'eau, un trésor à partager, Dunod, Paris.
- [5] Grivet D. S., 2011, Géopolitique de l'eau, Éditeur Ellipses, Paris.
- [6] Lacoste Y., 2010, L'eau dans le monde: les batailles pour la vie, Éditeur Larousse, Paris.

- [7] Hall N.D., Stuntz B.B., Abrams R.H., 2008 Climate Change and Freshwater Resources, *Natural Resources & Environment*, Vol. 22(3): 30-35.
- [8] Mășu S., 2014, Securitatea accesului la apă, obiectiv economic, geopolitic și geostrategic în sec. al XXI-lea, Comunicarea la Sesiunea Științifică de toamna a Academiei Oamenilor de Știință din România, „Omul și natura din perspectiva societății moderne”, 19-20 septembrie, 2014, Constanța.
- [9] Neron F., 2011, *Petit précis d'agriculture, France Agricole*, Paris.
- [10] Soutou G., 2013, *Le défi alimentaire*, Éditeur L'Harmattan, Paris.
- [11] Unteanu C., 2017, O ipoteză tulburătoare: relație directă între schimbările climatice și violența socială, ziarul „Adevărul” 27.02.2017.
- [12] Veyret Y., Jalta J., 2010, *Développements durables*, Autremet, Paris.
- [13] Web 1 <http://www.gandul.info/magazin/galerie-foto-ingrijoratoare-asa-arata-incalzirea-globala-13744827>
- [14] Web 2 <http://www.descopera.ro/dnews/5263645-in-2050-numarul-refugiatilor-climatici-va-ajunge-la-200-de-milioane>
- [15] Web 3 <http://epochtimes-romania.com/foto/copiii-africii-si-deficitul-de-apa-potabila---271>
- [16] Web 4 <https://www.vice.com/RO/article/triburile-din-darfur-se-ucid-intre-ele-pentru-aur-si-apa>